Skilled Trades Ontario | Métiers spécialisés Ontario

Apprenticeship Curriculum Standard

Machine Tool Builder and Integrator

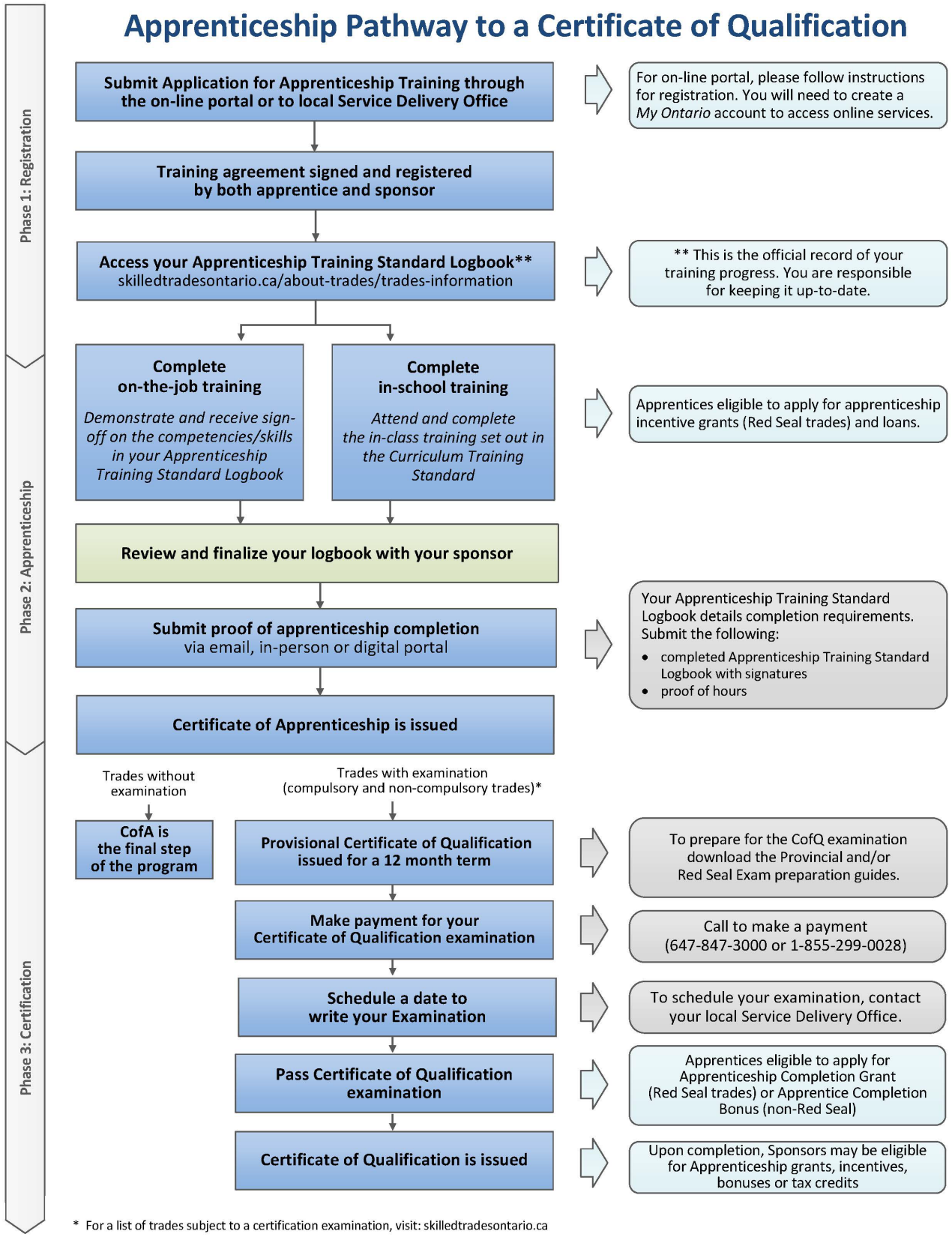
Level 2 Intermediate

Level 3-Advanced

430M

2008

Apprenticeship Pathway to a Certificate of Qualification



* For a list of trades subject to a certification examination, visit: skilledtradesontario.ca

Draft version: 2022-03-16

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Please Note: This Standard has been revised to reflect the visual identity of Skilled Trades Ontario (STO) which replaced the Ontario College of Trades on January 1, 2022. The content of this Standard may refer to the former organization; however, all trade specific information or content remains relevant and accurate based on the original date of publishing.

Please refer to STO's website: **skilledtradesontario.ca** for the most accurate and up to date information. For information about BOSTA and its regulations, please visit ***Building Opportunities in the Skilled Trades Act, 2021* (BOSTA).**

Any updates to this publication are available on-line; to download this document in PDF format, please follow the link: Skilled Trades Ontario.ca.

Maintained with transfer to Skilled Trades Ontario Level 2 2008, Level 3 2002 (V100)

Preface

This curriculum standard for the Machine Tool Builder and Integrator trade program is based upon the on-the-job performance objectives, located in the industry-approved training standard.

The curriculum is organized into 2 levels of training. The Reportable Subjects Summary chart (located on page 2) summarizes the training hours for each reportable subject.

The curriculum identifies the learning that takes place in-school. The in-school program focuses primarily on the theoretical knowledge and the essential skills required to support the performance objectives of the Apprenticeship Training Standards.

Employers/Sponsors are expected to extend the apprentice's knowledge and skills through practical training on a work site. Regular evaluations of the apprentice's knowledge and skills are conducted throughout training to verify that all apprentices have achieved the learning outcomes identified in the curriculum standard.

It is not the intent of the in-school curriculum to perfect on-the-job skills. The practical portion of the in-school program is used to reinforce theoretical knowledge. Skill training is provided on the job.

Please refer to Skilled Trades Ontario website (www.skilledtradesontario.ca) for the most accurate and up-to-date information about Skilled Trades Ontario. For information on *Building Opportunities in the Skilled Trades Act, 2021 (BOSTA)*) and its regulations, please visit Building Opportunities in the Skilled Trades Act, 2021, S.O. 2021, c. 28 - Bill 288 (ontario.ca)

Pre-requisites

In order to advance to Level 2 of the apprenticeship program, an individual must have completed all of the units outlined in Level 1. Similarly, in order to advance to Level 3 of the program, an individual must have completed all of the units outlined in Level 1 and 2.

Hours Disclaimer (if applicable)

It is agreed that Training Delivery Agents (TDAs) may need to make slight adjustments (with cause) according to particular apprentice needs and may deviate from the unit sequencing and the prescribed practical and theoretical hours shown within the standard. However, all TDAs will comply with the hours at the reportable subject level.

Suggested Equipment for Training Delivery Agencies

Personal and Safety Equipment: Personal protective equipment is at the discretion of the TDA who must conform to Ontario Provincial Health and Safety Regulations.

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practical
Level 2				
S090	Applied Mechanical Calculations	30	30	0
S091	Engineering Drawings, CAD Data, Layout Processes	30	30	0
S092	Metallurgy	6	4	2
S093	Metrology (Measuring and Checking)	6	4	2
S094	Turning Technology	12	3	9
S095	Milling Technology	18	4	14
S096	Cylindrical Grinding Technology	12	3	9
S097	CNC Turning Technology	12	3	9
S098	In-Process Tools/Tooling Technology (Swaging, Electrodes, Nozzles)	30	12	18
S099	Pneumatic and Hydraulic Systems	30	18	12
S100	Machine-Tool Electrical Basics	24	18	6
S101	Machine-Tool Power Transmission	30	18	12
	Total	**240**	**153**	**87**
Level 3				
102.0	Applied Mechanical Calculations	36	24	12
103.0	Mechanical Engineering Drawings & Documentation	24	12	12
104.0	Machine-Tool Feeder and Conveyor Technology	36	24	12
105.0	Planning of Machine-Tool Building and Integration	18	12	6
106.0	In-Process Tooling Technology (Forming, Trimming, Machining)	48	24	24
107.0	Machine-Tool Sub-Assembly Technology	42	24	18
108.0	Machine-Tool Main-Assembly Technology	36	18	18
	Total	**240**	**138**	**102**

Level 2

Reportable Subject Summary – Level 2

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practical
S090	Applied Mechanical Calculations	30	30	0
S091	Engineering Drawings, CAD Data, Layout Processes	30	30	0
S092	Metallurgy	6	4	2
S093	Metrology (Measuring and Checking)	6	4	2
S094	Turning Technology	12	3	9
S095	Milling Technology	18	4	14
S096	Cylindrical Grinding Technology	12	3	9
S097	CNC Turning Technology	12	3	9
S098	In-Process Tools/Tooling Technology (Swaging, Electrodes, Nozzles)	30	12	18
S099	Pneumatic and Hydraulic Systems	30	18	12
S100	Machine-Tool Electrical Basics	24	18	6
S101	Machine-Tool Power Transmission	30	18	12
	Total	**240**	**153**	**87**

Number:	S090		
Title:	**Applied Mechanical Calculations**		
Duration:	Total Hours: 30	Theory: 30	Practical: 0
Prerequisites:	L1 PMT CC - 1.0 to 11.0		

Learning Outcomes

90.1 Solve trade-specific problems involving the Pythagorean theorem and solve for unknown values. (3/0 hrs)

90.2 Solve trade-specific problems involving right triangle trigonometry and solve for unknown values. (3/0 hrs)

90.3 Calculate the values of angles and sides of right angle triangles. (2/0 hrs)

90.4 Solve trade-specific problems involving circles. (3/0 hrs)

90.5 Perform trade-specific calculations. (4/0 hrs)

90.6 Calculate the mechanical power requirements of a system driven by an electrical actuator. (5/0 hrs)

90.7 Perform simple power transmission calculations. (5/0 hrs)

90.8 Calculate and determine the basic principles of fluid power systems (gas laws, compressibility, storage, Pascal's law, continuity law). (5/0 hrs)

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Lecture
Video
Paper based material
CBT
Internet On-Line

Reference Materials:
Technology of Machine Tools
Shop Text Books
Mathematics for Machine Technology
Interpreting Engineering Drawings

Number:	S090.0		
Title:	**Applied Mechanical Calculations**		
Duration:	Total Hours: 30	Theory: 30	Practical: 0
Cross-Reference to Training Standards: 430M: 5530 - 5548			

General Learning Outcomes

Upon successful completion the apprentice is able to: solve problems involving the Pythagorean Theorem; solve problems involving right angle trigonometry; solve problems involving circles; calculate mechanical power requirements; perform simple transmission calculations; and, calculate basic principles of fluid power systems.

Learning Outcomes

Upon successful completion the apprentice is able to:

90.1 Solve trade-specific problems involving the Pythagorean theorem and solve for unknown values. (3/0 hrs)

Explain the concept of the Pythagorean theorem.

Calculate the values of unknown sides of right triangles using the Pythagorean theorem.

90.2 Solve trade-specific problems involving right triangle trigonometry and solve for unknown values. (3/0 hrs)

Describe definitions and relations of trigonometric functions including:
- definitions of trigonometric functions
- reciprocal relations of trigonometric functions
- variations of trigonometric functions from 0E - 90E
- fundamental relations between trigonometric functions

Describe the sides of a right triangle including:
- opposite
- adjacent
- hypotenuse

Describe the trigonometric functions of right triangles including:
- sine
- cosine
- tangent
- cotangent
- secant
- cosecant

90.3 Calculate the values of angles and sides of right angle triangles. (2/0 hrs)

Perform trigonometric calculations of angles and sides of right angle triangles including:
- determination of an unknown side
- determination of an unknown angle
- finding an angle corresponding to a given trigonometric function
- determining an angle when two sides of a right angle triangle are given
- rule for finding the function of an angle
- ratio method

90.4 Solve trade-specific problems involving circles. (3/0 hrs)

Identify and describe a circle and its parts including:
- circumference
- chord
- diameter
- radius
- arc
- tangent
- secant
- segment
- central angle
- inscribed angle

Calculate the values of unknown parts of a circle involving:
- angles formed inside a circle
- angles formed outside a circle
- internally tangent circles
- externally tangent circles

90.5 Perform tool making trade-specific calculations to produce parts. (4/0 hrs)

Perform trade-specific calculations required to machine a part including:

- tapers
- bevels
- isosceles triangles
- distance between holes
- distance between v slots
- vee-blocks
- dovetails
- draft angles
- angles
- slide
- cam

Perform calculations using trade-specific reference material, charts, and tables including:

- taper calculations
- trigonometric functions/laws
- thread data
- mathematical formulae
- draft angles
- three wire method (thread measurement)
- machining sequences

90.6 Identify and describe calculations required to determine the mechanical power requirements of a system driven by an electrical actuator. (5/0 hrs)

Describe F=ma to calculate the linear force required to accelerate a known mass.

Describe T=Fd to calculate the torque required to generate a linear force.

Describe P=Tω to calculate the motor power required to achieve an output torque at a given shaft rotation speed.

Describe tabulated formulae to calculate the mass moment of inertia (IM) of simple mechanical systems driven by rotational actuators.

Describe T= IMα to calculate the torque required to rotationally accelerate (α) a load with a known mass moment of inertia.

90.7 Describe simple power transmission calculations. (5/0 hrs)

Describe simple power transmission calculations including:

- speed change-ratios
- torque change ratios
- conversion between linear speed and rotary speed
- conversion between linear force and rotary torque
- Calculate power in watts and horsepower, based on speed and torque

90.8 Describe the basic principles of fluid power systems (gas laws, compressibility, storage, Pascal's law, continuity law). (5/0 hrs)

Describe theoretical force capabilities of pneumatic actuators using Pascal's Law.

Describe practical force limitations of pneumatic actuators given acceleration and velocity requirements.

Describe lifting capabilities of vacuum cups and vacuum surfaces.

Describe compressor tank and motor size for given application

Describe the relationship of the compressibility of air to its operational characteristics.

Describe air consumption and describe the effect of air leakage on the cost of operation.

