Skilled Trades Ontario | Métiers spécialisés Ontario

Apprenticeship Curriculum Standard

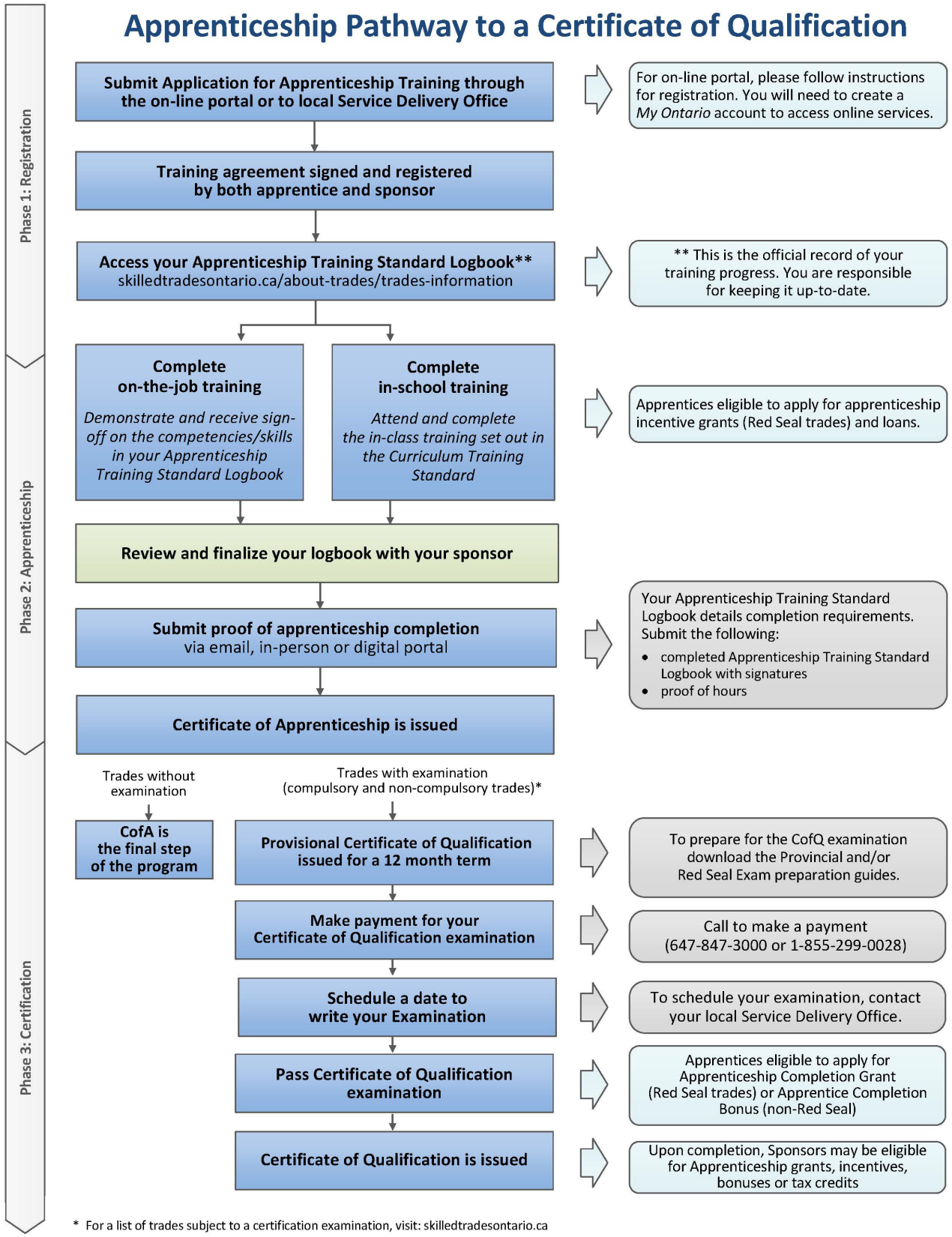
Instrumentation and Control Technician

Levels 1, 2 and 3

447A

2017

Apprenticeship Pathway to a Certificate of Qualification



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

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

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

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

Maintained with transfer to Skilled Trades Ontario 2017 (V100)

Preface

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

The curriculum is organized into 3 levels of training. The Reportable Subjects Summary chart (located on page 3) summarizes the training hours for each reportable subject.

