Skilled Trades Ontario | Métiers spécialisés Ontario

Apprenticeship Curriculum Standard

Welder and Metal Fabricator (Fitter)

Level 1 Common Core

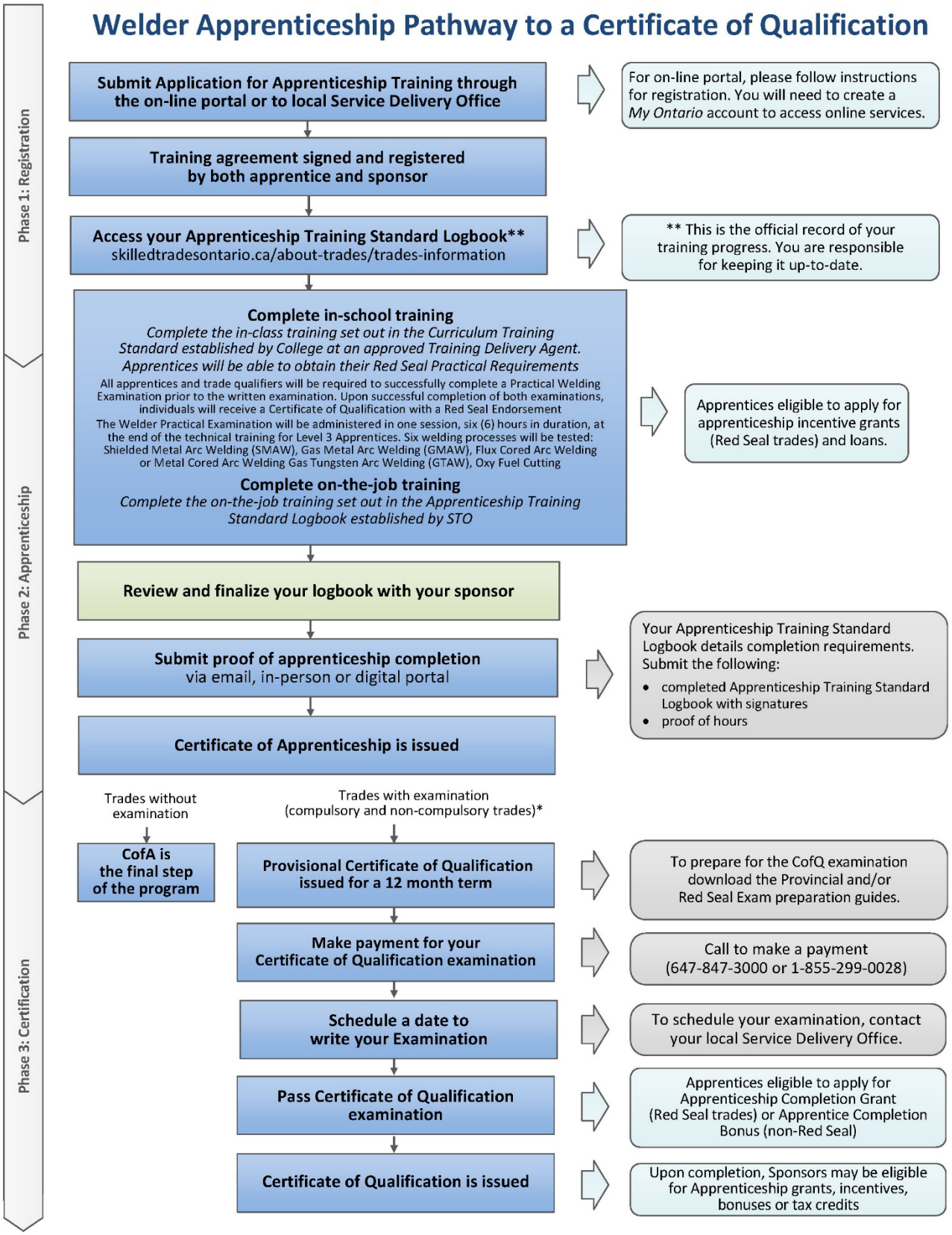
Welder

Levels 2 and 3

456A & 437A

2017

Welder Apprenticeship Pathway to a Certificate of Qualification



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

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Table of Contents

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Revised 2017 (V300)

Preface

This curriculum standard for the Welder trade program is based upon the on-the-job performance objectives, located in the industry-approved training standard.

The curriculum standard is organized into 3 levels of training. The Reportable Subjects Summary chart summarizes the training hours for each reportable subject.

The curriculum standard identifies only the learning that takes place off-the-job. 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 the work site. Regular evaluations of the apprentice's knowledge and skills are conducted throughout training to ensure 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

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.

Equipment for Training Delivery Agencies

The listing of tools on page 110 does not list minimum quantities based on the understanding that the TDA is in the best position to determine the need based on its delivery methodology.

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

Welder apprentices must supply their own work clothing, boots, coveralls, welding jacket, leather gloves welding helmets and prescription (safety) glasses. Items such as hard hats, eye and hearing protection, and all other tools and equipment are frequently the responsibility of the employer. Resource materials, charts, regulations, specifications, service bulletins, manufacturer's manuals, and logbooks are supplied by the employer or equipment owner.

Please note that all construction practices described in this standard must be done according to industry best practice.

Reportable Subject Summary – Level 1

Hours				
#	Reportable Subjects	Theory	Practical	Total
S3190: Trade Practices				
S3190.1	General Safety	12	0	12
S3190.2	Hand and Power Tools	4	5	9
S3190.3	Trade Calculations	24	0	24
Sub Totals		**40**	**5**	**45**
S3191: Applied Drawing Interpretation				
S3191.1	Applied Drawing Interpretation	27	12	39
S3191.2	Joint Design and Welding Symbols	9	0	9
Sub Totals		**36**	**12**	**48**
S3192: Welding Theory				
S3192.1	Power Sources and Equipment	9	0	9
S3192.2	Shielded Metal Arc Welding (SMAW)	9	0	9
S3192.3	Gas Metal Arc Welding (GMAW)	9	0	9
S3192.4	Flux Cored (FCAW) and Metal Cored (MCAW) Arc Welding	3	0	3
S3192.5	Thermal Cutting	9	0	9
Sub Totals		**39**	**0**	**39**
S3193: Material and Process Quality I				
S3193.1	Distortion	12	0	12
S3193.2	Weld Quality	15	0	15
Sub Totals		**27**	**0**	**27**
S3194: Shielded Metal Arc Welding (SMAW) Practical I				
S3194.1	Fillet Welds with Shielded Metal Arc Welding (SMAW) on Mild Steel	0	36	36
S3194.2	Groove Welds with Shielded Metal Arc Welding (SMAW) on Mild Steel	0	33	33
Sub Totals		**0**	**69**	**69**
S3195: Gas Shielded Semi-Automatic Welding Practical I				
S3195.1	Fillet Welds with Gas Metal Arc Welding (GMAW)	0	21	21
S3195.2	Groove Welds with Gas Metal Arc Welding (GMAW)	0	15	15
S3195.3	Fillet Welds with Flux Cored Arc Welding (FCAW)	0	9	9
S3195.4	Groove Welds with Flux Cored Arc Welding (FCAW)	0	9	9
Sub Totals		**0**	**54**	**54**
S3196: Thermal Cutting				
S3196.1	Oxy-Fuel-Gas Cutting	0	6	6
S3196.2	Plasma Arc Cutting	0	6	6
S3196.3	Air Carbon Arc Gouging	0	6	6
Sub Totals		**0**	**18**	**18**
Level 1 Totals		**142**	**158**	**300**

Number:	**S3190**		
Title:	**Trade Practices**		
Duration:	Total Hours: 45	Theory: 40	Practical: 5
Content:	S3190.1 General Safety		
	S3190.2 Hand and Power Tools		
	S3190.3 Trade Calculations		

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

General Safety - earplugs and muffs, leather gloves, face shields, leather jackets, fire blankets, masks, fire extinguishers, respirators, goggles, safety glasses, and leather aprons.

Tools & Equipment:

Hand Tools / Power Tools - adjustable wrenches, Allen wrenches, bench vice, “C” clamps, chalk-line, cold chisels, electric extension cords, files, friction lighter, grinding and sanding disks, hacksaw, hammers, hand shears, layout table, magnets, metal markers, pipe clamps, pipe cutter, pipe wrenches, pliers, positioners, pry bars, punches, screwdrivers, scribers, snips, soapstone markers, socket sets, temperature indicating crayons, tip cleaners, toolboxes, tungsten sharpening grinders, vice grips, wire brushes, wire cutters, wrench sets, sanders, electric drills, angle grinders, grinders.

Trade Calculations - calculators

Instructional Strategies: demonstrations and practice, continuing appropriate use, periodic quizzes, math applications.

S3190	**Trade Practices**		
S3190.1:	**General Safety**		
Hours:	Total: 12	Theory: 12	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to describe the safe material handling operations, Industrial Safety Acts and potential workplace hazards in accordance with government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

1.1 Explain material handling components and techniques and inspection methods.

- rigging/hoisting/material handling
  - equipment selection
  - tuggers
  - cable clamps
  - chain block hoists
  - chokers
  - connectors
  - ropes
  - chains
  - slings
  - clevices
  - hooks and plate clamps
  - spreaders
  - turning weldments
  - cranes
  - hand signals
  - mobile
  - jib
- overhead
- forklifts
- jacks
- come-along
- turn buckles

1.2 Describe the necessary PPE against common shop and construction hazards.

- electrical shock
  - water and electricity
  - good ground connection
  - cable connection

- fumes and gases
    - appropriate helmet and filter plates
    - respirators
    - flow meters
    - spatter
    - ozone
- fire
    - heat and burns
    - sparks
    - appropriate clothing
- radiation
    - Ultra-Violet
    - Infra-Red
    - white light
- noise
- fall protection
- falling objects
- scheduling
- sequence
- material selection and handling

1.3 Explain the safe use and operation of equipment.

- storage and handling of compressed gas cylinders
- power tools
- hand tools
- fabricating equipment
- automated equipment
- lockout
- scaffolding
- safety harness
- permits

1.4 Describe the *Workplace Hazardous Materials Information System (WHMIS).*

- right to know
- legislation including but not limited to *Canadian Center Occupational Health and Safety (CCOHS)*
- safe handling of products
- hazardous materials
- Threshold Limit Values (TLVs)
- Material Safety Data Sheets (MSDS)
- knowledge of company policies, workplace practices, government legislation and regulations

1.5 Describe the *Occupational Health and Safety Act (OHSA).*

- legislation
- responsibility of employer and employee

1.6 Identify potential Workplace Hazards.

- confined spaces
- oxygen depletion
- moving equipment
- tripping hazards
- near misses
- emergency responses
- incident reports
    - safety/hazard assessment forms
- fires
- hot work

1.7 Describe effective verbal and non-verbal communication.

- use of common trade or non-technical terminology depending on the audience
    - supervisor
    - related professionals
    - suppliers
    - clients
- explain processes and ideas in a clear, concise and precise manner

S3190	**Trade Practices**		
S3190.2:	**Hand and Power Tools**		
Hours:	Total: 9	Theory: 4	Practical: 5

General Learning Outcomes

Upon successful completion the apprentice is able to use measuring, small hand and power tools including but not limited to and in accordance with government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

2.1 Describe the application and use of small hand and power tools.

- small hand tools
  - chipping hammer
  - wire brush
  - side cutters
  - hammer
  - cold chisel
  - pliers
  - vise grips
  - hack saw
  - scalers
  - hole saw
- pneumatic powered hand tools
- electric powered hand tools
  - wheel grinders
  - pedestal grinders
  - disc grinders
  - portable drills
- bench grinders
- abrasive cut-off saws
- die grinders
- drill press
- nibblers

2.2 Use welding measuring tools.

- fillet gauge
- contour gauge
- throat gauges

2.3 Use fit-up measurement tools.

- measuring tape
- ruler
- Vernier
- micrometer
- level
- centre head
- combination square
- protractor
- bevel angle
- calibration

S3190	**Trade Practices**		
S3190.3	**Trade Calculations**		
Hours:	Total: 24	Theory: 24	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to explain basic arithmetic, applied calculations, systems of measurements and basic geometry in accordance with the requirements for the welding and fabricating trades.