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
100%	0%	100%

Number:	S091		
Title:	**Engineering Drawings, Cad Data, Layout Processes**		
Duration:	Total Hours: 30	Theory: 30	Practical: 0
Prerequisites:	L1 PMT CC - 1.0 to 11.0		

Learning Outcomes

91.1 Describe elements, features, graphic language, and symbols of engineering drawings. (2/0 hrs)

91.2 Describe dimensional terminology, symbols, and practices. (2/0 hrs)

91.3 Describe orthographic and auxiliary views to identify component features. (2/0 hrs)

91.4 Sketch revolved, removed, partial, and broken out sectional views. (2/0 hrs)

91.5 Describe geometric tolerancing dimensional terminology. (10/0 hrs)

91.6 Identify elements and features of tool drawings and production drawings (2/0 hrs)

91.7 Describe the features, elements, types, and terminology of engineering drawings for gears, cams, and bearings. (2/0 hrs)

91.8 Interpret trade-specific reference material, charts and tables (2/0 hrs)

91.9 Describe featur4es of electrical schematics and symbols. (1/0 hrs)

91.10 Describe features of pneumatic and hydraulic schematics and symbols (3/0 hrs)

91.11 Develop an operational plan for machining of in-process tooling components. (2/0 hrs)

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Lecture
Video
Paper based material
CBT
Internet On-Line

Reference Materials:

Technology of Machine Tools
Mathematics for Machine Technology
Interpreting Engineering Drawings
Jig & Fixture Making for Metal Working
Basic and Advanced Tool Making
Machine-Tool Building and Integrating Manuals and Documentation

Number:	S091.0		
Title:	**Engineering Drawings, CAD Data, Layout Processes**		
Duration:	Total Hours: 30	Theory: 30	Practical: 0
Cross-Reference to Training Standards: 430M: 5530 - 5548			

General Learning Outcomes

Upon successful completion, the apprentice is able to: describe three dimensional objects; use gear/cam/bearing charts and tables; describe pneumatic and hydraulic schematics and symbols; describe electrical schematics and symbols; develop an operational plan for in-process machine- tool components; and, sketch revolved, removed, partial and broken out sectional views

Learning Outcomes

Upon successful completion the apprentice is able to:

91.1 Describe elements, features, graphic language, and symbols of engineering drawings. (2/0 hrs)

Describe graphic language and symbols of engineering drawings including:

- manufacturing (detail)
- assembly
- sub-assembly (working assembly)
- location
- surface texture
- positional tolerancing
- machined surfaces
- not to scale
- grade numbers
- tolerancing

Describe elements and features of tool drawings and production drawings including:

- types of tool drawings
- methods to simplify tool drawings
- dimensional forms

91.2 Describe dimensional terminology symbols, and practices. (2/0 hrs)

Describe dimensional terms including:
- break line
- (PCD) pitch circle diameter
- (BCD) bolt circle diameter
- across flats
- pictorial
- schematic
- simplified

Describe dimensioning methods including:
- point-to-point
- datum
- tabular
- arrowless

Describe thread representations and designations including:
- acme
- pipe
- thread forms (ISO)
- metric
- pipe
- whitworth

Identify screw thread designations for CSA, ANSI, and ISO forms including:
- nominal diameter
- outside diameter (OD)
- TPI
- pitch and pitch diameter
- class of fit
- external/internal
- left/right
- thread forms

Identify drawing elements related to workpiece processing techniques including:
- welding symbols
- forging and casting (draft angles)
- fillets and rounds
- non-machined dimensional features
- nominal dimensions

91.3 Describe orthographic and auxiliary views to identify component features. (2/0 hrs)

Describe orthographic projections including:
- removed
- partial
- broken out

Describe auxiliary views of orthographic projection.

Describe the basic function of an auxiliary view including:
- angular position
- inclined surface
- true shape
- profile

Describe the types of auxiliary views including:
- primary
- secondary
- sectional

Describe types of sectional views including:
- partial
- revolved
- removed
- offset
- broken out

91.4 Sketch revolved, removed, partial, and broken out sectional views. (2/0 hrs)

Sketch to scale sectional views including:
- partial
- revolved
- removed
- offset
- broken out

91.5 Describe geometric tolerancing dimensional terminology. (10/0 hrs)

Describe geometric terminology as applied to engineering drawings including:

- straightness
- flatness
- roundness (circularity)
- cylindricity
- profile of a line
- profile of a surface
- angularity
- perpendicularity
- parallelism
- position
- concentricity
- symmetry
- feature control frame
- general rules
- virtual condition
- total runout
- maximum material condition
- regardless of feature size
- least material condition
- projected tolerance zone
- basic dimension
- datum feature
- datum targets
- circular run-out
- correlative tolerance
- datums

91.6 Identify elements and features of tool drawings and production drawings. (2/0 hrs)

Identify elements and features of tool drawings and production drawings including:

- ear, cam, and bearing drawings
- simplified tool drawings (production drawings)
- jigs
- fixtures
- gears
- cams
- bearings
- bushing

Interpret engineering drawings to identify features of a finished component using first or third angle projection.

91.7 Describe the features, elements, types, and terminology of engineering drawings for gears, cams, and bearings. (2/0 hrs)

interpret gear, cam, and bearing designations on engineering drawings to identify:

- addendum
- dedendum
- circular pitch
- diametrical pitch
- clearance
- whole depth
- tooth pressure angle
- rise
- fall
- anti-friction
- angular
- sleeve
- dwell
- drop

91.8 Interpret trade-specific reference material, charts and tables. (2/0 hrs)

Use material and value tables and charts to develop an operational plan:
- application
- type
- format
- dimensions
- standards
- abbreviations
- terminology
- graduations
- accuracy
- limitations

Interpret trade-specific documentation and drawings to determine in-process tooling including:
- swaging
- electrodes
- nozzles

91.9 Describe features of electrical schematics and symbols. (1/0 hr)

Interpret electrical schematics and engineering drawings to identify:
- switches
- transducers
- motors
- circuit breakers
- fuses
- overload devices
- breakers
- relays
- opto-isolators
- transformers

91.10 Describe features of pneumatic and hydraulic schematics and symbols. (3/0 hrs)

Interpret hydraulic and pneumatic schematics and engineering drawings to identify:

- hydraulic and pneumatic valves
- linear and rotary actuators
- vacuum system components
- filter
- lubricators
- regulators
- flow controls
- tubing
- piping
- hydraulic pumps
- reservoirs

91.11 Develop an operational plan for machining of in-process tooling components. (2/0 hrs)

Interpret drawings and develop a plan for machining methods and procedures.

Interpret drawings and develop a plan for operational sequences.

Sketch in-process tooling development work for:

- swaging
- electrodes
- nozzles

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
100%	0%	100%

Number:	S092		
Title:	**Metallurgy**		
Duration:	Total Hours: 6	Theory: 4	Practical: 2
Prerequisites:	L1 PMT CC - 1.0 to 11.0		

Learning Outcomes

92.1 Identify safe working procedures associated with heat-treating furnaces and hand-held equipment.

92.2 Describe ferrous metal heat-treating processes. (2/0 hrs)

92.3 Describe hardness testing methods. (0/2 hrs)

92.4 Describe non-ferrous metals. (2/0 hrs)

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Lecture
Video
Paper based material
CBT
Internet On-Line

Reference Materials:
Technology of Machine Tools
Mathematics for Machine Technology
Interpreting Engineering Drawings
Jig & Fixture Making for Metal Working
Basic and Advanced Tool Making
Machine-Tool Building and Integrating Manuals and Documentation

Number:	S092.0		
Title:	**Metallurgy**		
Duration:	Total Hours: 6	Theory: 4	Practical: 2
Cross-Reference to Training Standards: 430M: 5530 - 5548			

General Learning Outcomes

Upon successful completion, the apprentice is able to: describe heat-treating and testing of ferrous metals; and, describe hardness testing.

Learning Outcomes

Upon successful completion the apprentice is able to:

92.1 Identify safe working procedures associated with heat-treating furnaces and hand-held equipment.

Identify furnace heat-treating safety procedures and equipment including:
- personal protection equipment
- temperatures
- ventilation
- fire hazards

Identify hand-held heat-treating safety procedures and equipment including:
- personal protection equipment
- ventilation
- temperatures
- handling and storage of equipment
- fire hazards

92.2 Describe ferrous metal heat-treating processes.(0/2 hrs)

Describe flame hardening and tempering processes including:
- tempering colours
- quenching media
- surface preparation
- workpiece holding/positioning

Describe the process and advantages for hardening of ferrous metals including:

- heat-treating specifications
- quenching media
- metallurgical structural change
- hardness obtainable
- strength
- toughness
- wear resistance
- machinability
- distortion
- work preparation procedures
- time-temperature cycle
- depth of hardness
- quenching procedures
- pre-heating
- cooling
- case hardening

Describe the process and advantages for pack carburizing of steel including:

- heat-treating specifications
- carbon content
- hardenablity
- strength
- toughness
- wear resistance
- machinability
- type of furnace
- carbonaceous mixtures
- work preparation procedures
- depth of case
- selective areas to be carburized
- time-temperature cycle

Describe the process and advantages for tempering of ferrous metals including:

- heat-treating specifications
- metallurgical structural change
- hardness
- strength
- toughness
- wear resistance
- machinability
- type of furnace
- work preparation procedures
- temperature colours
- workpiece application colours

Describe the process and advantages for annealing of ferrous metals including:

- heat-treating specifications
- internal stresses
- machinability
- type of furnace
- cooling procedures

Describe the process and advantages for normalizing of ferrous metals including:

- heat-treating specifications
- internal stresses
- grain refinement
- machinability
- type of furnace
- cooling procedures

92.3 Describe hardness testing methods. (0/2 hrs)

Identify hardness testing methods and procedures.

Describe various types and operating principles of hardness testers including:

- Rockwell
- Brinell
- Vickers
- Scleroscope
- Scratch

Describe the range and values of hardness tester scales.

Identify the types of equipment for hardness testers including:
- penetrators
- anvils
- loads

92.4. Describe non-ferrous metals. (2/0 hrs)

Describe of non- ferrous metals including:
- smelting and shaping process
- shapes
- sizes
- tolerances
- surface conditions
- SAE/ASTM code classifications
- manufacturer's code classifications
- applications
- chemical/physical properties
- alloying elements
- tensile strength
- malleability
- ductility
- machinability
- castability
- weight comparison
- hardness
- corrosion resistance
- wear resistance
- colour
- melting point

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
66%	34%	100%

Number:	S093		
Title:	**Metrology (Measuring and Checking)**		
Duration:	Total Hours: 6	Theory: 4	Practical: 2
Prerequisites:	L1 PMT CC - 1.0 to 11.0		

93.1 Describe the fundamentals of dimensional metrology as related to machine-tool building. (0/0.5 hrs)

93.2 Describe the fundamentals of measuring, checking, and gauging equipment. (0/0.5 hrs)

93.3 Describe measuring techniques using direct/indirect reading linear measuring equipment. (0/0.5 hrs)

93.4 Describe measuring and checking procedures using inspection and checking gauges. (2/0 hrs)

93.5 Describe measuring and checking procedures using indicating

93.6 Describe surface roughness measurement procedures. (0/0.5 hrs)

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Lecture
Video
Paper based material
CBT
Internet On-Line

Reference Materials:
Technology of Machine Tools
Mathematics for Machine Technology
Interpreting Engineering Drawings
Jig & Fixture Making for Metal Working
Basic and Advanced Tool Making
Machine-Tool Building and Integrating Manuals

Number:	S093.0		
Title:	**Metrology (Measuring and Checking)**		
Duration:	Total Hours: 6	Theory: 4	Practical: 2
Cross-Reference to Training Standards: 430M: 5530 - 5548			

General Learning Outcomes

Upon successful completion, the apprentice is able to: demonstrate set up techniques using indicating gauges and comparators; use inspection and checking gauges; use direct/indirect reading linear measuring equipment; and, describe surface roughness measurement.

Learning Outcomes and Content

93.1 Describe the fundamentals of dimensional metrology as related to machine-tool building. (0/0.5 hrs)

Describe the fundamentals of dimensional metrology as related to machine-tool building including:

- accuracy
- precision
- tolerances
- reliability
- limits
- fits
- datums
- discrimination
- length/width
- angular
- straight
- flat
- square
- round
- surface texture
- perpendicular
- parallel

93.2 Describe the fundamentals of measuring, checking, and gauging equipment. (0/0.5 hrs)

Describe measuring, checking, and gauging equipment including:
- direct/indirect linear measuring equipment
- direct/indirect angular measuring equipment

Describe direct reading linear measuring equipment including:
- depth micrometer
- interchangeable anvil micrometer
- bench micrometer
- thread micrometer
- indicating micrometer
- deep throat micrometer
- v-anvil micrometer
- disc micrometer
- blade micrometer
- tube micrometer
- wire micrometer
- gear tooth vernier calliper

Describe indirect reading angular equipment including:
- sine plate
- compound sine plate
- tool maker’s square
- precision level

Describe indicating gauges and comparators including:
- air gauges
- optical comparators
- mechanical/electrical comparator
- optical flats

Describe inspecting and checking gauges including:
- plug gauges
- ring gauges
- snap gauges
- profilometer
- precision rollers
- precision balls
- tooling balls
- angular gauge blocks
- thread wires
- gear tooth rollers
- clinometer

93.3 Describe measuring techniques using direct/indirect reading linear measuring instruments. (0/0.5 hrs)

Describe direct reading linear measuring instruments.

Describe indirect reading angular equipment.

Describe inspection and checking gauges.

Describe indicating gauges and indicators.

93.4 Describe measuring and checking procedures using inspection and checking gauges. (2/0 hrs)

Describe cleaning techniques of calibrated test specimen surfaces.

Identify inspection and checking gauges by determining:
- gear forms (profiles)
- pitch diameters
- gear parts
- gear teeth

Demonstrate inspection and recording techniques.

Describe error sources in measurement techniques including:
- inherent instrument
- observational
- manipulative
- bias
- parallel

93.5 Describe measuring and checking procedures using indicating gauges and comparators. (2/0 hrs)

Describe cleaning techniques of calibrated test specimen surfaces.

Describe features to be checked.

Identify indicating gauge and comparator including:
- optical comparators
- mechanical/electrical comparators
- air gauges
- optical flats

Demonstrate inspection and recording techniques.

93.6. Describe surface roughness measurement procedures. (0/0.5 hrs)

Demonstrate cleaning techniques of calibrated test specimen surfaces.

Describe surface roughness range.

Identify surface roughness symbols including:

- waviness
- flaw
- profile
- lay
- microinch value
- micrometer value
- surface specifications

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
66%	34%	100%

Number:	S094		
Title:	**Turning Technology**		
Duration:	Total Hours: 12	Theory: 3	Practical: 9
Prerequisites:	L1 PMT CC - 1.0 to 11.0		

Learning Outcomes

94.1 Describe safety procedures when setting up and operating a lathe.

94.2 Identify lathe workholding devices, attachments, and accessories. (1/0 hrs)

94.3 Identify lathe thread and/or form cutting tools and tool holders. (1/0hrs)

94.4 Develop plan for turning external and internal tapers, angles, and contours. (1/0 hrs)

94.5 Perform turning techniques. (0/8 hrs)

94.6 Perform routine maintenance. (0/1 hrs)

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Lecture
Video
Paper based material
CBT
Internet On-Line

Reference Materials:
Technology of Machine Tools
Mathematics for Machine Technology
Interpreting Engineering Drawings
Jig & Fixture Making for Metal Working
Basic and Advanced Tool Making
Machine-Tool Building and Integrating Manuals

Number:	S094.0		
Title:	**Turning Technology**		
Duration:	Total Hours: 12	Theory: 3	Practical: 9
Cross-Reference to Training Standards: 430M: 5530-5533; 5541 - 5548			

General Learning Outcomes

Upon successful completion, the apprentice is able to: turn external and internal tapers or angles; and, turn contours.

Learning Outcomes and Content

94.1 Describe safety procedures when setting up and operating a lathe.

Describe safety hazards which can occur during lathe set-up and operational procedures.