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

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

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

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

Pre-requisites

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

Hours Disclaimer (if applicable)

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

Suggested Equipment for Training Delivery Agencies
The listing of tools on page 87 and page 88 does not list minimum quantities based on the understanding that the delivering 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.

Instrumentation and Control Technician apprentices must supply their own work clothing, boots, 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.

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practical
Level 1				
S3211	Applied Trade Practices and Procedures	9	9	0
S3212	Electrical Theory and Applied Trade Calculations	63	35	28
S3213	Electronic Systems	63	30	33
S3214	Computers and Documentation	30	1	29
S3215	Instrumentation I	75	33	42
	Total	**240**	**108**	**132**
Level 2				
S3216	Electrical Theory and Applied Trade Calculations II	33	26	7
S3217	Instrumentation II	69	35	34
S3218	Instrumentation Controls I	63	31	32
S3219	Discrete Control	27	16	11
S3220	Computer Control Systems	48	15	33
	Total	**240**	**123**	**117**
Level 3				
S3221	Applied Circuits	42	23	19
S3222	Advanced PLC and DCS	57	14	43
S3223	Instrumentation Controls II	90	52	38
S3224	Analytical Instrumentation	36	32	4
S3225	Fluid Power Systems	15	13	2
	Total	**240**	**134**	**106**

Level 1

Reportable Subject Summary – Level 1

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practical
S3211: Applied Trade Practices and Procedures				
S3211.1	Health and Safety	2	2	0
S3211.2	Trade Standards and Codes	2	2	0
S3211.3	Tools and Equipment	3	3	0
S3211.4	Locking and Tagging	2	2	0
	Sub Total	**9**	**9**	**0**
S3212: Electrical Theory and Applied Trade Calculations				
S3212.1	Electrical Fundamentals	10	8	2
S3212.2	Electrical Test Equipment	3	1	2
S3212.3	Electrical Circuits	25	13	12
S3212.4	Electrical Control Devices	25	13	12
	Sub Total	**63**	**35**	**28**
S3213: Electronic Systems				
S3213.1	Electronic Fundamentals	12	6	6
S3213.2	Electronic System Test Equipment	10	3	7
S3213.3	Digital Circuits and Schematics	41	21	20
	Sub Total	**63**	**30**	**33**
S3214: Computers and Documentation				
S3214.1	Computers Fundamentals	2	0.5	1.5
S3214.2	Computer Software	2	0.5	1.5
S3214.3	Computer Generated Documents	26	0	26
	Sub Total	**30**	**1**	**29**
S3215: Instrumentation I				
S3215.1	Introduction to Instrumentation	45	23	22
S3215.2	Instrumentation Installation Techniques	30	10	20
	Sub Total	**75**	**33**	**42**
	Level 1 Totals	**240**	**108**	**132**

Number:	S3211		
Title:	**Applied Trade Practices and Procedures**		
Duration:	Total Hours: 9	Theory: 9	Practical: 0
Content:	S3211.1	Health and Safety	
	S3211.2	Trade Standards and Codes	
	S3211.3	Tools and Equipment	
	S3211.4	Locking and Tagging	
Evaluation & 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.		

Number:	S3211.1		
Title:	**Health and Safety**		
Duration:	Total Hours: 9	Theory: 9	Practical: 0
Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.08, 6551.09, 6551.10			

General Learning Outcomes

Upon successful completion the apprentice is able to explain the relevant safe work practices, policies and procedures according to government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

1.1 Explain the significance of workplace legislation including but not limited to:
- Occupational Health and Safety Act (OHSA)
- Workplace Hazardous Material Information System (WHMIS)
- Materials Safety Data Sheets (MSDS)