Learning Outcomes and Content

3.1 Define the fundamentals of basic arithmetic and perform the applied calculations.
- adding, subtracting, multiplying and dividing
- exponents and square root
- mathematical calculations
  - work orders
  - estimates
  - invoices
  - use of calculators

3.2 Explain the procedures and perform calculations.
- fractions and decimals
- converting fractions to decimals and decimals to fractions
- percentages

3.3 Explain fundamental formulas and perform calculations.
- perimeter
- circumference
- area
- volume
- mass
- pressure

3.4 Explain the fundamentals of systems of measurement and perform calculations.
- difference between metric and imperial systems of measurement
- use of conversion tables and charts

3.5 Explain the fundamentals of basic geometry and perform basic “geometric shapes” calculations.
- angular measurements and calculations
- right angle triangle
- Pythagorean theorem
- 3-4-5 triangle

Number:	**S1391**		
Title:	**Applied Drawing Interpretation**		
Duration:	Total Hours: 48	Theory: 36	Practical: 12
Content	S3691.1	Applied Drawing Interpretation	
	S3191.2	Joint Design and Welding Symbols	

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3191	Applied Drawing Interpretation		
S3191.1:	Applied Drawing Interpretation		
Hours:	Total:39	Theory: 27	Practical: 12

General Learning Outcomes

Upon successful completion the apprentice is able to perform and interpret drawings, common views and basic drafting and sketching operations as applied to the welder/fabricator programs.

Learning Outcomes and Content

1.1 Define the content and organization of drawings.

- purpose of a drawing
- components of the drawing
  - lines
  - views
  - symbols
  - title block
  - bill of materials
  - notes and specifications
- types of work drawings
  - engineering drawings
  - erection drawings
  - erection diagrams
  - architectural drawings
  - assembly prints
  - sub-assembly prints
  - overview of CAD drawings
  - shop details or working drawings
  - sketches
  - common scales
  - imperial and metric measurements
  - third angle projection

    - first angle projection
- customer specifications
- work orders
- requisitions/purchase orders
- procedure sheets

1.2 Define the purpose and function of the common types of lines found on drawings.

- object lines
- hidden lines
- centre lines
- dimension and extension lines
- leader lines
- break lines
- cutting plane lines
- hatch lines
- phantom lines

1.3 Define the purpose and function of the common views and presentations found on drawings.

- orthographic projection
- six principal views
- revolved views
- selecting the appropriate “front” or most descriptive view
- isometric drawing
    - three dimensional sketching
    - oblique and perspective views
- pictorial drawing
    - “true” perspective
    - vanishing point
    - not to be scaled
- section views
    - full and partial selections
    - revolved section
    - half section

1.4 Describe the commonly available structural shapes.

- shapes available by weight and measures
- sheet
  - common sizes and gauge measurement system
- plate
  - commonly available sizes
  - thickness, width and length
- pipe
  - schedules available
  - nominal size and common lengths
  - Hollow Structural Sections (HSS)
  - round
- flat
  - bar
  - square
  - rectangular
  - round
  - square
  - hexagonal
- angle
  - common types and sizes
- channel
  - common types and sizes
  - dimensioning standards
- beams
  - common types and sizes

1.5 Perform assigned drafting and sketching operations.

- use appropriate drafting tools to complete drawing
  - compass
  - protractor
  - rule
  - divider
- complete orthographic drawing of a designated object showing various views
  - front
  - back
  - side (right or left)
  - top or bottom
  - types of lines
  - dimensioning
- complete three dimensional drawing or sketch of a designated object
  - isometric
  - oblique
  - pictorial

S3191	**Applied Drawing Interpretation**		
S3191.2	**Joint Design and Welding Symbols**		
Hours:	Total: 9	Theory: 9	Practical:0

General Learning Outcomes

Upon successful completion the apprentice is able to explain the features of joint types, positions and welding symbols as applied to the welder/fabricator programs.

Learning Outcomes and Content

2.1 Define the fundamental joint types and positions.

- five basic joints
  - butt
  - T
  - lap
  - corner
  - edge
  - geometry of joint preparation
  - terminology of joints
  - positions, plate and pipe
  - flat, (1F), (1G)
  - horizontal, (2F), (2G)
  - vertical, (3F), (3G)
  - progression up
  - progression down
  - overhead, (4F), (4G)

  o (5F), (5G), (6G)

2.2 Explain the purpose and use of different joints.

- application of each basic joint
- introduction to joint limitations
- thickness
- economy
- process
- position
- accessibility
- distortion
- complete and partial joint penetration
- bevelling/chamfering methods

2.3 Explain the components of welding symbols.

- reference line
- arrow side and other significance
- multiple reference lines
- arrows
- broken arrows
- tail
- specifications and notes
- process
- basic weld symbols
    - fillet
    - groove
    - plug/slot

2.4 Explain the design and application of welding symbols.

- groove welds
    - designation of complete and partial penetration groove welds
    - V-groove
    - bevel groove
    - J-groove
    - single and double – combination grooves
    - edge preparations
    - bevel angle
    - included angle
    - chamfer
    - dimensioning
    - root gap
    - root face
- back or backing welds
    - melt-thru
    - open grooves and use of backing
    - other/auxiliary
- surface contours and methods of finishing
- fillet welds
    - continuous
    - intermittent
    - opposite
    - staggered
    - dimensions
    - leg sizes
    - throat
    - face
    - length

- other welds
    - plug and slot
    - cladding
    - spot welds
    - auxiliary symbols
    - field weld symbols
    - weld all-around symbol
    - surface contours
    - methods of finishing

Number:	**S3192**		
Title:	**Welding Theory I**		
Duration:	Total Hours: 39	Theory: 39	Practical: 0
Content:	S3192.1 Power Sources and Equipment		
	S3192.2 Shielded Metal Arc Welding (SMAW)		
	S3192.3 Gas Metal Arc Welding (GMAW)		
	S3192.4 Flux Cored (FCAW) and Metal Cored (MCAW) Arc Welding		
	S3192.5 Thermal Cutting		

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3192	**Welding Theory I**		
S3192.1	**Power Sources and Equipment**		
Hours:	Total: 9	Theory: 9	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to describe the functions and controls of welding power sources in accordance with government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

1.1 Define the functions of welding power sources.

- constant current
- constant voltage
- inverters
- transformers
- transformer rectifiers
- generators
- engine drives
- amperage controls
- principle of inductance
- tapped control
- saturable reactor
- magnetic amplifier
- manuals/catalogues

1.2 Describe the effects of power source controls on welding processes.

- amperage (WFS)
- voltage
- voltage trim
- remote controls
- output characteristics
- current type
- polarity
- slope control
- inductance
- square wave
- high frequency
- AC balancer
- transformer rectifier
- inverter
- welding current output frequency
- inverter controls

S3192	**Welding Theory I**		
S3192.2	**Shielded Metal Arc Welding (SMAW)**		
Hours:	Total: 9	Theory: 9	Practical: 0

General Learning Outcomes
Upon successful completion the apprentice is able to describe the fundamentals of the Shielded Metal Arc Welding (SMAW) process in accordance with government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

2.1 Define the fundamentals of the Shielded Metal Arc Welding (SMAW) process.

- development of arc welding
- fusion
- arc characteristics
- arc length
- effects of amperage and voltage
- effects of polarity
- penetration
- travel speed
- optimum parameters
- effects of too fast or too slow travel speed
- control of weld contamination

2.2 Describe the equipment requirements for the Shielded Metal Arc Welding (SMAW) process.

- power sources
  - transformers
  - rectifiers
  - inverters
  - generators
  - engine driven
- power source controls
  - amperage (WFS)
  - duty cycle
  - voltage
  - current type
  - polarity
- arc force
- hot start
- electrode holders
  - alligator
  - pin hole

    - twist lock
- welding cables
    - cable size and condition
    - connector types and condition
    - relationship to required amperage
    - work lead
    - completion of welding circuit
    - work leads in good repair
    - work lead locations

2.3 Describe the construction and characteristics of Shielded Metal Arc Welding (SMAW) electrodes.

- basic construction features
    - core wire
    - flux covering
    - manufacturing methods of welding electrodes
    - electrode concentricity
    - functions of the flux coating
    - flux coating base material
    - chemical properties and alloying elements
    - shielding
- method of melting and freezing
- classification of Shielded Metal Arc Welding (SMAW) electrodes, CSA and AWS
    - low hydrogen (basic)
    - cellulose
    - rutile
    - iron powder
    - mild steel
    - low alloy
    - stainless steel
    - meaning of each letter and numerical group
    - imperial and metric versions
    - storage and handling
    - electrode conditioning
    - storage temperatures

2.4 Describe the Shielded Metal Arc Welding (SMAW) procedure variables and their effect on quality and productivity.

- primary variables (conducted prior to welding)
  - joint design, preparation and fit-up
  - consumables
  - current type and polarity
  - amperage (WFS)
  - pre-heat
  - electrode size
- secondary variables (conducted during welding)
  - travel speed
  - arc length
  - work angle
  - electrode angle
  - technique
  - whipping
  - weaving
  - stringer
  - multiple passes
  - drag

S3192	**Welding Theory**		
S3192.3	**Gas Metal Arc Welding (GMAW)**		
Hours:	Total: 9	Theory: 9	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to describe the fundamentals, construction features and consumables of the Gas Metal Arc Welding (GMAW) process in accordance with government
safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

3.1 Define the fundamentals of Gas Metal Arc Welding (GMAW) process.

- models of metal transfer
  - short-circuiting transfer
  - spray arc transfer
  - globular
  - pulsed
- power source technology
  - STT
  - RMD
  - CMT
- gas shielding
  - purpose
  - types
  - effects on weld integrity
  - Argon/Helium
  - CO_2
  - mixed gases
  - triple mix gas

3.2 Explain safety concerns applicable to the Gas Metal Arc Welding (GMAW) process.

- UV radiation protection
  - appropriate helmet and filter plate
  - Personal Protective Equipment (PPE)
- spatter and PPE
- flow meters
- fumes and gases
- oxygen depletion

3.3 Explain the function of the components of the Gas Metal Arc Welding (GMAW) process.

- fundamentals and characteristics of the Constant Voltage power source
    - self-correcting arc gap
    - application of Constant Current power sources
    - wire feeders
    - spool guns
    - push type
    - push-pull type
    - drive rolls (tension adjustment)
    - liners
    - metallic
    - non-metallic
    - gas diffusers
    - contact tips/contact tubes
        - nozzles
        - water cooled guns

3.4 Explain the selection and characteristics of consumables necessary for the Gas Metal Arc Welding (GMAW) short-circuit transfer and spray-arc transfer.

- optimal wire type and size (diameter)
- filler metal classification system
    - low alloy
    - steels
    - stainless steels
    - aluminium
    - types and sizes
    - purpose of copper plating
- shielding gasses
    - types
    - flow rate

3.5 Describe the variables for Gas Metal Arc Welding (GMAW) and their effects on quality and productivity.

- primary variables (conducted prior to welding)
  - joint design, preparation and fit-up
  - consumables
  - shielding gasses
  - current type and polarity
  - amperage (WFS)
  - wire diameter
  - voltage
  - pre-heat
- secondary variables (conducted during welding)
  - travel speed
  - nozzle to work distance
  - work angle
  - gun angle to work
  - technique
  - stringer
  - multi-passes
  - weaving
  - forehand
  - backhand
  - progression

S3192	**Welding Theory**		
S3192.4	**Flux Cored (FCAW) and Metal Cored (MCAW) Arc Welding**		
Hours:	Total: 3	Theory: 3	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to describe the fundamentals and the selection process of the consumables of the Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW) processes in accordance with government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

4.1 Define the fundamentals of the Flux Cored Arc Welding (FCAW) and the Metal Cored Arc Welding (MCAW) processes.

- metallic transfer
- construction of the tubular wire
  - wire types
  - flux types
- gas shielding
  - purpose
  - types

4.2 Explain the functions of the components of the Flux Cored Arc Welding (FCAW) and the Metal Cored Arc Welding (MCAW) processes.