Demonstrate safe working habits including:
- wearing protective clothing gear
- good housekeeping
- start up and shut off procedures
- securing and stabilizing of workpiece

94.2 Identify lathe workholding devices, attachments, and accessories. (1/0 hr)

Identify lathe workholding devices, attachments, and accessories including:
- face plate
- taper attachment
- tracing attachment
- steady rest
- follower rest
- fixtures
- chucks

Identify lathe workholding devices, attachments, and accessories including:
- tool and post grinder
- tracing attachment
- bungs and spigots
- tracing attachment

Identify contact surface cleaning procedures.

94.3 Identify lathe thread and/or form cutting tools and tool holders. (1/0 hr)

Describe geometry of cutting thread and/or tools (nomenclature).

Identify lathe thread and/or cutting tools including (but not limited to):
- right hand
- left hand
- form tools
- internal
- external

Describe mounting, positioning, alignment, and securing procedures.

Describe sharpening of cutting tools.

94.4 Develop plan for turning external and internal tapers, angles, and contours. (1/0 hr)

Identify types of internal and external tapers including:
- Jarro
- Morse
- Brown and Sharpe

Identify setup procedures to produce a taper using:
- tailstock offset
- compound rest
- taper turning attachments

Select methods of rough and finishing turning.

Identify methods of turning contoured surfaces including:
- external
- internal
- concave
- convex
- irregular

Identify the finish allowance required by determining:
- finish tolerance
- surface finish

Identify the turning sequences by determining:
- type and amount of material
- speeds
- feeds
- lubricant
- tool characteristics
- rigidity of the tool
- rigidity of the workpiece
- machine tool capacity

94.5 Perform turning techniques. (8/0 hrs)

Demonstrate turning of internal and external tapers and angles.

Demonstrate turning of contours.

94.6 Perform routine maintenance. (0/1 hr)

Identify routine maintenance procedures.

Identify lubrication procedures.

Demonstrate dismantling, handling, and storage of tools, tooling, workholding devices, and measuring instruments.

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
25%	75%	100%

Number:	S095		
Title:	**Milling Technology**		
Duration:	Total Hours: 18	Theory: 4	Practical: 14
Prerequisites:	L1 PMT CC - 1.0 to 11.0		

Learning Outcomes

95.1 Describe safety procedures when setting up and operating milling machines.

95.2 Identify horizontal and vertical milling workholding devices, attachments, and accessories. (2/0 hrs)

95.3 Assemble milling cutting tools and tool holders. (0/2 hrs)

95.4 Develop plan for milling and boring. (1/0 hrs)

95.5 Perform milling and boring techniques. (1/11 hrs)

95.6 Perform routine maintenance. (0/1 hrs)

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Lecture
Video
Paper based material
CBT
Internet On-Line

Reference Materials:
Technology of Machine Tools
Mathematics for Machine Technology
Interpreting Engineering Drawings
Jig & Fixture Making for Metal Working
Basic and Advanced Tool Making
Machine-Tool Building and Integrating Manuals

Number:	S095.0		
Title:	**Milling Technology**		
Duration:	Total Hours: 18	Theory: 4	Practical: 14
Cross-Reference to Training Standards: 430M: 5530-5533; 5540 - 5548			

General Learning Outcomes

Upon successful completion, the apprentice is able to: perform horizontal and vertical milling procedures.

Learning Outcomes and Content

95.1 Describe safe working procedures when setting up and operating milling machines.

Identify safety hazards that can occur during milling set-up and operational procedures.

Identify safe working habits including:
- wearing all required protective clothing and gear
- good housekeeping
- start up and shut off procedures
- securing and stabilizing of workpiece
- lock out procedures

95.2 Identify horizontal and vertical milling workholding devices and accessories. (2/0 hrs)

Identify milling workholding devices and accessories including:
- angle plates
- vee-blocks
- fixtures
- clamping accessories
- plain vise
- swivel base vise
- universal vise
- T-slot stops
- adjustable stops
- screw jacks
- parallels

Identify milling workholding devices and accessories by determining:
- application and operating principles
- type
- size
- function
- holding/mounting characteristics
- location accessibility
- workpiece characteristics
- handling, storing and maintenance procedures

Identify horizontal milling workholding devices and accessories including:
- dividing head
- rotary table

Describe contact surface cleaning procedures.

Describe mounting, positioning, aligning, and securing procedures.

95.3 Assemble milling cutting tools and tool holders. (0/2 hrs)

Describe geometry of cutting tools (nomenclature).

Identify cutting tools and tool holders including:
- plain-milling
- side milling
- angular milling
- form-milling
- slitting saws
- inserted tips
- key seat
- T-slot
- dovetail
- arbours
- adaptors
- shell cutters
- boring tools
- collets
- boring heads

Identify cutting tools and tool holders by determining:
- type
- size
- cutting tool material
- shape
- application
- operating principles
- holding/mounting characteristics
- cutting tool geometry
- tolerances
- surface finish required

95.4 Develop a plan for milling and boring. (1/0 hr)

Identify milling procedures to mill types of surfaces including:
- horizontal
- vertical
- angular
- contoured (formed)

Select milling procedures to bore holes.

Select milling procedures to produce slots.

Select milling workholding devices.

Select cutting tools and tool holding devices/accessories.

95.5 Perform milling and boring techniques. (1/11 hrs)

Demonstrate milling of horizontal, vertical, and angular flat, and contoured surfaces.

Demonstrate boring of holes.

Demonstrate index milling using a dividing head.

Demonstrate index milling using a rotary table.

95.6 Perform routine maintenance procedures. (0/1 hr)

Describe routine maintenance procedures.

Describe lubrication procedures.

Demonstrate dismantling, handling and storage of tools, tooling, workholding devices, and measuring instruments.

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
25%	75%	100%

Number:	S096		
Title:	**Grinding Technology**		
Duration:	Total Hours: 12	Theory: 3	Practical: 9
Prerequisites:	L1 PMT CC - 1.0 to 11.0		

Learning Outcomes

96.1 Describe safety procedures when setting up and operating surface and cylindrical grinders.

96.2 Identify surface and cylindrical grinder controls and coolant. (0/0.5 hr)

96.3 Identify surface and cylindrical grinder workholding devices, accessories, and attachments (1/0 hr)

96.4 Describe the mounting, truing, and dressing of grinding wheels. (1/0 hr)

96.5 Develop plan for grinding flat surfaces, tapers, angles, and profiles. (1/0 hr)

96.6 Perform grinding techniques. (1/8 hrs)

96.7 Perform routine maintenance. (0. 0.5 hrs)

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Lecture
Video
Paper based material
CBT
Internet On-Line

Reference Materials:
Technology of Machine Tools
Mathematics for Machine Technology
Interpreting Engineering Drawings
Jig & Fixture Making for Metal Working
Basic and Advanced Tool Making
Machine-Tool Building and Integrating Manuals

Number:	S096.0		
Title:	**Grinding Technology**		
Duration:	Total Hours: 12	Theory: 3	Practical: 9
Cross-Reference to Training Standards: 430M: 5530-5533; 5536; 5540 - 5548			

General Learning Outcomes

Upon successful completion, the apprentice is able to identify and describe: grinding of horizontal, vertical, and angular flat surfaces; O/D grinding; grinding of external tapers; grinding of profiles; and grinding combination angles and radii.

Learning Outcomes and Content

96.1 Describe safe procedures when setting up and operating cylindrical and surface grinders.

Describe safety hazards which can occur during grinder set-up and operational procedures.

Demonstrate safe working habits including:
- protective clothing and gear
- good housekeeping
- start up and shut off procedures & lock out procedures
- securing and stabilizing of workpiece
- guards
- dust extraction system
- maximum wheel RPM
- ringing of wheel

96.2 Identify surface and cylindrical grinder controls and coolant. (0/0.5 hr)

Describe parts and operating principles of surface grinder.

Identify parts of a cylindrical grinder including:
- in-feed control
- table
- bedways
- base
- wheelhead
- table traverse mechanism
- trip dogs
- saddle
- footstock

- swivel table adjustment
- work head

Identify grinder controls including:
- main switch
- stop-start switch
- table traverse
- in-feed
- cross-feed
- wheel feel
- cutting fluid
- table dwell
- work head (RPM)
- feeds

Identify cutting fluids including:
- soluble oils
- synthetics
- semi-synthetics

96.3 Identify surface and cylindrical grinder workholding devices, accessories, and attachments. (0/0.5 hr)

Identify grinder workholding devices, accessories, and attachments including:
- diamond dressing attachment
- magnetic chuck blocks
- laminated blocks
- magna-vise clamps
- double-faced tape
- grinding vises/universal
- magnetic sine chucks
- compound sine chucks
- adjustable angle vises
- angle plate
- vee-blocks
- fixtures
- angular wheel dresser
- radius dresser
- magnetic chuck
- collet chuck
- centres
- sine bar
- demagnetizer

Identify workholding devices, accessories, and attachments by determining:
- type
- size
- function
- holding/mounting characteristics
- type of wheel
- workpiece characteristics
- handling, storing, and maintaining

Describe contact surface cleaning procedures.

Describe magnetizing procedures for permanent/electromagnetic chucks.

Demonstrate procedures for demagnetizing the workpiece.

Describe mounting, positioning, aligning, and securing procedures.

96.4 Describe mounting, truing, and dressing of grinding wheels. (1/0 hr)

Describe mounting, truing, balancing, and dressing of grinding wheel.

Demonstrate balancing of wheel.

Describe safe mounting of wheels on surface/cylindrical grinders.

Demonstrate dressing for side grinding/form grinding.

Demonstrate radius tangent wheel dresser.

96.5 Develop plan for grinding flat surfaces, tapers, angles, and profiles. (1/0 hr)

Describe grinding procedures including:
- surface
- plunge
- cut off
- O/D
- profile
- parallel/traverse
- external taper

Identify required grinder workholding devices and accessories.

Identify required surface or cylindrical grinder.

Describe combination angle and radius grinding.

96.6 Perform grinding techniques. (0/8 hrs)

Demonstrate grinding of horizontal flat surfaces.

Demonstrate grinding of vertical flat surfaces.

Demonstrate grinding of angular flat surfaces.

Demonstrate O/D grinding.

Demonstrate taper O/D grinding.

Describe grinding of profiles.

Describe plunge/angular grinding.

Describe combination angle and radius grinding.

96.7 Perform routine maintenance. (0/0.5 hrs)

Demonstrate routine maintenance procedures.

Demonstrate lubrication procedures.

Demonstrate dismantling, handling and storage of tools/tooling.

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
25%	75%	100%

Number:	S097		
Title:	**Machining Centre CNC Technology**		
Duration:	Total Hours: 12	Theory: 3	Practical: 9
Prerequisites:	L1 PMT CC - 1.0 to 11.0		

Learning Outcomes

97.1 Describe safety procedures when setting up and operating CNC machining centres.

97.2 Describe operating principles and applications of CNC machining centres. (0/0.5 hr)

97.3 Describe the basics of CNC dimensioning. (0/0.5 hr)

97.4 Describe part programming methods, set-up sheets, tooling lists, part program manuscripts, and input media. (1/0 hr)

97.5 Describe manual operation systems for CNC machines. (1/0 hrs)

97.6 Prepare a plan for CNC machining centre. (1/0 hr)

97.7 Enter and verify programs for CNC machining centre to perform linear and circular machining exercises. (0/8 hrs)

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Lecture
Video
Paper based material
CBT
Internet On-Line

Reference Materials:
Technology of Machine Tools
Mathematics for Machine Technology
Interpreting Engineering Drawings
Jig & Fixture Making for Metal Working
Basic and Advanced Tool Making
CNC Technology

Number:	S097.0		
Title:	**Machining Centre CNC Technology**		
Duration:	Total Hours: 12	Theory: 3	Practical: 9
Cross-Reference to Training Standards: 430M: 5530-5533; 5536; 5540 - 5548			

General Learning Outcomes

Upon successful completion, the apprentice is able to: read and interpret CNC documentation; and enter and verify a program to produce a drawing

Learning Outcomes and Content

97.1 Describe safety procedures when setting up and operating CNC machining centres.

Identify safety hazards which can occur during CNC machine set-up and operational procedures.

Demonstrate safe working habits including:
- wearing all required protective clothing and gear
- good housekeeping
- start-up and shut-off procedures
- securing and stabilizing of workpiece

97.2 Describe operating principles and applications of CNC machining centres. (0/0.5 hrs)

Identify types of CNC machining centres including:
- multi-axis
- vertical
- horizontal

Identify the capabilities of CNC machining centres including:
- types of equipment
- editing capability
- program path ability
- processing power

Describe the operating principles of CNC machining centre controls including:
- CNC controls
- tape less control
- PC/DNC systems

Describe the major features and functions of CNC machining centres including:
- ball screws
- CPU
- input devices
- tool changers
- work envelope
- holding devices
- safety interlocks
- power drive systems

Identify the major features of a CNC manufacturing process including:
- engineering drawing
- CNC part program
- input media
- CNC machine-tool
- finished part
- repeatability

97.3 Describe the basics of CNC dimensioning. (0/0.5 hrs)

Describe the Cartesian Coordinate System including:
- quadrant notation
- point location in XZ plane
- point location in X & Z space

Describe machine-tool axis designations including:
- primary linear axis
- secondary linear axis
- primary rotary axis
- secondary rotary axis
- right hand rule
- axis orientation

Identify types of machine zero point locations including:
- fixed zero points
- full zero shift
- floating zero

Establish set-up point locations by determining:
- machine home position
- absolute zero position
- Z axis touch off points

Describe the capabilities of positioning and contouring using CNC machining centres including:
- linear interpolation
- circular interpolation

Describe use of dimensioning practices including:
- baseline dimensioning (datum)
- relative (chain) dimensioning

Select coordinate systems for CNC machining centres including:
- type of machine
- axis designation
- typical specifications

97.4 Describe part programming methods, set-up sheets, tooling lists, part program manuscripts, and input media. (1/0 hr)

Identify required documentation for CNC machining process including:
- set-up sheet
- tooling list
- part program manuscript
- input media

Identify the individual components of a part program manuscript including:
- sequence numbers
- preparatory functions
- axis motions
- feed rates
- spindle speeds
- tool numbers
- miscellaneous functions

Identify additional word and block structures that exist within the part program code including:
- decimal point programming
- block delete
- comments

Identify the components of a set-up sheet including:
- part zero position
- part location
- clamp
- fixtures

Identify the components of a tooling list including:
- tool type
- tool number
- tool length offset number
- diameter offset number

Identify methods of producing part program files including:
- CAM systems
- manual programming

97.5 Describe manual operation systems for CNC machining centres. (1/0 hr)

Describe manual interruption including:
- single block operation
- feedhold
- emergency stop

Describe manual data input (MDI) including:
- line command execution
- set-up applications

Describe practical applications of the program data override including:
- rapid motion override
- spindle speed override
- feedrate override
- dry run operation
- manual absolute setting

Identify interfacing to peripherals including:
- RS-232C Interface
- PC/DNC

97.6 Prepare a plan for a CNC machining centres. (1/0 hr)

Interpret documentation to determine:
- workpiece material specifications
- method of routing instructions
- special fixturing requirements

Plan sequence of machining by identifying:
- order of operations
- tooling requirements
- workpiece setup