1.2 Describe the proper use of relevant Personal Protective Equipment (PPE)

1.3 Describe the effect of electricity on the human body

1.4 Describe zero energy state

1.5 Describe intrinsic safety requirements

Number:	S3211.2		
Title:	**Trade Standards and Codes**		
Duration:	Total Hours: 2	Theory: 2	Practical: 0
Cross-Reference to Training Standard: 6551.04, 6551.10; 6552.05			

General Learning Outcomes

Upon successful completion the apprentice is able to describe Trade Standards and Codes according to government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

2.1 Interpret the Instrumentation and Control Trade Standards and Codes

- Instrumentation Systems Automation Society (ISA)
- Canadian Standards Association (CSA)
- Canadian Electrical Code (CEC)
- American National Standards Institute (ANSI)
- International Standards Organization (ISO)

2.2 Describe the application of Instrumentation and Control Trade Standards and Codes

- Instrumentation Systems Automation Society (ISA)
- Canadian Standards Association (CSA)
- Canadian Electrical Code (CEC)
- American National Standards Institute (ANSI)
- International Standards Organization (ISO)

Number:	S3211.3		
Title:	**Tools and Equipment**		
Duration:	Total Hours: 3	Theory: 3	Practical: 0
Cross-Reference to Training Standard: 6551.05, 6551.06, 6551.07; 6552.01, 6552.02, 6552.03, 6552.06, 6552.07, 6552.08			

General Learning Outcomes

Upon successful completion the apprentice is able to describe the application of tools and equipment required for the Instrumentation and Control trade according to government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

3.1 Identify the tools and equipment required for the Instrumentation and Control trade

- trade related tools
- measuring devices including but not limited to:
  - digital multi meter
  - calibrators
  - standards (primary/secondary)

3.2 Describe the application of tools and equipment required for the Instrumentation and Control trade

- trade related tools
- measuring devices including but not limited to:
  - digital multi meter
  - calibrators
  - standards (primary/secondary)

Number:	S3211.4		
Title:	**Locking and Tagging Procedures**		
Duration:	Total Hours: 2	Theory: 2	Practical: 0
Cross-Reference to Training Standard: 6551.01, 6551.04, 6551.07, 6551.10; 6552.05; 6553.06			

General Learning Outcomes

Upon successful completion the apprentice is able to describe the locking and tagging procedures for equipment according to government safety regulations, manufacturer's recommendations and approved industry standards.

Learning Outcomes and Content

4.1 Describe the locking and tagging procedures for equipment

- determine which conditions would cause mechanical and electrical equipment to be tagged and locked out
- describe how to lock out mechanical and electrical equipment according to applicable codes, manufacturer's recommendations and company standards
- describe tagging procedures of defective mechanical and electrical equipment according to applicable codes, manufacturer's recommendations and company standards
- describe how to re-energize mechanical and electrical equipment according to applicable codes, manufacturer's recommendations and company standards
- describe safety procedures involved in working on process equipment including but not limited to:
  - hazard assessment
  - acquisition of work permits
  - required notification process

Number:	S3212		
Title:	**Electrical Theory and Applied Trade Calculations I**		
Duration:	Total Hours: 63	Theory: 35	Practical: 28
Content:	S3212.1	Electrical Fundamentals	
	S3212.2	Electrical Test Equipment	
	S3212.3	Electrical Circuits	
	S3212.4	Electrical Control Devices	
Evaluation & 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.		

Number:	S3212.1		
Title:	**Electrical Fundamentals**		
Duration:	Total Hours: 10	Theory: 8	Practical: 2
Cross-Reference to Training Standard: 6552.04; 6556.04, 6556.05; 6557.01, 6557.05, 6557.06			

General Learning Outcomes

Upon successful completion the apprentice is able to describe the electrical fundamentals and apply mathematical tools according to prescribed industry standards.