- fundamentals and characteristics of the Constant Current power source
- fundamentals and characteristics of the Constant Voltage power source
- electrode wire classification
  - types and sizes
- mechanical feeders
  - drive rolls (tension adjustment)
  - liners
  - contact tips/contact tubes
  - nozzles
- gas shielding
  - gas diffusers

4.3 Describe the selection of welding parameters and consumable necessary for the Flux Cored Arc Welding (FCAW) and the Metal Cored Arc Welding (MCAW).

- (post and pre-heat) material thickness
- position of welding
- voltage
- wire type and size
- drive rolls (tension adjustment)
- contact tips
- selection of shielding gasses
- types
- flow rate
- gun angle
- direction of travel

S3192	**Welding Theory**		
S3192.5	**Thermal Cutting**		
Hours:	Total: 9	Theory: 9	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to describe the fundamentals and the selection process of the consumables of Oxy-Fuel Cutting, Plasma Arc Cutting and Air Carbon Arc Gouging processes in accordance with government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

5.1 Define safety related concepts.

- PPE
  - clothing
  - safety glasses
  - cutting goggles
  - noise protection
  - fumes protection
  - protection against falling material
  - electrical safety
  - grounding
  - bonding
  - radiation
  - high open circuit voltage
  - preparing the work site
- cylinders
  - basic construction and features
  - fusible plugs
  - rupture disk
  - flashback arrestors
  - reverse flow check valves
  - compressed air pressure
  - high pressure cylinders
- fire hazards
  - flammable distances of sparks/dross
  - fire prevention
  - fire blankets
  - fire extinguishers
  - oxygen hazards
  - heat

5.2 Describe the characteristics, applications and controls of gases.

- manifold systems
- arrestors (manufacturers' recommendations)
- fuel gases
    - acetylene
    - maximum safe pressure
    - safe withdrawal rates
    - cylinder handling
    - type of piping
    - propane
    - polypropylene
    - MAPP
    - natural gas
    - flammable ranges
    - oxygen
    - fire hazard
    - explosion hazard
- liquid bulk storage
- cylinder handling
- preparing the work site
    - fire hazards
- cutting closed containers
    - cleaning
    - water filling
    - purging
- cutting in confined spaces

5.3 Explain the operation and handling of oxy-fuel and plasma arc cutting equipment.

- power supplies
    - amperage (WFS)
    - voltage
- secure cylinders
- gauges
- hoses
    - sizes
    - colour
    - length
- torches
    - manual and machine
    - heating equipment
    - fittings
    - tips
    - installing
    - types
    - size selection

    - cleaning
    - gas pressures
    - maintenance
- electrode selection
    - diameter
    - shapes
- fittings
- tips
- pressures
- speed of travel
- types of cuts
- material types
- material thickness
- piercing
- quality control

5.4 Set up, light and shut down equipment.

- safe set up
- correct lightning procedure
- correct shut down procedure

5.5 Perform manual oxy-fuel gas and plasma arc cutting.

- set-up parameters
    - square cuts
    - bevel cuts
    - piercing
    - straight cutting
    - shape cutting
    - depth of cut
    - material types
    - gas pressures
    - speed of travel
    - quality control
    - tip to metal distance
    - shut down

5.6 Correct common cutting faults.

- cut edge quality
- kerf lines
- cutting direction based on square side of cut
- dross adherence (slag)

Number:	**S3193**		
Title:	**Material and Process Quality I**		
Duration:	Total Hours: 27	Theory: 27	Practical: 0
Content:	S3193.1 Distortion		
	S3193.2 Welds Quality		

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3193	**Material and Process Quality I**		
S3193.1	**Distortion**		
Hours:	Total: 12	Theory: 12	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to describe the fundamental causes, effects and correction procedures of distortion in accordance with the effects of heat and stress of metals in accordance with government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

1.1 Define the fundamental causes of distortion.

- types of shrinkages
  - transverse
  - longitudinal
  - volumetric
  - shape change
  - stress/strain
  - unbalanced shrinkage stress

1.2 Describe the factors affecting distortion.

- types of metal
- physical properties affecting distortion
- thermal conduction
- thermal expansion
- carbon vs. austenitic stainless steel
- aluminums
- type of joints
  - T joints
  - single
  - double

    - prepared T
    - lap joints
    - single sided groove joints
    - double sided groove joints
- joint volumes
    - effect of bevel angle
    - effect of included angle
    - J-grooves
    - U-grooves
    - material thickness
- welding process
    - Shielded Metal Arc Welding (SMAW)
    - Gas Metal Arc Welding (GMAW)
    - Flux Cored Arc Welding (FCAW)
    - Submerged Arc Welding (SAW)
    - heat input
    - deposit rate
    - manual vs. automatic processes
    - travel speed

1.3 Explain the methods used to prevent distortion.

- welding sequence
- back step
- weld progression
- vertical up
- vertical down
- continuous
- intermittent welding
- pre-setting joint
- preheating
- jigs and fixturing
- weld size
- effects of over welding
    - multiple passes
    - single pass
    - effects of bead size
    - selection of preventative method
    - distortion allowances

1.4 Describe actions used to correct distortion.

- measuring distortion
- heat wedges
- heat spots
- back welding
- stress relief
- mechanical straightening
- stress/strain
- restraint
- work hardening

S3193	**Material and Process Quality I**		
S3193.2	**Weld Quality**		
Hours:	Total: 15	Theory: 15	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to describe the features of weld quality, welding discontinuity and welding procedures in accordance with government safety regulations,
manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

2.1 Define welding discontinuities and their effect on weld quality.

- types of welding discontinuities
  - weld quality
  - intended function of a weld
  - acceptance of criteria of a weld
  - applicable specification
  - acceptable discontinuities
  - unacceptable discontinuities
  - applicable specification

2.2 Explain the types and causes of dimensional and/or geometric discontinuities.

- fillet weld leg
  - throat dimension measurement
- causes of and significance of insufficient leg length or throat dimension
  - incorrect weld shape
  - convexity
  - concavity
  - excess reinforcement

2.3 Identify the types and causes of structural soundness discontinuities.

- cracks
  - inclusions
  - porosity
  - lack of fusion
  - incomplete fusion
  - undercut
  - overlap

2.4 Explain how weld quality is assured through documented welding procedures.

- specification of welding variables within permissible tolerances
  - specification of material type
  - preparation and joint fit-up
  - pre-heat, interpass and post-heat temperature requirements
  - electrical characteristics
  - consumables
  - filler metals
  - fluxes
  - shielding gasses
  - welding position
  - welding technique

2.5 Describe the need for other functions to assure weld quality.

- qualification of welding personnel
  - welding procedure qualification requirements
  - in-process weld monitoring
  - techniques to avoid arc blow
  - post-weld inspection
  - non-destructive testing requirements

2.6 Define procedures for correction of defective weld quality.

- defect excavation procedures
- inspection of cavity prior to weld repair
- weld repair procedures

Number:	**S3194**		
Title:	**Shielded Metal Arc Welding (SMAW) Practical I**		
Duration:	Total Hours: 69	Theory: 0	Practical: 69
Content:	S3194.1 Fillet Welds with Shielded Metal Arc Welding (SMAW) on Mild Steel		
	S3194.2 Groove Welds with Shielded Metal Arc Welding (SMAW) on Mild Steel		

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3194	**Shielded Metal Arc Welding (SMAW) Practical I**		
S3194.1	**Fillet Welds with Shielded Metal Arc Welding (SMAW) on Mild Steel**		
Hours:	Total: 36	Theory: 0	Practical: 36

General Learning Outcomes

Upon successful completion the apprentice is able to perform fillet welding with the Shielded Metal Arc Welding (SMAW) process in accordance with government safety regulations, manufacturer's recommendations and approved industry standards with a focus of meeting or exceeding the testing requirements of C.S.A. W47–4F position regarding weld quality.

Learning Outcomes and Content

1.1 Review the equipment set-up and the process of the Shielded Metal Arc Welding (SMAW) process.

- power source
- equipment
- consumables
- safety
- PPE
- material
- technique
- type of welds

1.2 Set-up and maintain equipment for Shielded Metal Arc Welding (SMAW) applications.

- electrode selection
  - type
  - size
- power sources
  - transformers

- rectifiers
- inverters
- generators
- engine driven
- motor driven

- power source controls
  - amperage (WFS)
  - voltage
  - current type
  - polarity
- electrode holders
  - jaw types
- welding cables
  - size and condition
  - relationship to required amperage
  - work lead
  - completion of welding circuit
  - clamps in good repair
  - work lead locations
  - safety concerns

1.3 Fillet weld on mild steel using the Shielded Metal Arc Welding (SMAW) process.

- striking the arc
- running beads
- stops and restarts
- filling crater
- fillet welds
  - T joint
  - lap joint
- material
  - plate
  - structural shapes
  - structural shapes to plate
- positions
  - 1F
  - 2F
- electrodes
  - cellulose
  - rutile
  - basic

1.4 Perform post-weld operations.

- methods of cleaning and finishing of completed weld to specifications
  - removing all slag
  - removing all spatter
  - wire brushing
  - filing
  - grinding
  - hand and power tools
  - measuring welds to meet specifications
- visual examination of weld for discontinuities
  - porosity
  - cracks
  - slag inclusion
  - undercut
  - overlap

S3194	**Shielded Metal Arc Welding (SMAW) Practical I**		
S3194.2	**Groove Welds with Shielded Metal Arc Welding (SMAW) on Mild Steel**		
Hours:	Total: 33	Theory: 0	Practical: 33

General Learning Outcomes

Upon successful completion the apprentice is able to perform groove welding procedures with the Shielded Metal Arc Welding (SMAW) process in accordance with government safety regulations, manufacturer's recommendations and approved industry standards with a focus of meeting or exceeding the testing requirements of C.S.A. W47–3GF position regarding weld quality.

Learning Outcomes and Content

2.1 Prepare base metal for groove welding.

- type of groove joint
- welding symbol
- type of metal
- backing requirement
- method of joint preparation
- surface finish
- joint opening
- placement of tacks
- pre-heat requirement

2.2 Perform groove welding of mild steel using the Shielded Metal Arc Welding (SMAW) process.

- single bevel
  - backing bar
- single V-groove
  - backing bar
  - flat position (1G)
  - structural shapes
- GF combination test plates
  - 1GF
  - 2GF
  - 3GF
- electrodes
  - cellulose
  - rutile
  - basic

2.3 Perform post-weld operations.

- methods of cleaning completed weld to specifications
  - removing all slag
  - removing all spatter
  - wire brushing
  - filing
  - grinding
  - hand and power tools
  - measuring welds to meet specifications
- visual examination of weld for discontinuities
  - porosity
  - cracks
  - slag inclusion
  - undercut
  - overlap
  - incomplete penetration
- inspect of welds
  - non-destructive test methods
  - destructive test methods

Number:	**S3195**		
Title:	**Gas Shielded Semi-Automatic Welding Practical I**		
Duration:	Total Hours: 54	Theory: 0	Practical: 54
Content:	S3195.1 Fillet Welds with Gas Metal Arc Welding (GMAW)		
	S3195.2 Groove Welds with Gas Metal Arc Welding (GMAW)		
	S3195.3 Fillet Welds with Flux Cored Arc Welding (FCAW)		
	S3195.4 Groove Welds with Flux Cored Arc Welding (GCAW)		

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3195	**Gas Shielded Semi-Automatic Welding Practical I**		
S3195.1	**Fillet Welds with Gas Metal Arc Welding (GMAW)**		
Hours:	Total: 21	Theory: 0	Practical: 21

General Learning Outcomes

Upon successful completion the apprentice is able to perform fillet welding with the Gas Metal Arc Welding (GMAW) process in accordance with government safety regulations, manufacturer's recommendations and approved industry standards with a focus of meeting or exceeding the testing requirements of C.S.A. W47–2F position regarding weld quality.