97.7 Enter and verify programs for a CNC machining centre to perform linear and circular machining exercises. (0/8 hrs)

Use G-codes in a block for applications on a machining centre including:
- modality of G-codes
- recognize conflicting commands
- order in a block

Use M-codes including:
- typical M-codes
- M-codes in a block

Use codes to specify dimensions including:
- metric/inch selection
- absolute data input – G90
- incremental input – G91
- combination in the same program
- radius programming

Use codes to specify speeds and feeds including:
- spindle speed
- spindle rotation direction
- spindle stop
- spindle orientation

Use codes to specify tool function including:
- tool offset
- tool number
- tool change format

Use codes to specify reference points including:
- machine reference point
- workpiece reference point
- tool reference point
- position register command – G54

Use common machine function controls including:
- mode selector
- rapid, feed rate, and spindle overrides
- single block
- manual feed functions
- soft keys
- offset registers

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
25%	75%	100%

Number:	S098		
Title:	**In-Process Tooling Technology (Swaging, Electrodes, Nozzles)**		
Duration:	Total Hours: 30	Theory: 12	Practical: 18
Prerequisites:	L1 PMT CC - 1.0 to 11.0		

Learning Outcomes

98.1 Identify swaging, electrodes and nozzle in-process tooling used in machine-tool building and integration. (4/0 hrs)

98.2 Interpret in-process tool-building documentation. (2/2 hrs)

98.3 Interpret documentation to determine various industry company standards for in-process tooling. (2/0 hrs)

98.4 Perform in-process tool-building related calculations. (1/1 hrs)

98.5 Produce a detailed sketch of the swaging, electrodes and nozzle tooling from job specifications. (0/4 hrs)

98.6 Verify the workpiece material application for in-process tooling. (1/1 hrs)

98.7 Plan in-process tooling development. (2/0 hrs)

98.8 Fabricate in-process swaging, electrodes and nozzles components. (0/8 hrs)

98.9 Demonstrate try-out procedures for the assembly of tooling for the machine-tool. (0/2 hrs)

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Lecture
Video
Paper based material
CBT
Internet On-Line

Reference Materials:

Technology of Machine Tools
Mathematics for Machine Technology
Interpreting Engineering Drawings
Jig & Fixture Making for Metal Working
Basic and Advanced Tool Making
Machine-Tool Building and Integrating Manuals

Number:	S098.0		
Title:	**In-Process Tooling Technology (Swaging, Electrodes, Nozzles)**		
Duration:	Total Hours: 30	Theory: 12	Practical: 18
Cross-Reference to Training Standards: 430M: 5530- 5548			

General Learning Outcomes

Upon successful completion, the apprentice is able to: identify various types and applications of in- process tooling; demonstrate methods of developing and fabricating in-process swaging, electrodes, and nozzle in-process tools.

Learning Outcomes and Content

98.1 Identify swaging, electrodes and nozzle in-process tooling used in machine-tool building and integration. (4/0 hrs)

Describe elements, features and functions of in-process tools used in machine-tool building including:
- swaging tools
- electrodes
- nozzles

Describe types, functions and operating principles of in-process swaging tools used in machine-tools including:
- rivet tooling
- crimping tooling
- hot swaging of plastic projections
- rigid
- spin

Describe types functions and operating principles of in-process electrode tooling used in machine-tools including:
- spot welding electrodes
- fusing electrodes
- ultra sonic welding electrodes

Describe types functions and operating principles of in-process nozzles used in machine- tool including:
- glue nozzle
- grease nozzle
- washer-system nozzle
- coolant nozzle

98.2 Interpret in-process tool-building documentation. (2/2 hrs)

Interpret in-process tool-building documentation including:
- part drawings
- engineering drawings
- bill of materials
- sketches
- piece parts
- job specifications

Describe features and elements of assemblies including:
- sub-assembly identification
- assembly sequencing and procedures
- assembly and sub-assembly numbers

Interpret specifications to identify dimensions, tolerances, limits, finish condition, and material type.

Interpret in-process tooling features to determine in-process tooling development.

98.3 Interpret documentation to determine various industry company standards for in- process tooling. (2/0 hrs)

Identify industry standards for swaging, electrodes, and nozzles including:
- type
- workpiece material

98.4 Perform in-process tool-building related calculations. (1/1 hrs)

Calculate the in-process tooling dimensions and values by identifying:
- clearances
- size
- dimensions
- tolerances
- finishes

98.5 Produce a detailed sketch of swaging, electrodes or nozzles from job specifications. (0/4hrs)

Produce shop floor sketches from job specifications to determine in-process tooling features, functions, and operational sequences including:

- shape
- dimensions
- tolerances
- finishes
- clearance

98.6 Verify the workpiece material application for in-process tooling. (1/1 hrs)

Interpret job specifications to determine required materials including:

- type
- grade
- dimensions
- surface condition
- hardenability
- heat-treatment

98.7 Plan in-process tooling development. (2/0 hrs)

Interpret mechanical engineering drawings and job documentation including:

- CAD data
- engineering drawings
- bill of materials
- job specifications
- piece-part features

Describe final design production parameter:

- sequence of operations
- types of operations
- design parameters
- space limitations
- interfacing requirements
- final piece part features

Describe the type and design of the tooling required.

Describe fabrication procedures for tool development.

Develop a plan for the fabrication and development of the in-process tooling that identifies:

- sequence of operation
- type of operation
- design parameters
- space limitations
- interfacing requirements
- final piece-part features
- machine-tools
- machining procedures
- machine accessories
- tooling aids
- building sequence
- fabrication processes

98.8 Fabricate in-process swaging, electrode, and nozzle tooling components. (0/8 hrs)

Interpret engineering drawings and documentation including:

- engineering drawings
- specifications
- bill of materials
- reference materials
- piece-part features
- tool-building plan

Identify types, application, and methods of developing and fabricating swaging, electrode and nozzle tooling including:

- machining processes
- accessories

Prepare a sketch of in-process tooling that identifies:

- types
- shapes
- dimensions
- tolerances
- functions
- part assembly inter-relationship

Identify measuring instruments and checking devices including:
- gauge blocks
- micrometers
- verniers
- height gauges
- dial test indicators

Fabricate swaging, electrodes, and nozzle tooling by:
- measuring and checking
- machining
- mills
- grinders
- drills
- lathes
- saws
- sketching

Describe the processes for fitting, positioning, and aligning of in-process tooling components.

Inspect components to verify accuracy of finished in-process tooling.

98.9 Demonstrate try-out procedures for the assembly of in-process tooling on to the machine-tool. (0/2 hrs)

Test, modify, and adjust the in-process tooling.

Perform try-out of tooling.

Verify accuracy and mechanical functioning of the tooling.

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
40%	60%	100%

Number:	S099		
Title:	**Pneumatic and Hydraulic Systems**		
Duration:	Total Hours: 30	Theory: 18	Practical: 12
Prerequisites:	L1 PMT CC - 1.0 to 11.0		

Learning Outcomes

99.1 Identify safe working procedures when setting up and operating fluid power systems.

99.2 Identify fluid power measurements in both SI and Imperial system. (2/0 hrs)

99.3 Describe basic principles of fluid power systems (gas laws, compressibility, storage, Pascal's law, continuity law). (2/0 hrs)

99.4 Identify the features and operating principles of fluid power systems on a machine-tool application. (2/0 hrs)

99.5 Describe fluid power actuators and their applications on a machine- tool. (6/0 hrs)

99.6 Describe fluid power control valves and their applications. (2/0 hrs)

99.7 Identify methods of speed control for fluid power actuators used on a machine-tool. (1/0 hrs)

99.8 Demonstrate the steps to plan for the building of fluid power circuits used in machine-tool building. (0/2 hrs)

99.9 Demonstrate the procedures required to prepare pneumaticand hydraulic components. (0/4 hrs)

99.10 Demonstrate the installation of pneumatic and hydraulic systems used on machine-tools. (2/4 hrs)

99.11 Demonstrate the process of testing the functionality of pneumatic and hydraulic components. (0/2 hrs)

99.12 Describe routine maintenance operations on fluid power equipment. (1/0 hrs)

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Instructional and Delivery Strategies:
- Lecture
- Video
- Paper based material
- CBT
- Internet On-Line

Reference Materials:
- Technology of Machine Tools
- Mathematics for Machine Technology
- Interpreting Engineering Drawings
- Machine-Tool Building and Integrating Manuals
- Pneumatic and Hydraulics Manuals

Number:	S099.0		
Title:	**Pneumatic and Hydraulic Systems**		
Duration:	Total Hours: 30	Theory: 18	Practical: 12
Cross-Reference to Training Standards: 430M: 5530- 5533 U5540 - 5548			

General Learning Outcomes

Upon successful completion, the apprentice is able to: read fluid power schematics; identify suitable fluid power components for a given application; demonstrate suitable fluid power component installation methods.

Learning Outcomes and Content

99.1 Identify safe working procedures when setting up and operating fluid power systems.

99.2 Identify fluid power measurements, in both SI and Imperial system. (2/0 hrs)

Describe the relationship between SI and Imperial units of measure for fluid flow rates.

Describe the relationship between SI and Imperial units of measure for pressure.

Describe the relationship between SI and Imperial units of measure for mechanical and fluid power.

Describe filter media ratings and their relationship to component requirements.

99.3 Describe the basic principles of fluid power systems (gas laws, compressibility, storage, Pascal's law, continuity law) (2/0 hrs)

Calculate theoretical force capabilities of pneumatic actuators using Pascal's Law.

Determine practical force limitations of pneumatic actuators given acceleration and velocity requirements.

Calculate lifting capabilities of vacuum cups and vacuum surfaces.

Determine compressor tank and motor size for given application.

Describe the relationship of the compressibility of air to its operational characteristics.

Calculate air consumption and describe the effect of air leakage on the cost of operation.

Determine actuator speed given hydraulic fluid flow rates.

99.4 Identify the features and operating principles of fluid power systems on a machine-tool application. (2/0 hrs)

Describe the various features and purposes of the hydraulic power pack used on a machine-tool including:

- motor/pump
- reservoir
- filters
- valves
- temperature control
- pressure regulators

Identify types of filtration media for pneumatic and hydraulic systems used on a machine-tool.

99.5 Describe fluid power actuators and their applications on a machine-tool. (6/0 hrs)

Identify type and applications of actuators used on a machine-tool, including:

- ram-type single acting cylinders
- single-acting cylinders with spring return
- double-acting cylinders
- cylinders with end cushions
- cylinders with integral flow control valves
- guided cylinders
- rod-less cylinders
- rotary index tables

Describe methods of mounting actuators on a machine-tool including:

- clevis
- rod
- hinge
- rigid
- tie-rod
- flange
- foot

Identify the type and application of vacuum actuators used on a machine-tool including:
- chucks
- end effectors

99.6.0 Describe fluid power control valves and their applications. (2/0 hrs)

Describe appropriate valve body style (port and mounting configuration) and their symbols for a given application:
- 2-way/2-position
- 3-way/2-position
- 4-way/2-position
- 5-way/2-position

Describe 3 and 4 position valves and their applications:
- open-centre
- closed-centre
- float-centre
- tandem-centre

Identify and describe appropriate valve body style for a given application.

Identify and describe various valve actuation methods including:
- air-piloted
- manual
- electrical

Identify and describe appropriate valve actuation methods for a given application.

Identify and describe suitable valve port connector type.

Identify and discuss the difference between poppet and spool configuration valves including the concept of ‘memory’.

99.7 Identify methods of speed control for fluid power actuator used on machine-tools. (1/0 hr)

Describe the difference between meter-in and meter-out speed control.

Identify various types of flow control valves and their symbols including:
- needle-type flow control valves
- pressure compensated flow control valves
- temperature and pressure compensated flow control valves

Describe suitable speed control methods for resistive and tractive loads.

Identify appropriate valve body style (port and mounting configuration) for a given application.

99.8 Demonstrate the steps required to plan for the building of fluid power circuits used in machine- tool building. (0/2 hrs)

Identify component symbols in both ANSI and ISO standard systems.

Read and interpret:
- schematics
- manufacturer's specifications
- engineering drawings
- bills of materials
- job specifications

Identify the sizes, pressure ratings, and flow ratings of pneumatic and hydraulic components.

Read charts to determine flow rate.

Determine the sizes of:
- flow controls
- piping
- hoses
- fittings

Identify line and connector sizes given fluid consumption specifications of actuators.

Identify port connections on fluid power components using both alphabetic and numeric notation.

Draft simple fluid power schematics to control actuators speed, force, and direction of motion.

99.9 Describe the procedures required to prepare pneumatic and hydraulic components. (0/4 hrs)

Demonstrate procedures to ensure the correct contact of mating surfaces.

Describe the implications of inadequate surface preparation.

Identify the hand tools required for pneumatic and hydraulic installations, including:
- files
- honing stones
- wrenches

Describe the types and applications of thread sealants.

Demonstrate assembly procedures of pneumatic and hydraulic fittings and components.

99.10 Demonstrate the installation of pneumatic and hydraulic systems used in machine-tools. (2/4 hrs)

Identify types, application, and operating principles of mechanical fasteners.

Describe various applications of fasteners and mounting hardware.

Describe the implications of incorrect selection and application of components.

Demonstrate the application, installation, and fitting of various types of hoses.

Identify alignment and layout tools and measuring equipment including:
- indicators
- feeler gauges
- verniers
- squares
- gauge blocks
- scales
- layout medium and dye
- height gauges
- high spot blue

Demonstrate alignment techniques.

Demonstrate the procedures to perform a pre-start up check.

99.11 Demonstrate the process of testing the functionality of pneumatic and hydraulic components. (0/2 hrs)

Describe the process and methods of testing pneumatic and hydraulic components and sub-assemblies to verify:

- valve action
- directional flow of air or hydraulic fluid
- amount of actuator movement
- speed of actuator
- actuator force

Describe the implications of incorrect testing setup.

Describe the implications of incorrect setup of hydraulic and pneumatic systems.

Demonstrate troubleshooting techniques to identify common errors in pneumatic or hydraulic sub-assemblies.

Demonstrate adjustment techniques to ensure the subsystem meets cycle time criteria.

99.12 Describe routine maintenance on fluid power equipment. (1/0 hrs)

Identify maintenance operations on fluid power equipment:

- actuator disassembly/assembly
- valve disassembly/assembly
- filter cleaning/replacement

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
60%	40%	100%

Number:	S100		
Title:	**Machine-Tool Electrical Basics**		
Duration:	Total Hours: 24	Theory: 18	Practical: 6
Prerequisites:	L1 PMT CC - 1.0 to 11.0		

Learning Outcomes

100.1 Identify safe working procedures when installing electrical components on a machine-tool.

100.2 Interpret electrical documentation. (1/2 hrs)

100.3 Describe the function and application of electrical components used on a machine-tool. (1/2 hrs)

100.4 Calculate the mechanical power requirements of a system driven by an electrical actuator, and select the required actuator (1/2 hrs)

100.5 Describe controller devices used in machine-tools. (1/6 hrs)

100.6 Demonstrate procedures for installing electrical components on to a machine-tool. (1/3 hrs)

100.7 Demonstrate the process of testing the functionality of electrical components. (1/3 hrs)

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Lecture
Video
Paper based material
CBT
Internet On-Line

Reference Materials:
Technology of Machine Tools
Machine-Tool Building and Integrating Manuals
Basic Electrical Technology

Number:	S100.0		
Title:	**Machine-Tool Electrical Basics**		
Duration:	Total Hours: 24	Theory: 18	Practical: 6
Cross-Reference to Training Standards: 430M: 5530- 5533 U5540 - 5548			

General Learning Outcomes

Upon successful completion, the apprentice is able to: read and interpret electrical documentation; select various electrical components used on a machine-tool; install electrical sensors and actuators; and, test and adjust assemblies containing sensors and actuators.