Learning Outcomes and Content

1.1 Define the terms and fundamentals of electricity
- voltage
- current
- resistance
  - colour codes
  - impedance
- Ohm's Law
- Kirchoff's Law
- direct current (DC)
- alternating current (AC)
- Electro-Motive Force (EMF)
- Potential Difference (PD)
- electrical sources

1.2 Describe the features and applications of electrical and mechanical energy
- current
- power and energy

1.3 Explain the principles of common sources of Electro-Motive Force (EMF)
- magnetism
- motor principles
- generator principles

Number:	S3212.2		
Title:	**Electrical Test Equipment**		
Duration:	Total Hours: 3	Theory: 1	Practical: 2
Cross-Reference to Training Standard: 6552.03, 6552.04, 6552.05, 6552.08; 6554.04; 6556.05			

General Learning Outcomes

Upon successful completion the apprentice is able to explain the principles of operation and application of electrical test equipment used in the Instrumentation and Control trade according to manufacturer's recommendations.

Learning Outcomes and Content

2.1 Identify the electrical test equipment types and applications used in industry

2.2 Explain the principle of operation and application of electrical test equipment including but not limited to:

- digital multimeter
- clamp on ammeter
- insulation tester
- millivolt calibrators
- current calibrators

Number:	S3212.3		
Title:	**Electrical Circuits**		
Duration:	Total Hours: 25	Theory: 13	Practical: 12
Cross-Reference to Training Standard: 6551.05; 6552.04, 6552.05; 6556.04, 6556.05			

General Learning Outcomes

Upon successful completion the apprentice is able to assemble, analyze and troubleshoot electrical circuits, applying mathematical tools and using electronic test equipment according to industrial applications.

Learning Outcomes and Content

3.1 Analyze direct current (DC) circuits y applying Ohm's law and Kirchoff's law
- series circuits
- parallel circuits
- combined direct current (DC) circuits

3.2 Calculate voltage, current, resistance and power of DC electrical circuits
- series circuit calculations for total resistance, current and voltage
- parallel circuit calculations for total resistance, current and voltage
- combined circuit calculations for total resistance, current and voltage

3.3 Assemble series, parallel and combined DC circuits

3.4 Measure the voltage, current and resistance of series, parallel and combined circuits

3.5 Troubleshoot series, parallel and combined DC circuits

Number:	S3212.4		
Title:	**Electrical Control Devices**		
Duration:	Total Hours: 25	Theory: 13	Practical: 12
Cross-Reference to Training Standard: 6551.05; 6552.04, 6552.05; 6556.04, 6556.05			

General Learning Outcomes

Upon successful completion the apprentice is able to explain the application, assemble and test of electrical control devices used in industrial applications.

Learning Outcomes and Content

4.1 Describe the fundamental principles of electrical control devices including but not limited to:

- transformers
- solenoids
- relays
- switches

4.2 Explain the applications of electrical control devices

4.3 Assemble and test electrical control devices

Number:	S3213		
Title:	**Electronic Systems**		
Duration:	Total Hours: 63	Theory: 30	Practical: 33
Content:	S3213.1	Electronic Fundamentals	
	S3213.2	Electronic System Test Equipment	
	S3213.3	Digital Circuits and Schematics	
Evaluation & 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.		

Number:	S3213.1		
Title:	**Electronic Fundamentals**		
Duration:	Total Hours: 12	Theory: 6	Practical: 6
Cross-Reference to Training Standard: 6551.05; 6552.04, 6552.05; 6556.04, 6552.05; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05, 6557.06			

General Learning Outcomes

Upon successful completion the apprentice is able to assemble, measure and troubleshoot electronic circuits and semi-conductor components used in industry.

Learning Outcomes and Content

1.1 Identify basic semi-conductors and symbols including but not limited to:
- diodes
- transistors
- LED’s
- optocouplers

1.2 Describe the application of basic semi-conductor components including but not limited to:
- diodes
- transistors
- LED’s
- Optocouplers

1.3 Explain the operation of basic semi-conductor components including but not limited to:
- diodes
- transistors
- LED’s
- Optocouplers

1.4 Assemble electronic circuits.

1.5 Use electronic test equipment to verify the operation of electronic circuits

1.6 Measure and troubleshoot a variety of electronic semi-conductor circuits

Number:	S3213.2		
Title:	**Electronic System Test Equipment**		
Duration:	Total Hours: 10	Theory: 3	Practical: 7
Cross-Reference to Training Standard: 6551.05; 6552.03, 6552.04, 6552.05; 6556.04, 6556.05; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05, 6557.06			

General Learning Outcomes

Upon successful completion the apprentice is able to describe the recommended procedures and use electronic test equipment according to government regulations, manufacturer's recommendations and industry standards.