Learning Outcomes and Content

1.1 Review equipment set-up and the process of the Gas Metal Arc Welding (GMAW).

- power source
- wire feeder
- shielding gasses
- consumables
- safety
- PPE
- material
- technique
- type of welds

1.2 Set-up and maintain equipment for a variety of Gas Metal Arc Welding (GMAW) applications.

- consumables for the application
  - wire type
  - size
  - gas type

- welding parameters
    - voltage
    - amperage (WFS)
    - gas flow rate
- demonstrate mode of metal transfer
    - short circuit
    - globular
    - spray transfer
- maintenance of equipment
    - work lead connection
    - mechanical feeders
    - drive rolls (tension adjustment)
    - spool axle tension
    - contact tip
    - gun nozzle
    - gun liner
    - wear
    - restriction
    - loops
    - circulator
    - changing shielding gas cylinders
    - gas leaks

1.3 Perform fillet welding on mild steel using the Gas Metal Arc Welding (GMAW) process.

- pre-cleaning and preparation
- modes of metal transfer
    - short circuit
    - spray
    - globular
- fillet welds
    - lap joint
    - T joint
    - corner joint
    - flat position (1F)
    - horizontal position (2F)
    - plate and sheet
    - structural shapes
    - structural shapes to plate
- consumables
    - wire
    - shielding gasses

1.4 Perform post weld operations.

- clean and finish welds to specifications
- visually inspect and evaluate finished welds

S3195	**Gas Shielded Semi-Automatic Welding Practical I**		
S3195.2	**Groove Welds with Gas Metal Arc Welding (GMAW)**		
Hours:	Total: 15	Theory: 0	Practical: 15

General Learning Outcomes

Upon successful completion the apprentice is able to perform groove welding with the Gas Metal Arc Welding (GMAW) process in accordance with government safety regulations, manufacturer's recommendations and approved industry standards with a focus of meeting or exceeding the testing requirements of C.S.A. W47–2G position regarding weld quality.

Learning Outcomes and Content

2.1 Prepare base metal for groove welding.

- type of groove joint
- welding symbol
- type of metal
- backing requirements
- method of joint preparation
- surface finish
- joint opening
- placement of tacks
- pre-heat requirement

2.2 Perform groove welding on mild steel using the Gas Metal Arc Welding (GMAW) process.

- pre-cleaning and preparation
- modes of metal transfer
  - short circuit
  - spray
  - globular
- single bevel
  - backing
- double bevel
  - single V groove
  - flat position (1G)
  - horizontal position (2G)
  - plate
  - structural shapes
- consumables
  - wire
  - shielding gasses

2.3 Perform post weld operations.

- clean and finish weld to specifications
- visually inspect and evaluate finished welds

S3195	**Gas Shielded Semi-Automatic Welding Practical I**		
S3195.3	**Fillet Welds with Flux Cored Arc Welding (FCAW)**		
Hours:	Total: 9	Theory: 0	Practical: 9

General Learning Outcomes

Upon successful completion the apprentice is able to perform fillet welding with the Flux Cored Arc Welding (FCAW) process in accordance with government safety regulations, manufacturer's recommendations and approved industry standards with a focus of meeting or exceeding the testing requirements of C.S.A. W47–2F position regarding weld quality.

Learning Outcomes and Content

3.1 Review equipment and the process of the Flux Cored Arc Welding (FCAW).

- power source
- wire feeder
- shielding gasses
- consumables
- safety
- PPE
- material
- technique
- type of welds

3.2 Set-up equipment for a variety of Flux Cored Arc Welding (FCAW) applications.

- consumables for the application
  - wire type
  - gas shielded
  - self-shielded
  - size
  - gas type
- welding parameters
  - voltage
  - amperage (WFS)
  - gas flow rate
- demonstrate mode of metal transfer
  - short circuit
  - globular
  - spray transfer
- maintenance of equipment
  - work lead connection
  - wire feeders
  - drive rolls (tension adjustment)

- spool axle tension
- contact tip
- gun nozzle
- gun liner
- wear
- restriction
- loops
- water cooled guns
- circulator
- changing shielding gas cylinders
- gas leaks

3.3 Perform fillet welding on mild steel using the Flux Cored Arc Welding (FCAW) process.

- fillet welds
  - lap joint
  - T joint
  - corner joint
  - flat position (1F)
  - horizontal position (2F)
  - plate
  - structural shapes
  - structural shapes to plate
- consumables
  - wire
  - shielding gasses

3.4 Perform post weld operations.

- clean and finish welds to specifications
- visually inspect and evaluate finished welds

S3195	**Gas Shielded Semi-Automatic Welding Practical I**		
S3195.4	**Groove Welds with Flux Cored Arc Welding (FCAW)**		
Hours:	Total: 9	Theory: 0	Practical: 9

General Learning Outcomes

Upon successful completion the apprentice is able to perform groove welding with the Flux Cored Arc Welding (FCAW) process in accordance with government safety regulations, manufacturer's recommendations and approved industry standards with a focus of meeting or exceeding the testing requirements of C.S.A. W47–2G position regarding weld quality.

Learning Outcomes and Content

4.1 Prepare base metal for groove welding.

- type of groove joint
- welding symbol
- type of metal
- backing requirements
- method of joint preparation
- surface finish
- joint opening
- placement of tacks
- pre-heat requirement

4.2 Perform groove welding on mild steel using the Flux Cored Arc Welding (FCAW) process.

- single bevel
  - backing bar
- double bevel
  - single V groove
  - backing bar
  - flat position (1G)
  - plate
- consumables
  - wire
  - shielding gasses

4.3 Perform post weld operations.

- clean and finish weld to specifications
- visually inspect and evaluate finished welds

Number:	**S3196**		
Title:	**Thermal Cutting**		
Duration:	Total Hours: 18	Theory: 0	Practical: 18
Content:	S3196.1 Oxy-Fuel Gas Cutting		
	S3196.2 Plasma Arc Cutting		
	S3196.3 Air Carbon Arc Gouging		

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3196	**Thermal Cutting**		
S3196.1	**Oxy-Fuel Gas Cutting**		
Hours:	Total: 6	Theory: 0	Practical: 6

General Learning Outcomes
Upon successful completion the apprentice is able to perform safe set-up and shut down operation and correction of common cutting faults for the Oxy-Fuel Cutting equipment applications in accordance with government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

1.1 Set-up, light and shut down equipment.

- single and double stage regulators (different kind of gauges are utilized by industry)
- safe set-up
- correct lighting procedure
- correct shut down procedure

1.2 Perform manual Oxy-Fuel gas cutting.

- square cuts
- bevel cuts
- piercing
- straight cutting
- shape cutting
- gas pressures
- speed of travel
- tip to metal distance

1.3 Correct common cut faults.

- cut edge quality
- kerf lines
- dross adherence (slag)

S3196	**Thermal Cutting**		
S3196.2	**Plasma Arc Cutting**		
Hours:	Total: 6	Theory: 0	Practical: 6

General Learning Outcomes

Upon successful completion the apprentice is able to perform safe set-up and shut down operation and correction of common cutting faults for the Plasma Arc Cutting equipment applications in accordance with government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

2.1 Cut manually using Plasma Arc equipment.

- Set-up parameters
  - square cuts
  - bevel cuts
  - piercing
  - straight cutting
  - shape cutting
  - shut down

2.2 Correct common cutting faults.

- cut edge quality
- kerf lines
- cutting direction based on square side of cut
- dross adherence (slag)

S3196	**Thermal Cutting**		
S3196.3	**Air Carbon Arc Gouging**		
Hours:	Total: 6	Theory: 0	Practical: 6

General Learning Outcomes

Upon successful completion the apprentice is able to perform safe set-up and shut down operation and correction of common cutting faults for the Air Carbon Arc Gouging equipment applications in accordance with government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

3.1 Gouging manually using Air Carbon Arc equipment.

- defect excavation
  - weld removal
  - back gouging to sound metal
  - weld joint preparation

3.2 Correct common cutting faults.

- cut edge quality
- post cleaning

Level 2

Reportable Subject Summary-Level 2

Hours				
#	Reportable Subject	Theory	Practical	Total
S3197: Drawing Interpretation/Fitting				
S3197.1	Drawing Interpretation I	24	0	24
S3197.2	Fitting I	3	12	15
Sub Totals		**27**	**12**	**39**
S3198: Welding Theory II				
S3198.1	Brazing	3	0	3
S3198.2	Metallurgy	9	0	9
S3198.3	Inspection and Testing	6	0	6
S3198.4	Gas Tungsten Arc Welding (GTAW)	3	0	3
Sub Totals		**21**	**0**	**21**
S3199: Shielded Metal Arc Welding (SMAW) Practical II				
S3199.1	Fillet Weld in all positions with Shielded Metal Arc Welding (SMAW)	0	15	15
S3199.2	Groove Weld in all positions with Shielded Metal Arc Welding (SMAW)	0	21	21
S3199.3	Perform Shielded Metal Arc Welding (SMAW) Welds for Destructive Testing	0	15	15
Sub Totals		**0**	**51**	**51**
S3200: Semi-Automatic Welding Practical II				
S3200.1	Fillet Welds with Gas Metal Arc Welding (GMAW) Practical II	0	9	9
S3200.2	Groove Welds with Gas Metal Arc Welding (GMAW) Practical II	0	18	18
S3200.3	Fillet Welds with Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW) Practical II	0	6	6
S3200.4	Groove Welds with Flux Cored Arc Welding and Metal Cored Arc Welding (MCAW) (FCAW) Practical II	0	6	6
Sub Totals		**0**	**39**	**39**
S3201: Gas Tungsten Arc Welding (GTAW) Practical I				
S3201.1	Gas Tungsten Arc Welding (GTAW) Practical I	0	30	30
Sub Totals		**0**	**30**	**30**
Level 2 Totals		**48**	**132**	**180**

Number:	**S3197**		
Title:	**Drawing Interpretation/Fitting**		
Duration:	Total Hours: 39	Theory: 27	Practical: 12
Content:	S3197.1 Drawing Interpretation I		
	S3197.2 Fitting I		

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3197	**Drawing Interpretation/Fitting**		
S3197.1	**Drawing Interpretation I**		
Hours:	Total: 24	Theory: 24	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of drawing interpretation and estimating.

Learning Outcomes and Content

1.1 Describe the various methods of presenting information on drawings.

- notes and specifications
  - title block
  - specification attachments
- tolerances
  - unilateral
  - bilateral
  - limit dimensioning
- holes
  - dimensioning
  - countersink
  - counter bore
- threads
  - internal and external
  - classifications
  - metric and imperial
  - threads per inch
  - diameter and pitch
- welding symbols
- dimensioning
- location of welds
  - plug and slot

- surfacing
- spot and projection welds
- stud welds

- welding procedures and specifications, notes
  - testing methods

1.2 Explain methods of estimating material requirements for weldments and fabrications.

- material take-off
- bill of materials
- process allocation
  - cutting list
  - efficient and economic use of materials
- estimation
  - calculate weight (mass)
  - take-off list
  - standard tables
  - cost of materials
    - standard weight tables
    - current prices

1.3 Perform assigned classroom projects-drawings.

- sketching
  - views
  - scales
  - drawing techniques
    - protractor
    - compass
  - dimensioning
  - symbols
  - notes and specifications
    - material take-off
  - bill of material
  - cutting list
  - estimation
    - weight
    - cost

S3197	**Drawing Interpretation/Fitting**		
S3197.2	**Fitting I**		
Hours:	Total: 15	Theory: 3	Practical: 12

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of layout and fitting techniques.