Learning Outcomes and Content

100.1 Identify safe working procedures when installing electrical components on a machine-tool.

Identify safety hazards which can occur when using electrical devices.

Identify electrical safety devices.

100.2 Interpret electrical documentation. (1/2 hrs)

Interpret electrical documentation including:
- engineering drawings
- bills of material
- job specifications
- schematics

Identify electrical component numbers, sizes, types, and capacity ratings.

Identify procedures for the assembly of electrical components on to a machine-tool.

100.3 Describe the function and application of electrical components used on a machine-tool. (1/2 hrs)

Describe the application and operating principles of electrical sensors used on a machine- tool including:

- switches
- inductive proximity sensors
- capacitive proximity sensors
- optical proximity sensors:
- thru-beam type
- retro-reflective type
- diffuse type
- encoders/scales
- load cells
- cameras
- laser measuring devices

Describe the application and operating principles of electrical devices and actuators including:

- AC motors
- DC motors
- stepper motors
- servo-motors
- linear motors
- robots
- indicator lamps
- annunciators
- push, pull, and rotary-acting solenoids
- solenoid-actuated valves
- proportional valves
- servo-valves
- welding processes
- rotary vibratory feeders
- linear vibratory feeders

100.4 Calculate the mechanical power requirements of a system driven by an electrical actuator, and select the required actuator. (1/2 hrs)

Use F=ma to calculate the linear force required to accelerate a known mass.

Use T=Fd to calculate the torque required to generate a linear force.

Use P=Tω to calculate the motor power required to achieve an output torque at a given shaft rotation speed.

Use tabulated formulae to calculate the mass moment of inertia (IM) of simple mechanical systems driven by rotational actuators.

Use T= IMα to calculate the torque required to rotationally accelerate (α) a load with a known mass moment of inertia.

100.5 Describe controller devices used in machine-tools. (1/6 hrs)

Identify the purposes of typical automation controllers, used in machine-tools including:

- programmable logic controllers (PLC)
- personal computer (PC) based controllers
- robot controllers
- motion controllers
- adaptive controllers
- temperature controllers
- vision system controllers
- welding process controllers

Identify typical feedback devices used in machine-tool control systems including:

- incremental encoders
- absolute encoders
- load cells
- RTD temperature sensors
- thermocouples
- LVDTs
- tachometers
- resolvers
- laser interferometers
- ultrasonic position sensors

Describe vision system components including:
- cameras
- lighting
- lenses
- extension tubes
- camera support

Describe computer-controlled actuators used in machine-tools, including:
- robots
  - hydraulic
  - electric
  - pneumatic
  - articulating arm
  - gantry
  - pick and place
- motion-control systems for electric motors and hydraulic servo-valves

100.6 Demonstrate procedures for installing electrical components on to a machine-tool. (1/3 hrs)

Describe various types, applications, and principles of mechanical fasteners for electrical components.

Describe alignment techniques for electrical components.

Describe procedures for checking installation of electrical components including:
- range of component
- switch actuator
- alignment of component

Describe the implication of incorrect selection and mounting of electrical components.

Identify measuring equipment for the mounting of electrical components, including:
- indicators
- feeler gauges
- verniers
- squares
- gauge blocks
- scales
- layout and high spot blue
- height gauges
- high spot blue

Demonstrate mounting and alignment techniques

100.7 Demonstrate the process of testing the functionality of electrical components. (1/3 hrs)

Identify testing procedures for electrical sensors, including:

- limit switches
- proximity switches
- flow switches

Demonstrate positioning and switch point adjustment techniques for various sensors.

Demonstrate checking procedures for electrical actuator setup and alignment.

Describe troubleshooting techniques for the common errors in electrical component setup and installation.

Demonstrate adjustment techniques.

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
25%	75%	100%

Number:	S101		
Title:	**Machine-Tool Power Transmission Technology**		
Duration:	Total Hours: 30	Theory: 18	Practical: 12
Prerequisites:	L1 PMT CC - 1.0 to 11.0		

Learning Outcomes

101.1 Identify safe working procedures when setting up and operating mechanical power transmission equipment.

101.2 Identify types, application, and operating principles of various power transmission systems used on a machine-tool. (3/0 hrs)

101.3 Perform machine-tool power transmission calculations. (2/0 hrs)

101.4 Interpret power transmission documentation. (5/0 hrs)

101.5 Describe various types, application, and operating principles of machine-tool power transmission components. (5/0 hrs)

101.6 Describe the correct procedures to prepare power transmission components. (1/3 hrs)

101.7 Describe the methods and procedures for fitting and assembling power transmission components. (1/6 hrs)

101.8 Describe procedures for the installation of power transmission assemblies in a machine-tool (1/3 hrs)

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Lecture
Video
Paper based material
CBT
Internet On-Line

Reference Materials:
Technology of Machine Tools
Machine-Tool Building and Integrating Manuals
Power Transmission Technology Manuals and documentation

Number:	S101.0		
Title:	**Machine-Tool Power Transmission Technology**		
Duration:	Total Hours: 30	Theory: 18	Practical: 12
Cross-Reference to Training Standards: 430M: 5530- 5533 U5540 - 5548			

General Learning Outcomes

Upon successful completion, the apprentice is able to: interpret engineering documentation; identify power transmission installation techniques; and, describe techniques for aligning and testing power transmission systems

Learning Outcomes and Content

101.1 Identify safe working procedures when setting up and operating mechanical power transmission equipment.

Identify safety hazards that can occur during installation and operation of power transmission equipment.

101.2 Identify types, application, and operating principles of various power transmission systems used on a machine-tool. (3/0 hrs)

Identify types, application and operating principles of various power transmission systems used on a machine-tool including:

- conveyor
- cam
- rotary

101.3 Perform machine-tool power transmission calculations. (2/0 hrs)

Perform machine-tool power transmission calculations, to determine:

- speed ratios
- sizes
- rotary speed
- torque
- linear movement
- force
- speed

101.4 Interpret power transmission documentation. (5/0 hrs)

Interpret machine-tool power transmission documentation including:
- schematics
- mechanical engineering drawings
- bill of materials
- job specifications
- manufacturer's specifications

Interpret power transmission documentation to identify:
- conveyor drives
- cam drives
- rotary indexing dials
- size
- ratios
- speed
- assembly procedures
- power transmission component number
- part identification

101.5 Describe various types, application and operating principles of machine-tool power transmission components. (5/0 hrs)

Interpret power transmission documentation including:
- bill of materials
- engineering drawings
- job specifications
- schematics

Identify the types, application and operating principles of power transmission components including:
- gear boxes
- reducers
- rotary tables
- pulleys
- belts
- sprockets
- chains
- couplings
- cam boxes
- rack and pinions

Perform calculations to determine:
- ratios
- speed
- linear movement

Perform verification procedures of the correct selections of components for the assembly and integration of a power transmission system used in a machine-tool.

101.6 Describe demonstrate the correct procedures to prepare power transmission components. (1/3 hrs)

Interpret power transmission documentation including:
- schematics
- engineering drawings
- bill of materials
- manufacturer’s specifications

Describe preparation procedures that will ensure correct contact of mating of mating surface.

Describe the implication of inadequate surface preparation.

Identify the hand tools and measuring equipment used in preparing and fitting power transmission components including:
- files
- stones
- indicators
- verniers
- micrometers
- feeler gauges
- height gauges
- bearing blue

Describe assembly procedures for power transmission components including:
- cleaning mating surfaces
- fitting and assembling parts
- lubricating moving parts
- checking alignments and fits

Identify types and applications of lubricants.

Describe methods for alignment, fits, and adjustments.

Describe troubleshooting techniques to identify common errors of alignment and fits.

Describe adjustment techniques.

101.7 Describe the methods and procedures for fitting and assembling power transmission components. (1/6 hrs)

Identify methods, steps, and procedures for the fitting and assembling of power transmission components including:

- setting and adjusting gear clearance/backlash
- setting and adjusting tension or pre-load of chains and belts
- aligning sprockets, pulleys and shafts
- setting gear squareness and alignments
- setting bearing pre-loads
- aligning cams
- making required adjustments
- installation of gear boxes and reducers

Describe the type and application of fasteners.

Describe methods of aligning and adjusting components.

Describe clearance and pre-load of components in the assembly.

Describe methods of setting and adjusting gear clearance/backlash.

Describe of methods of setting and adjusting tension and preload of chains and belts.

Identify of tools and precision measuring instruments to make required adjustments including:

- torque wrenches
- high spot blue
- indicators
- feeler gauges
- verniers
- height gauges
- squares
- gauge blocks
- depth micrometer

Describe types and application of lubricants including:
- synthetic and natural oils and greases dry lubricants

Describe fitting and assembly techniques.

Describe common errors of adjustment and alignment.

Describe adjustment techniques.

101.8 Describe procedures for the installation of power transmission assemblies in a machine- tool. (1/3 hrs)

Interpret installation documentation including:
- schematics
- engineering drawings
- manufacturer's specifications
- bill of materials

Describe the types and applications of fasteners.

Describe methods of alignment and adjustments of assembled power transmission components.

Describe methods of mounting assembled components on to a machine-tool using:
- fasteners
- couplings
- gears
- keys
- keyways

Describe clearances and preload of components in a mechanical assembly.

Identify tools and precision measuring instruments used to make required adjustments including:
- indicators
- feelers
- gauges
- torque wrenches
- verniers
- squares
- gauge blocks
- height gauges
- scales
- laser inferometer

Describe the types and application of lubricants.

Describe installation procedures for power transmission assemblies using a gear box assembly.

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
60%	40%	100%

Level 3
Advanced

Reportable Subject Summary – Level 3 Advanced

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practical
102.0	Applied Mechanical Calculations	36	24	12
103.0	Mechanical Engineering Drawings & Documentation	24	12	12
104.0	Machine-Tool Feeder and Conveyor Technology	36	24	12
105.0	Planning of Machine-Tool Building and Integration	18	12	6
106.0	In-Process Tooling Technology (Forming, Trimming, Machining)	48	24	24
107.0	Machine-Tool Sub-Assembly Technology	42	24	18
108.0	Machine-Tool Main-Assembly Technology	36	18	18
	Total	**240**	**138**	**102**

Number:	102		
Title:	**Applied Mechanical Calculations**		
Duration:	Total Hours: 36	Theory: 24	Practical: 12
Prerequisites:	Common Core – Units 2, 3, 5		
Co-requisites:	Completion of Unit 102 is contingent upon successful completion of all MTBI Level 2 units.		
Cross Reference to Training Standards: U5843, U5845, U5846, U5847			

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate the ability to identify and apply drainage terms and definitions.

Learning Outcomes

Upon successful completion the apprentice is able to:

Trade	Unit	Learning Outcomes
MTBI	U5531	Ability to plan and prepare for machining operations.
MTBI	U5532	Ability to measure and analyze in-process workpiece dimensions and surface verification.
MTBI	U5533	Ability to perform benchwork operations.
MTBI	U5534	Ability to saw a workpiece.
MTBI	U5535	Ability to produce a workpiece on a drill press.
MTBI	U5536	Ability to machine grind a workpiece.
MTBI	U5537	Ability to machine a workpiece on a lathe.
MTBI	U5538	Ability to mill a workpiece.
MTBI	U5539	Ability to describe and the NC/CNC machining process.
MTBI	U5540	Ability to devise and detail a plan for the machine-tool-building process.
MTBI	U5541	Ability to identify, describe, and demonstrate methods of building in-process tooling for the machine-tool. (Forming,Trimming, and Machining)

MTBI	U5542	Ability to assemble and integrate pneumatic and hydraulic components.
MTBI	U5543	Ability to identify, describe, and demonstrate the assembly and integration of electrical components on a machine-tool.
MTBI	U5544	Ability to describe and demonstrate the process of assembly and integration of power transmission systems.
MTBI	U5545	Ability to identify and demonstrate the process and procedures for assembling and integrating a conveyor system on a machine-tool.
MTBI	U5546	Ability to read and interpret feeder system documentation.
MTBI	U5547	Ability to describe and demonstrate methods for sub-assembling machine-tool components.
MTBI	U5548	Ability to identify and describe the process for integrating main-assemblies.

Benchmark Hours	#	Curriculum Outcomes
6	102.1.0	Solve trade-specific problems involving oblique triangles and solve for unknown values.
6	102.2.0	Solve trade-specific problems involving the law of sines and solve for unknown values.
6	102.3.0	Solve trade specific problems involving the law of cosines/cotangents and solve for unknown values.
6	102.4.0	Calculate mean and variance of process measurements.
6	102.5.0	Identify and describe feeder and conveyor calculations.
6	102.6.0	Identify and describe machine-tool builder and integrator related calculations.

Learning Outcomes

Upon successful completion, the apprentice is able to:
- solve problems involving oblique triangle;
- solve problems using the law of sines;
- solve problems using the law of cosines/cotangents;
- perform feeder and conveyor calculations;
- perform machine-tool builder and integrator related calculations.

102.1.0 Solve trade-specific problems involving oblique triangles and solve for unknown values.

102.1.1 Identify and describe an oblique triangle.

102.1.2 Identify and calculate the values of unknown sides of oblique triangles.

102.2.0 Solve trade-specific problems involving the law of sines and solve for unknown values.

102.2.1 Identify and describe the sides of a right triangle with reference to each of its angles.

102.2.2 Identify and calculate the values of unknown sides and angles of oblique triangles using the law of sines including:
- the values of two angles and one side
- the values of two sides and one angle

102.3.0 Solve trade-specific problems involving the law of cosines and cotangents and solve for unknown values.

102.3.1 Identify and describe the law of cosines and cotangents.

102.3.2 Identify and calculate the values of the unknown sides and angles of oblique triangles using the law of cosines and cotangents including:
- the values of two sides and the included angle
- the values of three sides

102.4 Calculate mean and variance of process measurements.

102.4.1 Calculate mean value of process measurements.

102.4.2 Calculate variance of process measurements.

102.4.3 Plot SPC X-bar charts and R charts.

102.5 Identify and describe feeder and conveyor calculations.

102.5.1 Identify and describe feeder and conveyor calculations including:

- speed change-ratios
- torque change ratios
- conversion between linear speed and rotary speed
- conversion between linear force and rotary torque

Calculate power in watts and horsepower, based on speed and torque

102.6 Identify and describe machine-tool builder and integrator related calculations.

102.6.0 Identify and describe machine-tool builder and integrator related calculations including:

- read and interpret engineering drawings, bill of materials, specifications and reference materials
- determine required calculations including SI conversions, SPC data, and capability study
- perform calculations

Number:	103
Title:	**Mechanical Engineering – Drawings and Documents**
Duration:	Total Hours: 24 Theory: 12 Practical: 12
Prerequisites:	Common Core – Units 2, 3, 5
Co-requisites:	Completion of Unit 103 is contingent upon successful completion of all MTBI Level 2 units.