Learning Outcomes and Content

2.1 Identify the function of electronic test equipment including but not limited to:
- oscilloscope
- frequency counter
- function generator
- meters

2.2 Describe the recommended procedures to use electronic test equipment including but not limited to:
- oscilloscope
- frequency counter
- function generator
- meters

Number:	S3213.3		
Title:	**Digital Circuits and Schematics**		
Duration:	Total Hours: 41	Theory: 21	Practical: 20
Cross-Reference to Training Standard: 6551.05; 6552.03, 6552.04, 6552.05; 6556.04, 6556.05; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05, 6557.06			

General Learning Outcomes

Upon successful completion the apprentice is able to assemble, measure and troubleshoot basic logic circuits and schematics according to applications in industry.

Learning Outcomes and Content

3.1 Identify schematic symbols for North American and European basic logic gates

3.2 Explain the operating principles of basic logic gates

3.3 Use basic logic gates to create digital circuits

3.4 Identify and define Boolean equations for simple logic gates

3.5 Describe the electrical requirements for digital circuits including but not limited to:
- circuit loading
- voltage/current levels

3.6 Assemble, measure and troubleshoot a variety of basic logic results

Number:	S3214		
Title:	**Computers and Documentation**		
Duration:	Total Hours: 30	Theory: 2	Practical: 28
Content:	S3214.1	Computers Fundamentals	
	S3214.2	Computer Software	
	S3214.3	Computer Generated Documents	
Evaluation & 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.		

Number:	S3214.1		
Title:	**Computers Fundamentals**		
Duration:	Total Hours: 2	Theory: 0.5	Practical: 1.5
Cross-Reference to Training Standard: 6552.08			

General Learning Outcomes

Upon successful completion the apprentice is able to perform operations on computers in accordance with manufacturers and installed software recommendations.

Learning Outcomes and Content

1.1 Identify the purpose and function of basic computer components

- memory drive
- peripheral devices
- input/output ports (I/O)
- power supply
- mother board

Number:	S3214.2		
Title:	**Computer Software**		
Duration:	Total Hours: 2	Theory: 0.5	Practical: 1.5
Cross-Reference to Training Standard: 6552.04, 6552.05, 6552.08			

General Learning Outcomes

Upon successful completion the apprentice is able to describe computer software applications used to create Process and Instrument (P&I), wiring and loop diagrams; and to produce computerized presentations and technical documentations by incorporating information from multiple sources.

Learning Outcomes and Content

2.1 Identify and describe the features of computer software applications
- word processing
- presentation software
- spreadsheets
- Computer-Assisted Design (CAD)

2.2 Navigate software menus
- word processing
- presentation software
- spreadsheets
- Computer-Assisted Design (CAD)

Number:	S3214.3		
Title:	**Computer Generated Documents**		
Duration:	Total Hours: 26	Theory: 0	Practical: 26
Cross-Reference to Training Standard: 6552.04, 6552.05, 6552.08			

General Learning Outcomes

Upon successful completion the apprentice is able to use computer software applications used to create Process and Instrument (P&I), wiring and loop diagrams; and to produce computerized presentations and technical documentations by incorporating information from multiple sources.

Learning Outcomes and Content

3.1 Perform computer functions

- import and export functions for graphs, tables and drawings between applications
- create a document containing most of the elements common to technical reports, tables and graphics
- draw P&I, electrical and loop diagrams by using CAD software
- use ISA symbols
- save files to a storage device and make backup copies
- plot drawings by using various printers or plotters
- use computers to document laboratory procedures
- use spreadsheet software for graphing of calibration or other data

Number:	S3215		
Title:	**Instrumentation I**		
Duration:	Total Hours: 75	Theory: 33	Practical: 42
Content:	S3215.1	Introduction to Instrumentation	
	S3215.2	Instrumentation Installation Techniques	
Evaluation & 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.		