Learning Outcomes and Content

2.1 Explain various layout techniques.

- layout tools
- imperial and metric
- rulers
- scalers
- micrometers
- Verniers
- squares
- levels
- compass
- protractor
- marking lines
  - soap stone line
  - chalk line
  - paint stick
  - centre punch line
  - scribing
- layout math skills
  - fractions
  - addition
  - subtraction
  - angle measurement
  - joints
- butt
- lap
- corners
- miter
- cope
- structural shapes intersections
- angles
- channels
- beams
- HSS

2.2 Perform assigned shop projects – layout and fitting.

- layout project (s)
  - preparing material
- plate
- structural shapes
- HSS
- layout and mark cut lines
  - shapes
  - corners
  - 90 degree miter
  - cope corner
- manual flame cutting
  - dimensioning material
  - edge preparation
- semi-automatic flame cutting
  - dimensioning material
  - edge preparation
- saws
  - hacksaw
  - cut-off abrasive wheel saw
  - band saws
- hand grinders
  - edge and surface preparation
  - fitting and assembly parts
- corners
  - miter
  - lapped
  - coped
- dimensional accuracy
- squareness
  - diagonal measurement
  - 3-4-5 triangle
- tack weld assembly with prescribed process

Number:	**S3198**		
Title:	**Welding Theory II**		
Duration:	Total Hours: 21	Theory: 21	Practical: 0
Content:	S3198.1 Brazing		
	S3198.2 Metallurgy		
	S3198.3 Inspection and Testing		
	S3198.4 Gas Tungsten Arc Welding (GTAW)		

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3198	**Welding Theory II**		
S3198.1	**Brazing**		
Hours:	Total: 3	Theory: 3	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of brazing of deoxidized copper with the oxy-fuel equipment.

Learning Outcomes and Content

1.1 Describe general safety related concepts.

- Personal Protection Equipment (PPE)
- fumes
- flashback/reverse flow
- fuel gases
- cylinders
    - basic construction and features
        - fusible plugs
        - rupture disk
- regulators
- brazing in confined spaces

1.2 Explain the operation and handling of equipment and consumables.

- secure cylinders
- regulators and gauges
- hoses
- torches
- fittings
- flashback arrestors
- tips

    - installing
    - types
    - size selection
    - cleaning
- pressures
- speed of travel
- types of joints
- joint cleaning and preparation
- post-cleaning
- filler metals
    - brass
    - bronze
    - silver
    - alloys
    - copper phosphorus
- adhesion joining
- application techniques
- material types
- fluxes
    - coated rod
    - powder
    - liquid
- material thickness
- quality control
    - qualification tests

1.3 Explain set-up and shut-down of oxy-fuel equipment.

- set-up
- shut-down

1.4 Perform Brazing on deoxidized copper.

- oxy-fuel gas equipment parameters
- tip size
- adjustment of flame
- fuel gas pressure
- filler metal selection
    - size and type
- material preparation
- material fit-up to parameters
    - lap length
    - joint clearance
- braze laps and tee joints

S3198	**Welding Theory II**		
S3198.2	**Metallurgy**		
Hours:	Total: 9	Theory: 9	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to describe the characteristics of metals and their alloys, classifications and effects of welding heat in accordance with metallurgy principles in accordance with government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

2.1 Define metals and their properties.

- metals
- properties of metals affecting weldability
  - alloys
  - mechanical properties
  - tensile strength
  - impact strength
  - hardness
  - ductility
  - chemical properties
  - corrosion resistance

2.2 Describe the processes used to produce metals and alloys.

- blast furnace
- pig-iron
- cast-iron
- steel
  - continuous casting
- steel refining furnaces
  - basic oxygen furnace
  - electric arc furnace
  - stainless steel
- material forming methods
  - wrought
  - cast-metals
- structural shapes
  - HSS
  - plate
  - hot rolled
  - cold rolled

2.3 Identify steel types and classification systems.

- characteristics of
  - low carbon steel
  - medium carbon steel
  - high carbon steel
  - stainless steel
- classification numbering systems
- steel and metal identification methods
  - appearance
  - hardness test
  - magnetic test
  - chisel test
  - fracture test
  - flame test
  - spark test
  - weight test

2.4 Explain the purpose and effects of heat-treatments on steel.

- annealing
- normalizing
- quenching
- hardening
- tempering
- stress relieving

2.5 Describe the properties of metals and their effect on material selection, fabrication and welding considerations.

- physical properties
  - mass
  - melting point
  - thermal conductivity
  - coefficient of expansion
  - electrical conductivity
- mechanical properties
  - tensile strength
  - yield strength
  - ductility
  - impact strength

S3198	**Welding Theory II**		
S3198.3	**Inspection and Testing**		
Hours:	Total: 6	Theory: 6	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to explain the function and application of destructive and non-destructive testing methods for welds in accordance with government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

3.1 Explain the function and application of mechanical tests methods.

- tensile testing
- reduced section transverse test
- longitudinal tensile test
- all weld metal tensile test
- yield strength
- elongation
- reduction of area
- impact testing
- charpy
- izod
- bend testing
- face
- root
- side

3.2 Explain the function and application of non-destructive examination methods.

- visual inspection method
- gauges
- pre-weld preparation
- completed weld specifications
- penetrant testing
  - fluorescent
  - visible dye
  - leak-through techniques
- magnetic particle testing
  - prod method
  - yoke method

- radiography
    - x-ray method
    - gamma ray method
- interpretation of weld radiographs
- ultrasonic testing
    - instrumentation calibration
    - scanning techniques and defect location

S3198	**Welding Theory II**		
S3198.4	**Gas Tungsten and Arc Welding (GTAW)**		
Hours:	Total: 3	Theory: 3	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of weldability issues, accessories and shielding gas requirements for the Gas Tungsten Arc Welding (GTAW) process.

Learning Outcomes and Content

4.1 Describe the functions of Gas Tungsten Arc Welding (GTAW) power sources and their controls.

- power sources
  - inverter technology
  - types of currents
  - polarity settings
- controls
  - high frequency
  - square wave controls
  - AC amperage frequency control
  - AC balancer
  - pulse controls
  - up and down slope

4.2 Explain weldability issue with the Gas Tungsten Arc Welding (GTAW) process.

- oxide removal
- heat dissipation
- copper based alloys
  - brasses
  - bronzes
- aluminium
  - aluminium alloys
- magnesium
- titanium and zirconium
- dry box and trailing gas

Number:	**S3199**		
Title:	**Shielded Metal Arc Welding (SMAW) Practical II**		
Duration:	Total Hours: 51	Theory: 0	Practical: 51
Content:	S3199.1	Fillet Weld in all positions with Shielded Metal Arc Welding (SMAW)	
	S3199.2	Groove Weld in all positions with Shielded Metal Arc Welding (SMAW)	
	S31989.3	Perform Shielded Metal Arc Welding (SMAW) Welds For Destructive Testing	

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3199	**Shielded Metal Arc Welding (SMAW) Practical I**		
S3199.1	**Fillet Weld in all positions with Shielded Metal Arc Welding**		
Hours:	Total: 15	Theory: 0	Practical: 15

General Learning Outcomes

Upon successful completion the apprentice is able to review a working knowledge of fillet welding in all positions with the Shielded Metal Arc Welding (SMAW) process.

Learning Outcomes and Content

1.1 Describe the equipment set-up and the process of the Shielded Metal Arc Welding (SMAW).

- power source
- equipment
- consumables
- safety
- PPE
- material
- technique
- type of welds

1.2 Set-up equipment for the Shielded Metal Arc Welding (SMAW) applications.

- power sources
  - transformers
  - rectifiers
  - inverters
  - engine driven
- power source controls
  - amperage (WFS)

    - duty cycle
    - voltage
    - current type
    - polarity
- electrode holders
    - clamp
    - jaw types
- welding cables
    - cable size and condition
    - relationship to required amperage
    - work lead
    - completion of welding circuit
    - clamps in good repair
    - work lead locations

1.3 Fillet weld on mild steel in all positions.

- welding parameters
- filler metals
    - cellulose
    - rutile
    - basic
- fillet welds
- welding positions
    - flat (1F)
    - horizontal (2F)
    - vertical (3F)
    - overhead (4F)
- joints
    - lap
    - T
    - corner
- material
    - plate and sheet
    - structural shapes
    - HSS
    - fillet welds on studs

S3199	**Shielded Metal Arc Welding (SMAW) Practical II**		
S3199.2	**Grove Weld in all positions with Shielded Metal Arc Welding**		
Hours:	Total: 21	Theory: 0	Practical: 21

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of grove welding in all positions with the Shielded Metal Arc Welding (SMAW) process.

Learning Outcomes and Content

2.1 Review equipment set-up and the process of Shielded Metal Arc Welding (SMAW).

- power source
- equipment
- consumables
- safety
- PPE
- material
- technique
- type of welds

2.2 Groove weld on mild steel in all positions.

- power sources
- auxiliary equipment
- welding parameters
- filler metals
  - cellulose
  - rutile
  - basic
- welding positions
  - flat (1G)
  - horizontal (2G)
  - vertical (3G)
  - overhead (4G)
- joints
  - groove with backing
  - V-groove
- material
  - plate

S3199	**Shielded Metal Arc Welding (SMAW) Practical II**		
S3199.3	**Perform Shielded Metal Arc Welding Welds for Destructive Test**		
Hours:	Total: 15	Theory: 0	Practical: 15

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of preparing and performing destructive testing.

Learning Outcomes and Content

3.1 Perform Welds for Destructive Testing.

- groove weld tests in positions to identified procedures
- joints
  - bevel groove
  - backing
  - V-groove
- consumables
  - cellulose
  - basic
- position
  - 1G, 1GF, flat
  - 2G, 2GF, horizontal
  - 3G, 3GF, vertical
  - 4G, 4GF, overhead
- identify coupons for bend position

3.2 Perform preparatory operations for destructive testing.

- remove backing
- grind surface
- layout coupons
- cut coupons
- grind coupons

3.3 Perform destructive testing.

- root bends
- face bends
- side bends

Number:	**S3200**		
Title:	**Semi-Automatic Welding Practical II**		
Duration:	Total Hours: 39	Theory: 0	Practical: 39
Content:	S3200.1	Fillet Welds with Gas Metal Arc Welding (GMAW) Practical II	
	S3200.2	Groove Welds with Gas Metal Arc Welding (GMAW) Practical II	
	S3200.3	Fillet Welds with Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW) Practical II	
	S3200.4	Groove Welds with Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW) Practical II	

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3200	**Semi-Automatic Welding Practical II**		
S3200.1	**Fillet Welds with Gas Metal Arc Welding (GMAW) Practical II**		
Hours:	Total: 9	Theory: 0	Practical: 9

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of fillet welding with the Gas Metal Arc Welding (GMAW) process (II).

Learning Outcomes and Content

1.1 Describe equipment set-up and the process of Gas Metal Arc Welding (GMAW).

- power source
- wire feeder
- shielding gasses
- consumables
- safety
- PPE
- material
- technique
- type of welds

1.2 Fillet weld with the Gas Metal Arc Welding (GMAW) process.

- positions
  - vertical (3F)

- material
    - mild steel
- demonstrate various modes of metal transfer
- joints
    - lap
    - T
- corner
- consumables
- type
- size
- shielding gasses
- flow rate
- stainless steel
    - flat (1F)
    - horizontal (2F)
- aluminium
    - flat (1F)
    - horizontal (2F)

S3200	**Semi-Automatic Welding Practical II**		
S3200.2	**Groove Welds with Gas Metal Arc Welding (GMAW) Practical II**		
Hours:	Total: 18	Theory: 0	Practical: 18

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of groove welding with the Gas Metal Arc Welding (GMAW) process (II).