Cross Reference to Training Standards: MTBI Training Standards U5530 To U5548

Trade	Unit	Learning Outcomes
MTBI	U5531	Ability to plan and prepare for machining operations.
MTBI	U5532	Ability to measure and analyze in-process workpiece dimensions and surface verification.
MTBI	U5533	Ability to perform benchwork operations.
MTBI	U5534	Ability to saw a workpiece.
MTBI	U5535	Ability to produce a work piece on a drill press.
MTBI	U5536	Ability to machine grind a workpiece.
MTBI	U5537	Ability to machine a workpiece on a lathe.
MTBI	U5538	Ability to mill a workpiece.
MTBI	U5539	Ability to describe and the NC/CNC machining process.
MTBI	U5540	Ability to devise and detail a plan for the machine-tool-building process.
MTBI	U5541	Ability to identify, describe, and demonstrate methods of building in-process tooling for the machine-tool. (Forming, Trimming, Machining)
MTBI	U5542	Ability to assemble and integrate pneumatic and hydraulic components.
MTBI	U5544	Ability to describe and demonstrate the process of assembly and integration of power transmission systems.

MTBI	U5545	Ability to identify and demonstrate the process and procedures for assembling and integrating a conveyor system on a machine-tool.
MTBI	U5546	Ability to read and interpret feeder system documentation.
MTBI	U5547	Ability to describe and demonstrate methods for sub-assembling machine-tool components.
MTBI	U5548	Ability to identify and describe the process for integrating main-assemblies.

Benchmark Hours	#	Curriculum Outcomes
1	103.1.0	Review and describe the principle views of first and third angle projection to identify features of a finished component.
1	103.2.0	Review and describe sectional views.
1	103.3.0	Identify, describe, and interpret the ISO system of limits and fits as applied to features of a workpiece.
2	103.4.0	Identify and describe geometric tolerancing dimensional terminology.
3	103.5.0	Identify and describe geometric dimensioning and tolerancing symbols.
3	103.6.0	Read and interpret elements and features of machine-tool components and assembly drawings.
3	103.7.0	Identify and describe elements and features of machine-tool components and materials.
1	103.8.0	Review and interpret hydraulic and pneumatic schematics.
2	103.9.0	Read and interpret machine-tool floor layout drawings.
7	103.10.0	Develop and sketch in-process development modifications. (Forming, Trimming, Machining)

Learning Outcomes

Upon successful completion, the apprentice is able to:
- read and interpret geometric tolerancing on engineering drawings;
- identify and describe floor layout drawings;
- sketch in-process machine-tool modifications (forming, trimming, machining):
- develop an operational plan for machine-tool components and assembly.

103.1 Review and describe the principle views of first and third angle projection to identify features of a finished component.

103.1.1 Review and describe first and third angle projection including:
- first and third angle
- ISO orthographic projection symbol

103.2 Review and describe sectional views.

103.2.1 Identify and describe sectional conventions.

103.3 Identify, describe, and interpret the ISO system of limits and fits as applied to features of a workpiece.

103.3.1 Interpret and describe ISO standard limits, and fits including:
- designation of fits
- description of fits
- clearance
- interference
- interchangeability
- nominal size
- ISO standards

103.4 Identify and describe geometric tolerancing dimensional terminology.

103.4.1 Identify and describe geometric dimensional terminology as applied to engineering drawings including:
- regardless of feature size
- least material condition
- basic dimension
- datums
- feature control frame
- general rules
- virtual condition
- symbols
- individual and related features
- terms
- maximum material condition

- flatness
- straightness
- circularity
- cylindricity
- profile of a line
- profile of a surface
- perpendicularity
- angularity
- parallelism
- circular runout
- position
- concentricity
- coplanarity
- symmetry
- datum targets
- correlative tolerance

103.5.0 Identify and describe geometric dimensioning and tolerancing symbols.

103.5.1 Identify and describe geometric dimensioning and tolerancing symbols including:

- form control
- profile control
- run-out control
- location control
- geometric control
- datum control
- feature control frame
- supplementary symbols
- geometric engineering drawing

103.6.0 Read and interpret elements and features of machine-tool component and assembly drawings.

103.6.1 Read and interpret details of drawings including:

- types of component drawings
- methods to simplify component drawings
- dimensional forms
- plan for operational sequences

103.6.2 Read and interpret machine-tool assembly documentation including:
- interpret bill of materials (BOM)
- cross reference from BOM to assembly drawings
- plan for operational sequences

103.7.0 Identify and describe elements and features of machine-tool components and materials.

103.7.1 Identify and describe layout drawings, assembly drawings and detailed drawings.

103.7.2 Identify and describe machine-tool components.

103.7.3 Identify and describe the application, function, and operating principles of machine-tool components.

103.8.0 Review and interpret hydraulic and pneumatic schematics.

103.8.1 Read and interpret hydraulic and pneumatic drawings to identify:
- hydraulic and pneumatic valves
- linear and rotary actuators
- vacuum system components
- filter, lubricators, regulators
- flow controls
- tubing and piping
- hydraulic pumps and reservoirs
- develop plan for operational procedures

103.9.0 Read and interpret machine-tool floor layout drawings.

103.9.1 Read and interpret floor layout engineering drawings including:
- cell layout
- sub-assembly
- line layout

103.10.0 Develop and sketch machine-tool development modifications.

103.10.1 Read and interpret job documentation including:
- engineering drawings
- component drawings
- part drawings
- bill of materials
- piece parts

103.10.2 Sketch various in-process tooling for the building and assembly process including:
- forming tools
- trimming tools
- machining tools

103.10.3 Identify and describe in-process development work to identify:
- components
- parts
- sub-assemblies
- assemblies
- shapes
- dimensions
- tolerances
- finishes
- assembly interrelationships

103.10.4 Sketch in-process tool development for forming, trimming, and machining tooling.

Number:	104
Title:	**Machine-Tool Feeder and Conveyor Technology**
Duration:	Total Hours: 36 Theory: 24 Practical: 12
Prerequisites:	Common Core – Units 2, 3, 4, 5, 8, 9, 10, 11
Co-requisites:	Completion of Unit 104 is contingent upon successful completion of all MTBI Level 2 – Units 90 to 101

Cross Reference to Training Standards: MTBI Training Standards U5530 to U5548

Trade	Unit	Learning Outcomes
MTBI	U5531	Ability to plan and prepare for machining operations.
MTBI	U5532	Ability to measure and analyze in-process workpiece dimensions and surface verification.
MTBI	U5544	Ability to identify and demonstrate the process and procedures for assembling and integrating a conveyor system on a machine-tool: • read and interpret conveyor system documentation • identify and select conveyor system components • determine conveyor system floor layout • demonstrate fitting and assembly of conveyor system components • describe conveyor assembly installation procedures • describe methods for testing of conveyor systems • communicate with co-workers • complete documentation • maintain a clean and organized lab environment.

Benchmark Hours	#	Curriculum Outcomes
1	104.1.0	Identify and observe safe working procedures when installing feeder or conveyor components on to a machine-tool.
3	104.2.0	Read and interpret machine-tool conveyor system documentation.
3	104.3.0	Read and interpret machine-tool feeder system documentation.
3	104.4.0	Review and calculate conveyor or feeder features and movements.
4	104.5.0	Identify and describe the features, functions, and operational principles of conveyor or feeder system and components.
4	104.6.0	Identify, and describe conveyor site preparation procedures.
3	104.7.0	Identify and describe preparation procedures for feeder system components.
3	104.8.0	Identify, describe, and demonstrate procedures for fitting and assembling of feeder system components.
4	104.9.0	Identify, describe, and demonstrate the process for fitting and assembling components of a conveyor system.
4	104.10.0	Identify and describe conveyor and feeder system sub-assembly procedures.
2	104.11.0	Identify, describe, and demonstrate methods for testing the functionality of conveyor systems.
2	104.12.0	Identify, describe, and demonstrate procedures for testing the functionality of feeder systems.

Learning Outcomes

Upon successful completion, the apprentice is able to:
- read and interpret feeder and conveyor documentation;
- identify, describe, and demonstrate procedures to prepare feeder and conveyor components for assembly on to machine-tools
- identify and describe feeder and conveyor system installation procedures.

104.1.0 Identify and observe safe working procedures when installing feeder or conveyor components on to a machine-tool.

104.1.1 Identify and describe safety hazards that can occur when installing feeders or conveyors.

104.1.2 Identify and describe feeder and conveyor system safety devices

104.2.0 Read and interpret machine-tool conveyor system documentation.

104.2.1 Read and interpret schematics, bill of materials, and engineering drawings.

104.2.2 Identify and list conveyor system component number and part identification.

104.2.3 Identify and describe various types of conveyor systems used when building a machine-tool including:
- belt
- chain
- roller
- palletizer

104.2.4 Identify and describe various components of conveyor systems including:
- motors
- transmissions
- shafts
- stops
- bearings
- magnets
- sprockets
- chains
- pallet stations or registers
- switches

- part tracking read and write tags
- elevators
- rotates
- lifters
- pallets
- guide rails

104.2.5 Identify and list the size, functions, and assembly procedures for components of a conveyor system.

104.2.6 Identify and describe assembly procedures of a conveyor system for a machine-tool.

104.3 Read and interpret machine-tool feeder system documentation.

104.3.1 Read and interpret schematics, engineering drawings, bill of materials, and specifications.

104.3.2 Identify and describe various type of feeder systems used when building a machine-tool including:

- vibratory bowl
- in-line
- pneumatic feeder
- solenoid activated
- conveyor-type
- gravity
- hopper
- auger
- blow feeder

104.3.3 Identify and describe feeder system component number and part identification.

104.3.4 Identify and describe application, functions, and operational principles of various feeder systems.

104.3.5 Identify and describe various components of various feed systems.

104.3.6 Identify and describe methods of assembly and integration of a feeder system.

104.4.0 Review and calculate conveyor or feeder features and movements.

Perform feeder and conveyor calculations to determine:
- speed ratios
- sizes
- rotary speed
- torque
- linear movement
  - force
  - speed
- conversion between linear force and rotary torque
- belt/chain tension due to conveyor loading
- belt and chain lengths

104.5.0 Identify and describe the features, functions, and operational principles of conveyor or feeder systems and components.

104.5.1 Identify and describe the features, functions and operating principles of various types of conveyor systems including:
- belt
- chain
- roller
- palletizer system and components

104.5.2 Identify and describe the features, functions, and operating principles of various types of feeder systems including:
- vibratory bowl
- in-line
- pneumatic feeder
- solenoid-activated
- conveyor-type
- gravity
- hopper
- auger
- blow feeder

104.5.3 Identify and describe the application and operational principles of conveyor system components including:
- motors
- transmissions
- shafts
- stops
- bearings
- sprockets

- chains
- pallet stations or registers
- switches
- part tracking read and write tags
- elevators
- rotates
- lifters
- pallets
- guide rails

104.5.4 Identify and describe application and operating principles of feeder system components including:

- escapements
- stops
- orientation tooling
- switches
- fill levels
- pressures
- feed rates
- readers

104.6.0 Identify and describe conveyor site preparation procedures.

104.6.1 Read and interpret engineering drawings and specifications.

104.6.2 Perform calculations to determine floor layout parameters including:

- spacing
- height
- length
- clearance
- centre lines
- services required

104.6.3 Identify and describe methods of measuring and aligning floor layout.

104.6.4 Identify and describe type and application of layout tools including:

- laser transit
- chalk lines
- plumb line

104.6.5 Demonstrate methods and techniques for preparing a site for a conveyor installation.

104.7.0 Identify and describe preparation procedures for feeder system components.

104.7.1 Describe the procedure to ensure correct contact of mating surface.

104.7.2 Identify and describe the implications of inadequate surface preparation.

104.7.3 Identify and describe the hand tools and measuring equipment required for preparing the feeder system components.

104.7.4 List and describe the types and applications of lubricants.

104.7.5 Identify and describe procedures and techniques for preparing feeder system components including:

- deburring
- cleaning mating surfaces
- fitting and assembling parts
- fabricating or manufacturing mounting hardware
- lubricating moving parts

104.8.0 Identify, describe, and demonstrate procedures for fitting and assembling of feeder system components.

104.8.1 Identify and describe assembly procedures and use of tools and precision measuring instruments to fit and assemble feeder system components.

104.8.2 Identify and describe various fitting and assembly methods including:

- setting and adjusting:
  - heights
  - alignments
  - fits
- checking and setting:
  - escapements
  - stops
  - orientation tooling
  - switches
  - fill levels
  - pressures
  - feed rates
  - switches
  - readers

104.8.3 Identify and describe methods for checking, aligning, and making adjustments to feeder system assembly.

104.8.4 Identify and describe types and application of tools and measuring equipment including:
- height gauges
- master level
- straight edges
- feeler gauges
- indicators
- verniers
- high spot blue
- micrometer
- gauge blocks
- depth micrometer

104.8.5 Identify and describe implications of incorrect fits and assembly.

Troubleshoot common areas of adjustment and alignment.

104.8.6 Identify and describe methods of adjustment.

104.9.0 Identify, describe, and demonstrate the process for fitting and assembling components of a conveyor system.

104.9.1 Read and interpret manufacturer's specifications, engineering drawings, bill of materials, and job specifications.

104.9.2 Identify and describe the pre-load and tensions of chains and belts.

104.9.3 Identify and describe the alignment procedures for shafts and tracking of belts.

104.9.4 Identify and describe the process for adjusting and setting pallet registers.

104.9.5 Identify and describe process of setting height and position of conveyor.

104.9.6 Identify and describe process for checking and setting:
- switches
- pallets readers
- R.F. identification tags

104.9.7 Identify and describe types and application of fasteners and mounting hardware.

104.9.8 Identify and describe types and application of tools and measuring equipment including:
- levels
- piano wire
- laser
- squares
- tape measures
- hand tools

104.9.9 Identify and describe piece part identification and location components.

104.9.10 Troubleshoot common errors of adjustment and alignment.

104.9.11 Demonstrate methods of fitting and assembly conveyor system components.

104.10.0 Identify and describe conveyor or feeder system sub-assembly procedures.

104.10.1 Identify and describe types and application of fasteners and anchors.

104.10.2 Identify and describe methods of assembly installation including:
- calculating floor space, height and length requirements
- laying out
- placing assemblies on layout
- installing belts and chains
- hooking up:
  - belts
  - drive
  - chains
  - pneumatics
  - hydraulics
- setting and adjusting:
  - height
  - location
  - leveling system
  - tension
  - preload – shafts
  - tracking
  - stops
  - pallet stations
  - switches

  - tracks
  - tubes
  - floor space
  - height
  - length
- lubrication requirements

104.10.3 Identify and describe methods and procedures of aligning, leveling and checking conveyor or feeder assemblies including:

- setting heights, location, and positions
- leveling system
- aligning drive and take-up end
- preliminary alignment of conveyor sections, using:
  - laser systems
  - levels
  - height adjustment screws
  - square
  - tape measure
  - hand tools
- preliminary adjustment of pallet tracking and pallet locking devices, using:
  - adjustment screws
  - shims and spacer

104.10.4 Identify and describe types and application of lubrication including:

- synthetic/natural oils and greases
- dry lubricants

104.10.5 Identify and describe tools and equipment used in installing, aligning and checking conveyor or feeder assembly installation including:

- chalk line
- laser or laser transit
- plumb bob
- anchoring equipment
- hammer drills
- levels
- tape measures
- squares
- piano wire
- stones
- files

- scrapers
- height gauges
- master level
- straight edge
- feeler gauges
- indicators
- verniers
- high-spot blue
- micrometer
- gauge block
- depth micrometer

104.10.6 Identify and describe alignment techniques.

104.11.0 Identify, describe, and demonstrate methods for testing the functionality of conveyor systems.

104.11.1 Identify, describe and demonstrate methods of testing functionality of a conveyor system including

Performing a dry run to check:
- cycle time
- tension
- tracking
- pallet or part location
- stop locations
- switch locations
- part tracking system

104.11.2 Identify and describe test parameters of a conveyor system including:
- cycle time
- tension
- tracking
- pallet location
- part location

104.11.3 Identify and describe adjustment procedures.

104.11.4 Identify and describe tools and equipment used for testing and checking conveyor systems.

104.11.5 Identify and describe implications of incorrect setup of system.

104.11.6 Identify and demonstrate adjustment techniques.

104.12.0 Identify, describe and demonstrate procedures for testing the functionality of feeder systems.

104.12.1 Identify and describe methods of testing the functionality of feeder systems including checking of:
- cycle time
- feed rates
- part orientation
- noise levels
- alignments
- clearances
- fill levels
- back pressure
- stops
- switches
- vibratory function

104.12.2 Identify and describe tools and equipment used for testing and checking feeder systems, including:
- height gauges
- master level
- straight edges
- feeder gauges
- indicators
- verniers
- spotting blue
- micrometers
- depth micrometer
- sound level meter

104.12.3 Demonstrate adjustments required when testing feeder functionality.

104.12.4 Identify and describe implications of incorrect setup and alignment.

104.12.5 Demonstrate adjustment techniques.

Number:	105
Title:	**Planning of Machine-Tool Building and Integration**
Duration:	Total Hours: 18 Theory: 12 Practical: 6
Prerequisites:	Common Core – Units 2, 3, 5
Co-requisites:	Completion of Unit 105 is contingent upon successful completion of all MTBI Level 2 units.

Cross Reference to Training Standards: MTBI Training Standards U5530 to U5548

Trade	Unit	Learning Outcomes
MTBI	U5531	Ability to plan and prepare for machining operations.
MTBI	U5532	Ability to measure and analyze in-process workpiece dimensions and surface verification.
MTBI	U5540	Ability to devise and detail a plan for the machine-tool building and integration process.
MTBI	U5541	Ability to identify, describe, and demonstrate methods of building in-process tooling for the machine-tool (Forming, Trimming, Machining)
MTBI	U5542	Ability to assemble and integrate pneumatic and hydraulic components.
MTBI	U5543	Ability to identify, describe, and demonstrate the assembly and integration of electrical components on a machine-tool.
MTBI	U5544	Ability to describe and demonstrate the process of assembly and integration of power transmission systems.
MTBI	U5545	Ability to identify and demonstrate the process and procedures for assembling and integrating a conveyor system on a machine-tool.
MTBI	U5546	Ability to identify and demonstrate the process for assembly and integrating feeder systems.
MTBI	U5547	Ability to describe and demonstrate methods for sub-assembling machine-tool components.
MTBI	U5548	Ability to identify and describe the process for integrating main-assemblies.

Benchmark Hours	#	Curriculum Outcomes
1	105.1.0	Identify and describe machine-tool components and materials.
2	105.2.0	Identify and describe final production requirements of a machine-tool assembly.
5	105.3.0	Identify and describe detail parts and components used in assemblies.
5	105.4.0	Read and interpret various component part catalogues.
5	105.5.0	Devise and detail a plan for the building and integration of a machine-tool.

Learning Outcomes

Upon successful completion, the apprentice is able to:
- read and interpret machine-tool component, assembly, and product/part prints;
- read and interpret functional specifications;
- develop an operational plan for building and assembling a machine- tool.

105.1.0 Identify and describe machine-tool components and materials.

105.1.1 Read and interpret machine-tool documentation including:
- engineering drawings
- bill of materials
- specifications
- reference materials
- schematics
- piece-part features

105.1.2 Read and interpret layout drawings, assembly drawings, and detailed drawings.

105.1.3 Identify and describe the application, function, and operating principles of machine-tool components including:
- sequence of operations
- types of operations
- design parameters
- space limitations
- interfacing requirements
- final product part features
- tolerances

- sizes
- diameters
- revision level
- projection and section views
- component shapes
- number of stations
- number of working components
- material specifications
- workpiece materials

105.2.0 Identify and describe final production requirements of a machine-tool assembly.

105.2.1 Read and interpret machine-tool building documentation, including:

- engineering drawings
- bills of materials
- job specifications
- customer specifications
- reference materials
- CAD data

105.2.2 Identify and describe various types of machine-tool assemblies and final production specifications, including:

- sequence of operations
- types of operations
- design parameters
- space limitations
- interfacing requirements
- final product part features
- tolerances
- sizes and diameters
- revision level
- projection and section views
- component shapes
- number of stations
- number of working components
- material specifications
- thickness and type of workpiece materials
- assembly process
- number of functions
- quantity and type of parts, tools and components

105.2.3 Identify and describe the impact of the final features of a customer's final product or part.

105.2.4 Identify and describe the types of operations and design parameters of the machine-tool assembly's final production requirements.

105.2.5 Identify and describe assembly sequence of machine-tool assembly components.

105.3.0 Identify and describe detail parts and components used in assemblies.

105.3.1 Identify and describe types and applications of various details used in assemblies, including:

- part locators
- nests
- spacers
- wipers
- fingers
- slides
- stops
- punch and form tooling
- end effectors
- hold downs
- pallet tooling
- weldments
- pilots
- clamps
- castings and mouldings

105.3.2 Identify and describe the operating principles of various details used in machine-tool assemblies.

105.3.3 Identify and describe methods, processes, or procedures used for fabricating details used in assemblies, including:

- milling
- turning
- grinding
- drilling
- sawing

105.3.4 Identify and describe types and applications of fasteners and hardware.

105.3.5 Identify and describe methods of mounting and installing hardware.

105.3.6 Identify and describe methods of measuring and checking detailed parts.

105.3.7 Identify and describe methods for fabricating a detail for an assembly.

105.4.0 Read and interpret various component part catalogues.

105.4.1 Identify and select required parts for assembly.

105.4.2 Identify and determine catalogue sources for parts.

105.5.0 Devise and detail a plan for the building and integration of a machine-tool.

105.5.1 Devise and detail a plan by:
- verifying the features of machine-tool components
- developing and organizing machine-tool building and integration process.

Performing machine-tool builder and integrator related calculations

Identifying and listing machine-tool stock materials
- producing a sketch of tooling components and sub-assemblies

105.5.2 Identify and detail various types of assembly components.

105.5.3 Identify and detail methods, procedures, and sequence of the assembly process.

105.5.4 Identify and detail the tools required to build a machine-tool.

105.5.5 Identify the in-process tooling development required for a machine-tool assembly.

105.5.6 Identify and detail the manufacturing processes required to build a
machine-tool.

105.5.7 Demonstrate sketching techniques for a floor layout.

Number:	106		
Title:	**In-Process Tooling Technology (Forming, Trimming & Machining Tooling)**		
Duration:	Total Hours: 48	Theory: 24	Practical: 24
Prerequisites:	Common Core – All Units		
Co-requisites:	Completion of Unit 106 is contingent upon successful completion of all MTBI Level 2 – Units 90 to 101		
Cross Reference to Training Standards: MTBI Training Standards U5530 to U5548			

Trade	Unit	Learning Outcomes
MTBI	U5531	Ability to plan and prepare for machining operations.
MTBI	U5532	Ability to measure and analyze in-process workpiece dimensions and surface verification.
MTBI	U5540	Ability to devise and detail a plan for the machine-tool building and integration process.
MTBI	U5541	Ability to identify, describe and demonstrate methods of building in-process tooling for the machine-tool (forming, trimming, and machining): • read and interpret in-process tool-building documentation • Identify and plan in-process tooling development • produce preliminary sketches of tooling • cut and prepare raw material • block-up and establish datum on a workpiece • fabricate in-process tooling components • demonstrate the spot-forming process • set-up and operate a try-out press • inspect the operation produced by developed tooling • communicate with co-workers • complete documentation • maintain a clean and organized lab environment

Benchmark Hours	#	Curriculum Outcomes
4	106.1.0	Review, identify and describe types of in-process forming, trimming, and machining of tools used in cells and systems.
4	106.2.0	Read and interpret machine-tool building documentation to identify features and elements of in-process tool development.
4	106.3.0	Read and interpret documentation to determine industry/company standards for in-process tooling.
3	106.4.0	Perform in-process tool building calculations.
7	106.5.0	Produce a detailed sketch of trimming, forming or machining tools.
5	106.6.0	Verify the workpiece material application for in-process tooling.
12	106.7.0	Identify and plan in-process tooling development.
5	106.8.0	Fabricate forming, trimming and machining tools.
4	106.9.0	Identify, describe, and demonstrate try-out procedures for the assembly of in-process tooling for the machine-tool.

Learning Outcomes

Upon successful completion, the apprentice is able to:
- read and interpret machine-tool component, assembly, and product/part prints;
- read and interpret tables, charts, and functional specifications;
- develop an operational plan for building and assembling a machine-tool.

106.1.0 Review, identify and, describe in-process tooling including forming, trimming, and machining tools used in cells and systems.

106.1.1 Review and describe features, functions, and operating principles of in-process tooling including swaging, electrodes and nozzles.

106.1.2 Identify and describe elements, features and functions of in-process tooling including:
- forming
- trimming
- machining tools

106.1.3 Identify and describe types, functions, and operating principles of forming tools including:
- joining
- internal radius
- external radius

106.1.4 Identify and describe types, functions, and operating principles of trimming tools including:
- piercing
- slitting

106.1.5 Identify and describe types, functions, and operating principles of machining tools including:
- drilling
- milling
- countersinking
- tuning tools

106.2.0 Read and interpret machine-tool building documentation to identify features and elements of in-process tool development.

106.2.1 Read and interpret tool building documentation including:
- part drawings
- engineering drawings
- bill of materials
- sketches
- piece parts
- job specifications

106.2.2 Identify and describe features and elements of assembly drawings including:
- assembly and sub-assembly numbers
- sub-assembly identification
- assembly sequencing and procedures

106.2.3 Read and interpret specifications to identify:
- dimensions
- tolerances
- limits
- finish condition
- material type

106.2.4 Read and interpret in-process tooling features to determine in-process tooling development.

106.3.0 Read and interpret documentation to determine industry/company standards for in-process tooling.

106.3.1 Identify and describe industry/company standards for trimming, forming, and machining tools including:
- type
- workpiece material

106.4.0 Perform in-process tool building calculations.

106.4.1 Calculate and determine the tooling dimensions and values by identifying:
- clearances
- size
- dimensions
- tolerances
- finishes

106.5.0 Produce a detailed sketch of trimming, forming, or machining tools.

106.5.1 Produce shop floor sketches from job specifications and industry standards to identify tooling features including:
- shape
- dimensions
- tolerances
- finishes
- clearance

106.6.0 Verify the workpiece material application for in-process tooling.

106.6.1 Read and interpret job specifications and industry standards to determine required materials including:
- type
- grade
- dimensions
- surface condition
- hardenability

106.7.0 Identify and plan in-process tooling development for forming, trimming, or machining.

106.7.1 Read and interpret mechanical engineering drawings and job specifications including:
- CAD data
- engineering drawings
- bill of materials
- job specifications

106.7.2 Determine and develop a plan for the fabrication of the in-process tooling that identifies:
- sequence of operation
- type of operation
- design parameters
- space limitations
- interfacing requirements
- final piece-part features
- machine-tools
- machining procedures
- machine accessories
- tooling aids
- building sequence
- fabrication processes
- workpiece materials

106.7.3 Identify and describe final design production parameters including:
- sequence of operations
- types of operations
- design parameters
- space limitations
- interfacing requirements
- final piece part features

106.7.4 Determine and review the type and design of the tooling required.

106.7.5 Determine fabrication procedures for tool development.

106.8.0 Fabricate forming, trimming and machining tools.

106.8.1 Read and interpret tool documentation including:
- engineering drawings
- specifications
- bill of materials
- reference materials
- tool-building plan
- piece part features

106.8.2 Identify and select types, applications, and methods of fabricating forming, trimming and machining tools including:
- machining processes
- accessories

106.8.3 Develop and prepare a sketch of tooling that identifies:
- type
- shape
- dimensions
- functions
- tolerances
- part assembly interrelationship

106.8.4 Identify, review, and select measuring instruments and checking devices including:
- gauge blocks
- micrometers
- verniers
- height gauges
- dial test indicators

106.8.5 Fabricate forming, trimming and machining tools by:
- sketching
- machining
- mills
- grinders
- drills
- lathes
- saws
- measuring and checking

106.8.6 Inspect components to verify accuracy of finished tooling.

106.8.7 Identify and describe the processes for fitting, positioning, and aligning of tooling components.

106.9.0 Identify, describe, and demonstrate try-out procedures for the assembly of in-process tooling on the machine-tool.

106.9.1 Test, modify, and adjust the in-process tooling.

106.9.2 Perform try-out of tooling.

106.9.3 Verify accuracy and mechanical functioning of the tooling.

Number:	107
Title:	**Machine-Tool Sub-Assembly Technology**
Duration:	Total Hours: 42 Theory: 24 Practical: 18
Prerequisites:	Common Core – All Units
Co-requisites:	Completion of Unit 107 is contingent upon successful completion of all MTBI Level 2 – Units 90 to 101.

Cross Reference to Training Standards: MTBI Training Standards U5530 to U5548

Trade	Unit	Learning Outcomes
MTBI	U5531	Ability to plan and prepare for machining operations.
MTBI	U5532	Ability to measure and analyze in-process workpiece dimensions and surface verification.
MTBI	U5540	Ability to devise and detail a plan for the machine-tool building and integration process.
MTBI	U5547	Ability to describe and demonstrate methods for sub-assembling machine-tool components. • identify and describe final production requirements of a sub- assembly • read and interpret sub-assembly documentation • identify and describe detail parts/components used in sub-assemblies • read and interpret various component part catalogues • describe and demonstrate process for preparing sub-assembly parts • fit and assemble component parts and assemblies • describe and demonstrate methods of testing of sub-assemblies • communicate with co-workers. • complete documentation • maintain a clean and organized lab environment.