Learning Outcomes and Content

2.1 Review equipment set-up and the process of Gas Metal Arc Welding (GMAW).

- power source
- wire feeder
- shielding gasses
- consumables
- safety
- PPE
- material
- technique
- type of welds

2.2 Groove welds with the Gas Metal Arc Welding (GMAW) process.

- positions
  - 1GF -NPA
- material
  - mild steel
- demonstrate various modes of metal transfer
- joints
  - square butt groove
  - single bevel groove
  - single V-groove
  - open root
- consumables
- type
- size
- shielding gasses
- flow rate

2.3 Perform welds for destructive testing.

- positions
  - flat (1G)
  - horizontal (2G)
  - vertical (3G)

2.4 Perform operations for destructive testing.

- remove backing
- grind surfaces
- layout coupons
- cut coupons
- grind coupons
- identify coupons for bend position

2.5 Perform destructive testing.

- root bends
- face bends
- side bends

S3200	**Semi-Automatic Welding Practical II**		
S3200.3	**Fillet Welds with Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW) Practical II**		
Hours:	Total: 6	Theory: 0	Practical: 6

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of fillet welding with the Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW) processes (II).

Learning Outcomes and Content

3.1 Review equipment set-up and the process of Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW).

- power source
- wire feeder
- shielding gasses
- consumables
- safety
- PPE
- material
- technique
- type of welds

3.2 Fillet weld with the Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW) process.

- material
  - mild steel
- positions
  - 1F
  - 2F
  - vertical (3F)
- joints
  - lap
  - T
  - corner
- consumables
- gas shielded
- self-shielded
- type
- size
- shielding gasses

S3200	**Semi-Automatic Welding Practical II**		
S3200.4	**Groove Welds with Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW) Practical II**		
Hours:	Total: 6	Theory: 0	Practical: 6

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of groove welding with the Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW) processes (II).

Learning Outcomes and Content

4.1 Describe equipment set-up and the process of Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW).

- power source
- wire feeder
- shielding gasses
- consumables
- safety
- PPE
- material
- technique
- type of welds

4.2 Groove weld with the Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW) process.

- material
  - mild steel
- positions
  - 1GF
  - 2GF
  - vertical (3GF)
- joints
  - single bevel groove/backing
  - single V-groove/backing
- consumables
- gas shielded
- self-shielded
- type
- size
- shielding gasses
- type

4.3 Perform welds for destructive testing.

- positions
  - horizontal (2GF)
  - vertical (3GF)

4.4 Perform operations for destructive testing.

- remove backing
- grind surfaces
- layout coupons
- cut coupons
- grind coupons

4.5 Perform destructive testing.

- root bends
- face bends
- side bends

Number:	**S3201**		
Title:	**Gas Tungsten Arc Welding (GTAW) Practical I**		
Duration:	Total Hours: 30	Theory: 0	Practical: 30
Content:	S3201.1 Gas Tungsten Arc Welding (GTAW) Practical I		

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3201	**Gas Tungsten Arc Welding (GTAW) Practical I**		
S3201.1	**Gas Tungsten Arc Welding (GTAW) Practical I**		
Hours:	Total: 30	Theory: 0	Practical: 30

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of welding with the Gas Tungsten Arc Welding (GTAW) process.

Learning Outcomes and Content

1.1 Review equipment set-up and the process for Gas Tungsten Arc Welding (GTAW).

- power source
- equipment
- tungsten electrodes
- consumables (with or without)
- shielding gasses
- PPE
- material
- technique
- type of welds

1.2 Set-up equipment for a variety of Gas Tungsten Arc Welding (GTAW) applications.

- material preparation and fit-up
  - pre-weld cleaning methods
  - position of welding
- equipment set-up
  - current type and polarity
  - amperage
  - arc initiation method

- torch set-up
    - collet and body
    - nozzle type and size
    - tungsten electrode type and size
- shielding gasses
    - type
    - flow rate Cfh or Lpm
    - purging
- filler material
    - type (alloy)
    - size

1.3 Perform welds using the Gas Tungsten Arc Welding (GTAW) process.

- materials
    - mild steel
    - stainless steel
- fillet welds
    - T joints in 1F and 2F positions
    - lap joint in 1F and 2F positions
    - open corner joint in 1F and 2F positions
- groove welds
    - square butt in 1G and 2G positions
    - single V in 1G and 2G positions
- perform post-weld operations
    - prepare completed welds to specifications
    - visually inspect finished welds

Level 3

Level 3 Reportable Subject Summary

Hours				
#	Reportable Subjects	Theory	Practical	Total
S3202: Fitting				
S3202.1	Layout and Pattern Development	39	0	39
S3202.2	Fabrication Equipment	9	0	9
S3202.3	Practical Fitting Projects	0	39	39
Sub Totals		**48**	**39**	**87**
S3203: Quality				
S3203.1	Metallurgy II	15	0	15
S3203.2	Distortion II	6	3	9
S3203.3	Inspection and Codes	12	0	12
Sub Totals		**33**	**3**	**36**
S3204: Gas Tungsten Arc Welding (GTAW) Practical II and Plasma Arc Welding (PAW)				
S3204.1	Gas Tungsten Arc Welding (GTAW) Theory II	9	0	9
S3204.2	Fillet and Groove Welds with the Gas Tungsten Arc Welding (GTAW) Process	0	9	9
S3204.3	Pipe Welding with the Gas Tungsten Arc Welding (GTAW) Process	0	9	9
S3204.4	Fillet and Groove Welds on Aluminium with the Gas Tungsten Arc Welding (GTAW) Process	0	12	12
S3204.5	Plasma Arc Welding	3	0	3
Sub Totals		**12**	**30**	**42**
S3205: Automatic and Semi-Automatic Processes				
S3205.1	Fillet and Groove Welds with Gas Metal Arc Welding (GMAW-P) Pulsed Process	0	15	15
S3205.2	Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW)	0	6	6
S3205.3	Submerged Arc Welding (SAW)	3	0	3
S3205.4	Stud Welding (SW)	3	0	3
Sub Totals		**6**	**21**	**27**
S3206: Shielded Metal Arc Welding (SMAW) Practical III				
S3206.1	Groove Welds on Plate with the Shielded Metal Arc Welding (SMAW) Process	0	21	21
S3206.2	Groove Welds on Pipe with the Shielded Metal Arc Welding (SMAW) Process	0	21	21
S3206.3	Fillet and Groove Welds with Stainless Steel Electrodes using the Shielded Metal Arc Welding (SMAW) Process	0	6	6
Sub Totals		**0**	**48**	**48**
Level 3 Totals		**99**	**141**	**240**

Number:	**S3202**		
Title:	**Fitting**		
Duration:	Total Hours: 87	Theory: 48	Practical: 39
Content:	S3202.1 Layout Pattern Development		
	S3202.2 Fabrication Equipment		
	S3202.3 Practical Fitting Project		

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3202	**Fitting**		
S3202.1	**Layout Pattern Development**		
Hours:	Total: 39	Theory: 39	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of fundamental layout and pattern making techniques.

Learning Outcomes and Content

1.1 Identify the purpose and fundamentals of layout and development.

- classes of geometric forms
- manual layout development
- computer based pattern development

1.2 Describe the methods of pattern development.

- radial line
- parallel line
- triangulation

1.3 Perform pattern developing for shapes.

- layout method for flat surfaces
  - flat surfaces
  - bend allowance
  - hoppers, chutes
- flat, angled (sloping) surfaces
  - hoppers, chutes, pyramidal shapes

- layout method for conical surfaces with a common apex
    - concentric cones
    - offset cones
    - truncated cones
- layout method for cylindrical surfaces
    - straight, round, rolled shells and tanks
    - circular ducting
    - circular piping
    - circular elbows
    - circular branches
    - piping intersections
- layout method for odd shaped surfaces
    - square/rectangle to round
    - round to round
    - elliptical to round
    - elliptical to elliptical
    - concentric and offset shapes

S3202	**Fitting**		
S3202.2	**Fabrication Equipment**		
Hours:	Total: 9	Theory: 9	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge to use and maintenance of fabricating.

Learning Outcomes and Content

2.1 Define common fabrication equipment and their maintenance.

- plate shears
- roll bending machines
- brake press
- drill presses
- band saws
- nibblers
- ironworkers

2.2 Describe the applications of common fabrication equipment.

- plate shears
- capacity
- rake angle
- blade clearance
- back gauge
- roll bending machines
    - capacity
    - metal thickness
    - rolling radii limits
- brake press
- die sets
- bending limits
- drill presses
- band saws
- nibblers
- ironworkers
- punching
- notching
- cutting

S3202	**Fitting**		
S3202.3	**Practical Fitting Projects**		
Hours:	Total: 39	Theory: 0	Practical: 39

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of practical fitting techniques.

Learning Outcomes and Content

3.1 Demonstrate equipment set-up and use of common fabrication equipment.

- equipment selection
- plate shears
- roll bending machines
- brake press
- drill presses
- band saws
- nibblers
- iron workers

3.2 Perform assigned practical fitting projects.

- plan and prepare worksite
- structural steel projects
    - channel or angle or beam
        - cope and fit
- 45° cope
    - layout
    - cut
    - fit parts
    - tack parts
- 90° cope
    - layout
    - cut
    - fit parts
    - tack parts
        - pipe projects
- use wrap from layout and pattern development
- form lateral branch

- T connection
  - layout
  - cut
  - fit parts
  - tack parts
- box construction project
  - layout parts
  - bend
  - fit box
  - tack parts

Number:	**S3203**		
Title	**Quality**		
Duration:	Total Hours: 36	Theory: 33	Practical: 3
Content:	S3203.1 Metallurgy II		
	S3203.2 Distortion II		
	S3203.3 Inspection and Codes		

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3203	**Quality**		
S3203.1	**Metallurgy II**		
Hours:	Total: 15	Theory: 15	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of the principles of weldability and microstructures of metals.

Learning Outcomes and Content

1.1 Explain the significance of different microstructures of common metals.

- interpretation of features and data from an iron – iron carbide equilibrium diagram
- definition of solidus and liquidus
- crystalline structures
- phase transformation
- heat numbers
- carbon steel microstructures
    - ferrite
    - pearlite
    - martensite
    - austenite
    - stainless steel
    - austetinic
    - martensitic
    - ferritic
    - duplex
    - precipitation hardening
        - aluminium
    - designation system
    - mechanisms of strengthening
    - basic heat treatment
    - carbon and low alloy steels

- factors influencing weld cracking susceptibility
    - chemistry
    - thickness
    - joint geometry
    - restraint
    - Hydrogen Induced Cracking (HIC)
- carbon equivalent formulae
- considerations for steel with limited weldability
    - filler metal selection
    - pre-heat
    - interpass
    - post-heating
    - pass sequence
    - temperature indicating crayons
    - electro/mechanical temperature indicators
- post weld heat treatment
    - stainless steels
    - austenitic
    - martensitic
    - ferritic
    - duplex
    - precipitation hardening
    - thickness
    - joint geometry
    - restraint
    - corrosion
- aluminium and aluminium alloys
    - chemistry
    - thickness and thickness differences
    - pre-heating
    - shielding gas compositions
    - joint geometry
    - dissimilar alloys
    - filler metal selection
    - restraint
    - corrosion
    - cleaning and oxide thickness
- cast iron and non-ferrous metals
    - concepts of welding cast iron
    - concepts of welding copper and copper alloys
    - concepts of welding nickel alloys, Inconel, monel, hastalloy
    - concepts of welding titanium and titanium alloys
- significance of microstructure
- factors influencing weldability
- High Strength, Low Alloy steels (HSLA)
- Thermo-Mechanical Controlled Processing (TMCP)

S3203	**Quality**		
S3203.2	**Distortion II**		
Hours:	Total: 9	Theory: 6	Practical: 3

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of fundamentals and correction of weld distortion.