Benchmark Hours	#	Curriculum Outcomes
1	107.1.0	Identify and demonstrate safe working procedures when building sub-assemblies for machine-tools.
3	107.2.0	Identify and describe final production requirements for sub-assemblies.
3	107.3.0	Read and interpret sub-assembly documentation.
6	107.4.0	Identify, describe, and fabricate detailed parts and components used in sub-assemblies.
4	107.5.0	Read and interpret component part catalogues to identify fabricated parts and components for the assembly process.
6	107.6.0	Describe and demonstrate processes for preparing sub-assembly components and parts.
9	107.7.0	Fit and assemble parts and sub-assemblies.
10	107.8.0	Describe and demonstrate methods of testing and verifying functionality of sub-assemblies.

Learning Outcomes

Upon successful completion, the apprentice is able to:

- describe and demonstrate methods of sub-assembly of machine-tool components;
- describe and demonstrate processes for preparing sub-assembly parts;
- fit and assemble parts and sub-assemblies;
- describe and demonstrate methods of testing and verifying functionality of sub-assemblies.

107.1.0 Identify and demonstrate safe working procedures when building sub-assemblies for machine-tools.

107.2.0 Identify and describe final production requirements for sub-assemblies.

107.2.1 Read and interpret the contents of sub-assembly design specifications to identify final production requirements, including:
- assembly drawings
- bills of materials
- detail drawings
- job specifications
- customer specifications
- machine-tool building and integration plans

107.2.2 Identify and describe final production specifications for sub-assemblies, including:
- sequence of operations
- types of operations
- design parameters
- space limitations
- interface requirements

107.2.3 Identify and describe the impact of sub-assembly features on the final part or product to be manufactured by the machine-tool.

107.2.4 Identify and describe the types of operations and design parameters of a sub-assembly's final production requirements, including:
- end process or function
- cycle time

107.3.0 Read and interpret sub-assembly documentation.

107.3.1 Read and interpret sub-assembly documentation including:
- engineering drawings
- bills of materials
- machine-tool build plans
- job specifications
- CAD data

107.3.2 Identify and describe various types of sub-assembly components.

107.3.3 Identify and describe sub-assembly component numbers and part identification.

107.3.4 Identify and describe methods and procedures of assembly.

107.3.5 Identify and describe the relation of sub-assembly drawings to assembly drawings.

107.4.0 Identify, describe, and fabricate detailed parts and components used in sub-assemblies.

107.4.1 Read and interpret engineering drawings, bills of materials and job specifications.

107.4.2 Identify and describe type and application of details used in sub assemblies, including:

- part location
- nests
- spacers
- wipers
- fingers
- slides
- stops
- punch tooling
- form tooling
- end effectors
- hold downs
- pallet tooling
- weldments
- pilots
- clamps
- castings
- mouldings

107.4.3 Identify and describe the functions and operational principles of various details used in sub-assemblies.

107.4.4 Determine and describe the methods, processes, and procedures used in the fabrication of detailed parts, including:

- milling
- turning
- grinding
- honing
- drilling
- sawing

107.4.5 Identify and describe types and applications of fasteners and installation of hardware.

107.4.6 Describe methods of mounting and installing hardware.

107.4.7 Identify and describe methods of measuring, checking, and verifying detailed parts.

107.4.8 Fabricate a detail for sub-assembly.

107.5.0 Read and interpret component part catalogues to identify fabricated parts and components for the assembly process.

107.5.1 Read and interpret documentation including:
- sub-assembly
- engineering drawings
- bills of material
- job specifications

107.5.2 Demonstrate the identification and selection of parts for sub-assembly.

107.5.3 Demonstrate the use of catalogues in sourcing of purchased parts.

107.6.0 Describe and demonstrate processes for preparing sub-assembly components and parts.

107.6.1 Read and interpret sub-assembly documentation including:
- manufacturer’s specifications
- bills of materials
- engineering drawings
- job specifications
- machine-tool building and integrating specifications

107.6.2 Describe procedures to ensure correct contact of mating surfaces.

107.6.3 Identify and describe the implications of inadequate surface preparation.

107.6.4 Identify and describe types and applications of tools used for preparing parts for sub-assembly, including:
- files
- honing
- abrasive stone
- hand tools

107.6.5 Demonstrate fitting and assembling of parts in the sub-assemblies process, including:
- deburring
- cleaning mating surfaces
- fitting and assembling parts
- lubricating moving parts
- pre-inspection procedures

107.6.6 Identify and describe the implications of inadequate preparation and fitting of parts for sub-assembly.

107.6.7 Troubleshoot common sub-assembly errors.

107.6.8 Demonstrate procedures for adjusting sub-assemblies.

107.7.0 Fit and assemble parts and sub-assemblies.

107.7.1 Read and interpret assembly documentation including:
- engineering drawings
- job specifications
- bills of materials
- machine-tool building and integration plan

107.7.2 Identify and describe surface fitting procedures including:
- flaking
- grinding
- machining
- stoning
- honing

107.7.3 Identify and describe assembly procedures, including:
- dowelling
- fastening
- keying
- tacking
- welding

107.7.4 Identify and describe various types, functions, and operating principles of mechanical fasteners.

107.7.5 Demonstrate alignment procedures.

107.7.6 List and describe types and applications of:
- lubricants
- rust-prevention solutions

107.7.7 Demonstrate methods of fitting and assembling sub-assemblies.

107.7.8 Identify and describe the implications of incorrect fitting and assembling.

107.7.9 Troubleshoot common errors of fitting and assembling.

107.7.10 Demonstrate adjustment techniques.

107.8.0 Describe and demonstrate methods of testing and verifying the functionality of sub-assemblies.

107.8.1 Read and interpret machine-tool building documentation including:
- machine-tool build plans
- manufacturer's specifications
- job specifications
- engineering drawings

107.8.2 Identify, describe, and demonstrate methods of testing the functionality of sub-assemblies, including:
- running through operational sequences
- checking operational parameters
- making adjustments
- measuring and checking

107.8.3 Identify and describe operating parameters of sub-assemblies, including:
- clearances
- noise levels
- temperatures
- friction
- speed
- wear
- tolerances

107.8.4 Identify and demonstrate application of measuring and checking equipment for verifying sub-assembly functionality, including:

- height gauges
- machinist level
- straight edges
- feeler gauges
- indicators
- verniers
- spotting blue
- micrometer
- sound meters

107.8.5 Demonstrate testing and verification procedures for a sub-assembly.

107.8.6 Troubleshoot common errors.

107.8.7 Demonstrate adjustment techniques

Number:	108		
Title:	**Machine-Tool Main Assembly Technology**		
Duration:	Total Hours: 36	Theory: 18	Practical: 18
Prerequisites:	Common Core – All Units		
Co-requisites:	Completion of Unit 108 is contingent upon successful completion of all MTBI Level 2 – Units 90 to 101		

Cross Reference to Training Standards: MTBI Training Standards U5530 to U5548

Trade	Unit	Learning Outcomes
MTBI	U5540	Ability to devise and detail a plan for the machine-tool building and integration process.
MTBI	U5548	Ability to identify and describe the process for integrating main-assemblies. • Identify and describe final production requirements of main-assembly • read and interpret main-assembly documentation • determine and describe procedures for preparing components for the main-assembly • describe the processes for integrating sub-assemblies and components into a machine-tool • describe and demonstrate the testing and verification processes for tooling locations on a machine-tool • describe the dry-run testing process of a main-assembly • test-run the main-assembly with a finished part • describe the process for verifying a machine main-assembly • communicate with co-workers • complete documentation • maintain a clean and organized lab environment.

Benchmark Hours	#	Curriculum Outcomes
1	108.1.0	Identify and demonstrate safe working procedures when integrating main-assemblies on machine-tools.
3	108.2.0	Identify and describe final production requirements of the main-assembly.
2	108.3.0	Read and interpret main-assembly documentation.
2	108.4.0	Determine and describe procedures for preparing components for main-assembly.
5	108.5.0	Describe the processes for integrating sub-assemblies and components into a machine-tool.
5	108.6.0	Describe and demonstrate processes of testing and verifying tooling locations on a machine-tool.
6	108.7.0	Describe the dry-run testing process of a main-assembly.
6	108.8.0	Demonstrate the ability to test-run the main-assembly with a finished part.
6	108.9.0	Describe the process for verifying a machine main assembly.

Learning Outcomes

Upon successful completion, the apprentice is able to:
- identify and describe the process for integrating main-assemblies;
- describe the dry-run testing process of a main-assembly;
- demonstrate the ability to test-run the main-assembly with a finished part.

108.1.0 Identify and demonstrate safe working procedures when integrating main-assemblies on machine-tools.

108.1.1 Identify and describe safety hazards which can occur during the integration of main-assemblies on to machine-tools, including:

108.1.2 Identify and describe safe practices and procedures during the integration of main-assemblies of machine-tools.

108.2.0 Identify and describe final production requirements of the main-assembly.

108.2.1 Read and interpret the main-assembly design specifications and documentation including:
- CAD data
- engineering drawings
- bills of materials
- job documentation
- customer specifications
- machine-tool-building plans

108.2.2 Identify and describe final production specifications for the main- assembly, including:
- sequence of operations
- types of operations
- design parameters
- space limitations
- interface requirements
- final piece part features

108.2.3 Determine and describe the assembly sequence of main-assembly components.

108.3.0 Read and interpret main-assembly documentation.

108.3.1 Read and interpret main-assembly documentation including:
- machine-tool build plans
- engineering drawings
- bills of materials
- job specifications

108.3.2 Identify and describe features and elements of main assembly including:
- types of assembly
- sub-assembly numbering systems
- sub-assembly identification
- assembly sequencing
- sub-assembly procedures

108.3.3 Determine and describe assembly methods and sequence of main- assembly.

108.4.0 Determine and describe procedures for preparing components for main-assembly.

108.4.1 Read and interpret documentation including:
- engineering drawings
- machine-tool layout documentation
- bills of materials
- job specifications

108.4.2 Describe procedures to ensure correct contact of mating surfaces.

108.4.3 Identify and describe the implications of inadequate surface preparation.

108.4.4 Describe and demonstrate methods for preparing a floor layout.

108.4.5 Identify and describe methods and procedures for preparing components for the main assembly, including:
- laying out the floor or area
- benching(re-tapping and re-reaming holes) of main frames
- and bases
- cleaning and stoning mating surfaces

108.4.6 Identify and describe various rigging techniques for moving and installing main-assembly.

108.4.7 Troubleshoot common main-assembly errors.

108.4.8 Demonstrate adjustment techniques.

108.5.0 Describe the processes for integrating main-assemblies and components into a machine-tool.

108.5.1 Read and interpret integration documentation including:
- engineering drawings
- bills of material
- machine-tool build and integrate plans
- job specifications

108.5.2 Identify and describe layout techniques.

108.5.3 Identify and describe hoisting and rigging procedures.

108.5.4 Describe and demonstrate locating, leveling, and installation techniques of main-assemblies and components into machine-tools, including:
- leveling and locating bases
- anchoring bases
- setting and spotting sub-assemblies
- installing transfer systems
- installing pneumatic systems
- installing hydraulic systems
- installing electrical components
- installing lubrication systems
- installation tooling components

108.5.5 Demonstrate methods of aligning and adjust main-assemblies and components, including:
- aligning and locating components
- measuring, checking, and trimming sub-assemblies

108.5.6 Demonstrate methods of system integration.

108.5.7 Discuss and describe the implications of incorrect integration of systems.

108.5.8 Troubleshoot common errors.

108.5.9 Demonstrate adjustment techniques.

108.6.0 Describe and demonstrate processes of testing and verifying tooling locations on a machine-tool.

108.6.1 Read and interpret documentation including:
- engineering drawings
- final assembly drawings
- job specifications
- bills of materials

108.6.2 Demonstrate the use of measuring and checking tools and equipment, including:
- feeler gauges
- depth micrometers
- tape measures
- indicators

- gauge blocks
- laser systems
- squares
- piano wire
- plumb bob
- height gauges

108.6.3 Describe and demonstrate the process of manually stepping the workpiece through the operational sequence of the machine-tool.

108.6.4 Describe and demonstrate techniques for measuring and checking of the relation of the machine-tool to the final piece-part, including:
- depths
- clearances
- heights

108.6.5 Describe and demonstrate techniques for locating, positioning and aligning of tooling locations.

108.6.6 Troubleshoot common errors.

108.6.7 Identify and demonstrate adjustment techniques.

108.7.0 Describe the dry-run testing process of a main-assembly.

108.7.1 Read and interpret documentation including:
- engineering drawings
- machine-tool build final assembly drawings
- job specifications

108.7.2 Describe the methods of dry-run testing of the main-assembly.

108.7.3 Describe the methods used to verify the operational sequencing in the automatic mode, including testing out the:
- lubrication system
- programs
- cycle time
- sequencing
- repeatability
- Performance

108.7.4 Describe the methods used to verify no-load cycle time.

108.7.5 Describe the use of sensory skills, instrumentation and checking equipment to test:
- lubrication and cooling systems
- cycle times
- noise levels
- machine repeatability
- machine functions
- machine processing and process operations
- machine cycle time performance
- machine downtime
- changeover times

108.7.6 Identify and describe fault diagnosis techniques used to detect:
- faults
- leaks
- part wear
- noise levels
- temperature
- friction
- speed
- clearances
- inaccuracies

108.7.7 List and describe potential conditions requiring correction actions.

108.7.8 Troubleshoot common errors.

108.7.9 Identify and describe methods of adjustment and corrective actions.

108.8.0 Demonstrate the ability to test-run the main-assembly with a finished part.

108.8.1 Read and interpret documentation including:
- engineering drawings
- machine-tool build final assembly drawing
- job specifications

108.8.2 Describe and demonstrate the methods used to verify “loaded” cycle time.

108.8.3 Describe the methods used to test-run the main-assembly, including running with parts and coolants.

108.8.4 Describe and demonstrate the use of sensory skills, instrumentation, and checking equipment to test:
- lubrication and cooling systems
- cycle times
- noise levels
- machine repeatability
- machine functions
- machine processing and process operations
- chip control functions
- machine cycle time performance
- machine downtime
- changeover times

108.8.5 Identify and describe fault diagnosis techniques and recommended corrective actions.

108.8.6 List and describe potential conditions requiring corrective actions.

108.8.7 Describe methods of adjustment and corrective actions.

108.9.0 Describe the process for verifying a machine main assembly.

108.9.1 Read and interpret documentation including:
- capability index:
  - Cp/Cpk
  - Pp/Ppk
- job documentation
- machine-build assembly drawings

108.9.2 Describe and interpret a capability study.

108.9.3 Identify and describe the verification of part tolerances.

108.9.4 Describe part dimensional and functional properties including:
- measurement variation
- resolution and discrimination
- bias
- accuracy
- repeatability
- reproducibility
- linearity
- stability

108.9.5 Identify and describe the principle of machine variability including:
- histogram
- center
- spread

108.9.6 Identify and describe the basic principles of Statistical Process Control (SPC) and its applications in machine-tool building.

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