Learning Outcomes and Content

2.1 Define the fundamentals of distortion control.

- selection of preventative method
- distortion allowances
- pre-heating
- back step
- weld progression
  - vertical up Vs. vertical down
  - continuous Vs. intermittent welding
- pre-setting joints
- jigs and fixtures
- effects of travel speed
- effects of weld size
- effects of bead size
- effects of over welding
- multiple pass Vs. single pass

2.2 Perform correction of weld distortion.

- selection of corrective methods
- heat wedges
- heat spots
- back welding
- mechanical straightening

S3203	**Quality**		
S3203.3	**Inspection and Codes**		
Hours:	Total: 12	Theory: 12	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of destructive inspection and testing methods, welding performance and welding procedure qualification testing method, common welding codes and standards.

Learning Outcomes and Content

3.1 Explain destructive inspection and testing methods.

- hardness testing
  - Rockwell method
  - Brinell method
  - Vickers method
- metallography
- weld joint cross-sections
- polishing
- etching
- analysing
- macro-examination
- hydrostatic testing
- leak testing
- vacuum testing
- fracture testing
- chemical analysis

3.2 Explain the requirements for welding performance qualification testing.

- assessment of welding personnel
- format of tests
  - welding of tests plates
  - witnessed by inspector
  - visual inspection of test plates
  - bend testing
  - radiographic testing
  - issuing of certification document
  - range of process variables qualified
  - need for re-qualification
- duration of certification
- reason for loss of certification

3.3 Explain the requirements for welding procedure qualification testing.

- Procedure Qualification Record (PQR)
- Welding Procedure Specification (WPS)
- assessment of welding procedure
- essential variables
- non-essential variables
- mechanical properties
- qualification test
- welding of plate Vs. pie
- required tests
- development of associated welding procedures

3.4 Identify production-welding requirements based on content of welding procedure documents.

- need for access to welding procedures by production personnel (WPS/WPDS)
- purpose of welding procedure documents
- material preparation and fit-up
- consumables selection
- recommended pass sequence
- electrical parameters
- technique parameters

3.5 Describe the requirements of welding codes and standards.

- pressure welding applications to the ASME Boiler and Pressure Vessel Code
- base and filler metal requirements to Section II
- product design and manufacture requirements to Sections III or VIII
- welding procedure and performance qualification requirements to Sections V, IX
- structural welding applications to the CSA Structural Welding Standards
- filler metal requirements to CSA W48
- company and personnel requirements to CSA W47.1
- product design and manufacture requirements to CSA W59
- material test reports
- other codes and standards

Number:	**S3204**		
Title:	**Gas Tungsten Arc Welding (GTAW) Practical II and Plasma Arc Welding (PAW)**		
Duration:	Total Hours: 42	Theory: 12	Practical: 30
Content:	S3204.1 Gas Tungsten Arc Welding (GTAW) Theory II		
	S3204.2 Fillet and Groove Welds with the Gas Tungsten Arc Welding (GTAW) Process		
	S3204.3 Pipe Welding with the Gas Tungsten Arc Welding (GTAW) Process		
	S3204.4 Fillet and Groove Welds on Aluminum with the Gas Tungsten Arc Welding (GTAW) Process		
	S3204.5 Plasma Arc Welding (PAW)		

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3204	**Gas Tungsten Arc Welding (GTAW) Practical II and Plasma Arc Welding (PAW)**		
S3204.1	**Gas Tungsten Arc Welding (GTAW) Theory II**		
Hours:	Total: 9	Theory: 9	Practical: 0

General Learning Outcomes
Upon successful completion the apprentice is able to demonstrate a working knowledge of weldability issues, accessories and shielding gas requirements for the Gas Tungsten Arc Welding (GTAW) process.

Learning Outcomes and Content

1.1 Describe the function of Gas Tungsten Arc Welding (GTAW) power sources and their controls.

- power sources
  - inverter technology
  - types of currents
  - polarity settings
- controls
  - high frequency
  - square wave controls
  - AC amperage frequency control
  - AC balance
  - pulse controls
  - up and down slope

1.2 Explain weldability issues with the Gas Tungsten Arc Welding (GTAW) process.

- oxide removal
- heat dissipation
- copper based alloys
    - brasses
    - bronzes
- aluminium
- aluminium alloys
- magnesium
- titanium and zirconium
    - drybox and trailing gas

1.3 Explain shielding gas requirements for the Gas Tungsten Arc Welding (GTAW) process.

- specialty gasses
    - blended gasses
    - equipment
        - flow rates
    - influencing factors
    - tables
    - units and conversions
- purging
    - requirements
    - gases used
    - methods
    - equipment

1.4 Describe the functions of Gas Tungsten Arc Welding (GTAW) accessories.

- torches
    - types
    - gas lenses
    - amperage capacities
    - size
    - flexible and rigid style
    - needle head
    - air and liquid cooled
        - remote controls
        - foot controls
        - torch mounted controls
        - backing materials
    - consumables inserts
    - ceramic tape
    - flux paste
        - purging equipment
    - caps
    - dams
    - valves

S3204	**Gas Tungsten Arc Welding (GTAW) Practical II and Plasma Arc Welding (PAW)**		
S3204.2	**Fillet and Groove Welds with the Gas Tungsten Arc Welding (GTAW) Process**		
Hours:	Total: 9	Theory: 0	Practical: 9

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of fillet and groove welding with the Gas Tungsten Arc Welding (GTAW) process.

Learning Outcomes and Content

2.1 Demonstrate equipment set-up and the process of Gas Tungsten Arc Welding (GTAW).

- power source
- equipment
- tungsten electrodes
- consumables
- shielding gasses
- safety
- PPE
- material
- technique
- type of welds

2.2 Set-up equipment for a variety of Gas Tungsten Arc Welding (GTAW) applications.

- material preparation and fit-up
  - pre-weld cleaning methods
  - position of welding
- equipment set-up
  - current type and polarity
  - amperage
  - arc initiation method
- torch set-up
  - collet and body
  - nozzle type and size
  - tungsten electrode type and size
- shielding gasses
  - type
  - flow rate (CFH/LP)
  - purging methods
- filler material
  - type (alloy)
  - size

2.3 Perform fillet and groove welds on mild steel plate with the Gas Tungsten Arc Welding (GTAW) process.

- set-up
  - welding parameters
  - equipment set-up
  - filler material
  - surface condition
  - pre-heat operation
- fillet welds
  - 3F position
  - 4F position
- groove welds
  - 3G position (progression up)
  - 4G position
- post-weld operations
  - clean and prepare welds to specification
  - visually inspect finished welds
  - post-heat operation

S3204	**Gas Tungsten Arc Welding (GTAW) Practical II and Plasma Arc Welding (PAW)**		
S3204.3	**Pipe Welding with the Gas Tungsten Arc Welding (GTAW) Process**		
Hours:	Total: 9	Theory: 0	Practical: 9

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of pipe welding with the Gas Tungsten Arc Welding (GTAW) process.

Learning Outcomes and Content

3.1 Demonstrate the process of preparation for welding pipe using the Gas Tungsten Arc Welding (GTAW) process.

- joint geometry
  - edge preparations
  - bevelling methods
    - flame cut
    - mechanical
    - machining
    - electric grinder
    - hydraulic beveller
    - pneumatic grinder
  - bevel and included angle
  - root gap
  - root face (landing)
- positions
  - 1G (rotated)
  - 2G
  - 5G
  - 6G
  - fit-up
- pipe alignment
- fittings
  - clamps
  - jigs
  - spacers
  - pipe to pipe and pipe to fittings
- tooling
  - turntables
  - rollers
  - manual and mechanical positioners

3.2 Weld mild steel pipe using the Gas Tungsten Arc Welding (GTAW) process.

- preparation
- edge preparation
- pre-weld conditioning
  - chamfering
  - pre-heat
  - filing
  - grinding
- joint alignment
  - spacers
  - jigs
  - clamps
  - pipe vices
  - pipe to pipe and pipe to fittings
- welding pipe
  - set-up
    - welding parameters
    - equipment set-up
    - filler material
    - material surfaces
- pipe/tubing sizes
  - large diameter
  - small diameter
- pipe/tubing schedules
- sequence
  - Gas Tungsten Arc Welding (GTAW) root
  - fill and cap with Shielded Metal Arc Welding (SMAW) (E4918)
- positions
  - 2G
  - 5G
  - 6G
- post-weld operations
  - clean and prepare welds to specification
  - visually inspect finished welds
  - post-heat

S3204	**Gas Tungsten Arc Welding (GTAW) Practical II and Plasma Arc Welding (PAW)**		
S3204.4	**Fillet and Groove Welds on Aluminium with the Gas Tungsten Arc Welding (GTAW) Process**		
Hours:	Total: 12	Theory: 0	Practical: 12

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of fillet and groove welding on aluminum with the Gas Tungsten Arc Welding (GTAW) process.

Learning Outcomes and Content

4.1 Demonstrate equipment set-up and applications of aluminum welding with the Gas Tungsten Metal Arc Welding (GTAW).

- power source
- equipment
- electrodes
- material
- consumables
- shielding gasses
- techniques
- safety
- PPE
- type of welds

4.2 Set-up equipment for aluminum welding using the Gas Tungsten Metal Arc Welding (GTAW) process.

- consumables
    - filler rod
        - type
        - size
- shielding gasses
    - gas type
    - flow rate
    - backing gas
        - equipment
    - torch
    - foot controller
    - cooling equipment
- material preparation and cleaning
    - welding parameters
- current type and polarity
    - amperage

4.3 Perform fillet and groove welds on aluminum with the Gas Tungsten Metal Arc Welding (GTAW) process.

- set-up
  - welding parameters
  - equipment set-up
  - filler material
  - surface conditions
- fillet welds
  - 2F position
  - 3F position
  - 5F position
- groove welds (plate or pie)
  - 1G position
  - 1GR (rotate) position
  - 2G position
  - 3G progression up position
- post-weld operations
  - clean and prepare welds to specification
  - visually inspect finished welds

S3204	**Gas Tungsten Arc Welding (GTAW) Practical II and Plasma Arc Welding (PAW)**		
S3204.5	**Plasma Arc Welding**		
Hours:	Total: 12	Theory: 0	Practical: 12

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of the Plasma Arc Welding (PAW) process.

Learning Outcomes and Content

5.1 Explain the Plasma Arc Welding (PAW) process.

- safety concerns to the Plasma Arc Welding (PAW) process
- process utilization
- arc characteristics
  - transferred and non-transferred
  - current parameters (amperage and voltage)
- melt-in and keyhole modes
- power source and controls
- torches, types and sizes
  - electrodes
  - nozzles
- gases
  - plasma and shielding (cooling)
  - gas flow meters
  - gas flow parameters
- manual and automated process
- filler materials

Number:	**S3205**		
Title:	**Automatic and Semi-Automatic Processes**		
Duration:	Total Hours: 27	Theory: 6	Practical: 21
Content:	S3205.1	Fillet and Groove Welds with Gas Metal Arc Welding (GMAW-P) Pulsed Process	
	S3205.2	Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW)	
	S3205.3	Submerged Arc Welding (SAW)	
	S3205.4	Stud Welding (SW)	

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3205	**Automatic and Semi-Automatic Processes**		
S3205.1	**Fillet and Groove Welds with Gas Metal Arc Welding (GMAW-P) Pulsed Process**		
Hours:	Total: 15	Theory: 0	Practical: 15

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of fillets and groove welds with the Gas Metal Arc Welding-Pulsed (GMAW-P) process.

Learning Outcomes and Content

1.1 Describe equipment set-up and the process of Gas Metal Arc Welding - Pulsed (GMAW-P).

- power source
- equipment
- wire feeder
- pulsing variables
- shielding gasses
- consumables
- safety
- PPE
- material condition
- technique
- type of welds

1.2 Perform fillet and groove welds with the Gas Metal Arc Welding - Pulsed (GMAW-P) process on mild steel.

- fillets
- flat (1F)
- horizontal (2F)
- vertical-up (3F)
- vertical-up (3G)
- material types

S3205	**Automatic and Semi-Automatic Processes**		
S3205.2	**Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW)**		
Hours:	Total: 6	Theory: 0	Practical: 6

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of fillet welding with the Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW) processes.

Learning Outcomes and Content

2.1 Groove weld with the Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW) processes.

- material
- mild steel
- positions
  - 3GF
  - 4GF - NPA
- consumables
  - classification
  - size
- shielding gasses
  - type
  - flow rate
  - clean and inspect

S3205	**Automatic and Semi-Automatic Processes**		
S3205.3	**Submerged Arc Welding (SAW)**		
Hours:	Total: 3	Theory: 3	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to describe a working knowledge of the fundamentals of the Submerged Arc Welding (SAW) process.

Learning Outcomes and Content

3.1 Describe the fundamentals of the Submerged Arc Welding (SAW) process.

- process fundamentals
- applications
- power sources
- wire feeders
- consumables
- process variations
- advantages
- limitations

3.2 State the equipment requirements for the Submerged Arc Welding (SAW) process.

- welding equipment
- power sources
    - AC machines
    - DC machines
- controls
    - tandem arc
    - twin arc
- contact tips/contact tubes
- wire drive rolls
    - single wire
    - multi-wire
- wire guides
- welding cables
    - cable size
    - condition
    - capacity
- work leads
    - clamps in good repair
    - clamping locations
        - operational equipment
- welding manipulators
- drive rolls

- positioners
- flux recovery

3.3 Identify compatible Submerged Arc Welding (SAW) consumable combinations.

- filler wire
  - classification
  - filler wire delivery
    - spool
    - drum
  - filler wire diameters
- flux
  - functions of flux
  - chemical properties
  - alloying elements
  - shielding
  - flux classification system
    - imperial version
    - metric version
- storage and handling
  - filler wire storage
  - flux storage
    - storage conditions

3.4 Explain Submerged Arc Welding (SAW) parameter selection.

- travel speed
  - carriage travel
  - boom travel
- electrical variables
  - amperage
  - voltage
- pre-heat
- post-heat
- filler wire
  - stick out
  - drive roll tension
  - travel angle
  - work angle

3.5 Explain Submerged Arc Welding (SAW) process on low carbon and stainless steel to CSA and ASME codes.

- fillet welds
  - single and multi-pass sequencing
- groove welds
  - with back
  - sequencing
- post-cleaning
- inspect and measure weld size with appropriate (necessary) tools to meet specified requirements or standards

S3205	**Automatic and Semi-Automatic Processes**		
S3205.4	**Stud Welding (SW)**		
Hours:	Total: 3	Theory: 3	Practical: 0

General Learning Outcomes

Upon successful completion the apprentice is able to describe a working knowledge of the fundamentals of the Stud Welding (SW) process.

Learning Outcomes and Content

4.1 Describe the fundamentals of the Stud Welding (SW) process.

- process fundamentals
- power sources and equipment
- applications
- consumables
  - studs
  - ferrules

4.2 Explain the Stud Welding (SW) process.

- equipment set-up
- adjustment and verification of variables
- corrective actions and repairs to defective stud welds and parent materials

Number:	**S3206**		
Title:	**Shielded Metal Arc Welding (SMAW) Practical III**		
Duration:	Total Hours: 48	Theory: 0	Practical: 48
Content:	S3206.1	Groove Welds on Plate with the Shielded Metal Arc Welding (SMAW) Process	
	S3206.2	Groove Welds on Pipe with the Shielded Metal Arc Welding (SMAW) Process	
	S3206.3	Fillet and Groove Welds on Pipe with the Shielded Metal Arc Welding (SMAW) Process	

Evaluation and Testing: Mark distribution proportionate to theory and practical hours. Specific evaluation of theory and practical components of training varies due to the resource material and training aides utilized.

S3206	**Shielded Metal Arc Welding (Smaw) Practical III**		
S3206.1	**Groove Welds on Plate with the Shielded Metal Arc Welding (SMAW) Process**		
Hours:	Total: 21	Theory: 0	Practical: 21

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of groove welding on plate with the Shielded Metal Arc Welding (SMAW) process.

Learning Outcomes and Content

1.1 Describe the equipment set-up and the process of the Shielded Metal Arc Welding (SMAW).

- power source
- equipment
- consumables
- safety
- PPE
- material
- technique
- type of welds

1.2 Set-up equipment for Shielded Metal Arc Welding (SMAW) applications.

- power sources
  - transformers
    - rectifiers
    - inverters
  - engine driven

- power source controls
    - amperage
    - voltage
    - current type
    - polarity

1.3 Groove weld on plate using the Shielded Metal Arc Welding (SMAW) process.

- groove welds
    - open root
- positions
    - flat (1G)
    - horizontal (2G)
    - vertical (3G)
        - progression up
    - overhead (4G)
- material
    - mild steel plate
- joints
    - single V-groove, open root
- consumables
    - cellulose
    - basic

S3206	**Shielded Metal Arc Welding (SMAW) Practical III**		
S3206.2	**Groove Welds on Plate with the Shielded Metal Arc Welding (SMAW) Process**		
Hours:	Total: 21	Theory: 0	Practical: 21

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of groove welding on pipe with the Shielded Metal Arc Welding (SMAW) process.

Learning Outcomes and Content

2.1 Perform groove welds on pipe for destructive testing using the Shielded Metal Arc Welding (SMAW) process.

- groove welds
  - open root
- positions
  - horizontal (2G)
  - vertical (5G)
  - all (6G)
- material
  - mild steel pipe
- joints
  - single V-groove, open root
- consumables
  - cellulose
  - basic

2.2 Perform preparations for destructive testing.

- layout coupons
- cut coupons
- grind surfaces
- grind coupons

2.3 Perform destructive testing.

- destructive test welds
  - root bend
  - face bend

S3206	**Shielded Metal Arc Welding (SMAW) Practical III**		
S3206.3	**Fillet and Groove Welds with Stainless Steel Electrodes using the Shielded Metal Arc Welding (SMAW) Process**		
Hours:	Total: 6	Theory: 0	Practical: 6

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate a working knowledge of fillet and groove welding with stainless electrodes using the Shielded Metal Arc Welding (SMAW) process.

Learning Outcomes and Content

3.1 Perform fillet and groove welds on plate using the Shielded Metal Arc Welding (SMAW) process with Stainless Steel Electrodes.

- fillet welds
  - flat (1F)
  - horizontal (2F)
- groove welds with backing
  - flat (1G)
  - horizontal (2G)
- consumable (any)
  - o E308 (L)
  - o E316 (L)
  - o E309 (L)

Welder Practical Examination Test Record

Important Note to Training Delivery Agents (TDA) and Instructors:

1. This test record is to be submitted for each apprentice to Skilled Trades Ontario at practicals@skilledtradesontario.ca at the end of Level 3 completion. Please submit the entire level 3 class test records in one email with a class list.
2. Subject line should indicate as follows: APPRENTICE Welder Practical Results for TDA regarding prerequisite criteria to write the Red Seal Certificate of Qualification".
3. A copy MUST also be given to each successful Apprentice at the end of Level 3 completion as they will be required to submit a copy to the Ministry for completion purposes.

Name of Applicant: Apprentice # (if applicable)	Testing Centre/Training Delivery Agent and Location:	Date:

Process	WPS	Test Results (Please circle the correct test result)	
SMAW	NWPE #1	Pass	Fail
SMAW	NWPE #2	Pass	Fail
GMAW	NWPE #3	Pass	Fail
GTAW	NWPE #4	Pass	Fail
FCAW	NWPE #5	Pass	Fail
Oxy-Fuel	NWPE #6	Pass	Fail

Acceptance Criteria Results

The applicant named on this document meets all required fields and has demonstrated their practical competency in the Red Seal Trade of **Welder**.

Pass	Fail

Examination Officer Name (please print)	**Examination Officer Signature**

Mandatory Equipment List for Training Delivery Agents

Power Sources and Equipment	Quantity
SMAW (CC) (AC/DC) power source and equipment	1 per apprentice
GMAW/FCAW/MCAW (CV) power source and equipment (capable of spray-transfer)	1 per apprentice
GMAW-PULSED power source and equipment	1 per 5 apprentices
Pulsed power source and equipment	1 per 5 apprentices
Water-cooled torch, Foot controller	1 per 5 apprentices
Plasma Arc Cutting power source and equipment	1 per 5 apprentices
Air Carbon- Arc Gouging power source and equipment	1 per 5 apprentices
Oxy-Fuel Gas Manual Cutting equipment	1 per apprentice
Oxy-Fuel Gas Semi-Automatic Cutting equipment	1 per 5 apprentices
Oxy-Fuel Gas Heating Torch and equipment	1 per 5 apprentices
Approved Electrode Storage Oven	1 per shop
Compressed Air Supply (80-100 PSI)	1 per shop

Basic Hand Tools and Equipment (1 per apprentice)	
Adjustable wrenches (various sizes)	Pliers (needle, nose, slip joint)
Allen wrenches (metric and imperial)	Positioners
Bench vice	Pry Bars
“C” clamps (various sizes)	Punches
Chalk-line	Screwdrivers (slot, Phillips, Robertson, various sizes)
Cold chisels (various sizes)	Scribers
Electric extension cords	Snips (heavy duty sheet metal cutting)
Files (flat, half-round, rat-tail, bastard)	Soapstone markers
Friction lighter	Socket sets (metric and imperial)
Grinding and sanding disks (for carbon, aluminium and stainless steel)	Temperature indicating crayons
Hacksaw	Tip cleaners
Hammers (chipping, ball, peen, claw, sledge, various sizes)	Toolboxes
Hand shears	Tungsten sharpening grinders
Layout table	Vice grips (various sizes and types)
Magnets	Wire brushes (for carbon, aluminum and stainless steel)
Metal markers	Wire cutters
Pipe clamps	Work bench
Pipe cutter	Wrench sets (open and close ends, metric and imperial)
Pipe wrenches	

Measuring Tools (1 per apprentice)	
Drafting equipment	Combination square
Fillet gauges	Spirit level
Vernier caliper	Square
Micrometer	Straight edge
Scriber	Tape measure

Power Tools and Equipment (1 per 5 apprentices)	
Electric drills (9mm-3/8” to 12.5mm-1/2”) chuck size	Wire wheel (angle grinder with wire brush)
Grinders, electric and/or pneumatic (wire brush, angle grinders)	Sanders

Hoisting and Lifting Equipment (1 per shop)	
Rope	Come-along (cable or chain)
Slings	Forklift
Chains	Overhead hoist or crane

Safety Equipment (1 per apprentice)	
Earplugs and muffs	Leather gloves (provided by apprentice)
Face shields	Leather jackets (provided by apprentice)
Fire blankets	Masks (particle, vapor)
Fire extinguishers	Respirators
Goggles	Safety glasses
Leather aprons	

Optional Equipment List for Training Delivery Agents

Power Sources and Equipment	Quantity
Plasma Arc Welding power source and equipment	1 per shop
Sub Arc Welding power source and equipment	1 per shop
Stud Welding power source and equipment	1 per shop

Fabrication Machines (1 each per shop)	
Plate shear	Pedestal grinders
Brake press	Cut-off abrasive wheel saw
Roll bending machine	Weld-bevel preparation equipment for plate and pipe
Band saw	Weld-coupon bending apparatus
Nibbler	Approved smoke extraction/air make-up unit
Ironworker	

Welding and Fabricating shops must be well lit, appropriately heated and ventilated

Resource Materials

Codebooks

Engineering specifications

Manufacturer’s specifications, manuals and charts

Safety manuals

Reference Materials

ILM Alberta Learning Modules

Modern Welding Technology Text

Blueprint Reading for Welders, A.E. Bennett

Practical Problems in Mathematics for Welders, Frank R. Schell & Bill J. Matlock

Welding Handbook, American Welding Society

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Welder