Number:	S3215.1		
Title:	**Introduction to Instrumentation**		
Duration:	Total Hours: 45	Theory: 23	Practical: 22

Cross-Reference to Training Standard: 6551.05, 6551.06; 6552.03, 6552.04, 6552.05, 6552.07, 6552.08; 6553.01, 6553.02; 6556.01, 6556.02, 6556.04, 6556.05; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05

General Learning Outcomes

Upon successful completion the apprentice is able to identify, explain and calibrate temperature, pressure, level and flow measurement devices.

Learning Outcomes and Content

1.1 Explain the terminology and symbology used in instrumentation measurement

1.2 Describe the operation and application of pressure, temperature, level and flow measuring devices

- define temperature as a measure of heat energy
- explain common temperature scales and their relationship
- explain the physics of heat transfer
- define pressure and explain its significance in process control
- explain absolute, gauge, head, hydrostatic and differential pressure
- identify and define the types of pressure elements
- explain Pascal’s Law and its application
- explain flow rates
  - volumetric
  - mass flow
- explain fluid physical properties and factors that affect flow measurement

1.3 Describe the features of instrumentation devices

- describe instruments used for temperature measurement
- identify common pressure scales and units used in pressure measurement
- describe instruments used for pressure measurement
- explain important considerations in pressure management using manometers
- explain devices used in the calibration of pressure transmitters

- explain the importance of level measurement
- explain point level measurement versus continuous level measurement
- describe instruments used for level measurement
- describe instruments used for flow measurement

1.4 Calibrate pressure, temperature, level and flow transmitters

Number:	S3215.2		
Title:	**Instrumentation Installation Techniques**		
Duration:	Total Hours: 30	Theory: 10	Practical: 20
Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.09, 6551.10; 6552.01, 6552.02, 6552.04, 6552.05, 6552.06, 6552.07			

General Learning Outcomes

Upon successful completion the apprentice is able to install instruments and control systems according to government regulations, manufacturer's recommendations and industry standards.

Learning Outcomes and Content

2.1 Describe installation techniques for tubing used in instrumentation
- explain tube layout, measuring and cutting
- calculate tube bending lengths for various configurations that use different angles
- identify approved mechanical fittings

2.2 Describe installation techniques for conduit used in instrumentation
- identify threading tools
- identify thread types and fittings
- design support brackets

2.3 Apply installation techniques for wiring and circuit boards used in instrumentation
- solder and de-solder electronic components on a printed circuit board
- identify static and anti-static devices when working with electronic components
- use wire-stripping and terminating practices
- install wire and connect temperature, pressure, level and flow measurement instruments

2.4 Install tubing used in instrumentation
- sketch and measure tube layouts
- cut and bend tubing
- install tube fittings
- test tubing for leaks

2.5 Install conduit used in instrumentation

- thread conduit using threading tools
- install threaded pipe and fittings for a safe, leak-tight installation
- fabricate brackets

2.6 Install wires and circuit boards used in instrumentation

- solder and de-solder electronic components on a printed circuit board
- use static and anti-static devices when working with electronic components
- stripping and terminate wires

Level 2

Reportable Subject Summary – Level 2

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practical
S3216: Electrical Theory and Applied Trade Calculations II				
S3216.1	Principles of Magnetism	6	4	2
S3216.2	Magnetic Devices	6	6	0
S3216.3	Capacitance	3	3	0
S3216.4	Capacitors, Inductors and Resistive Devices	13	8	5
S3216.5	Motors and Generators	5	5	0
	Sub Total	**33**	**26**	**7**
S3217: Instrumentation II				
S3217.1	Instrumentation Test Equipment	5	1	4
S3217.2	Pressure Measurement	10	5	5
S3217.3	Level Measurement	12	6	6
S3217.4	Temperature Measurement	12	6	6
S3217.5	Flow Measurement	20	12	8
S3217.6	Secondary Process Measurement	10	5	5
	Sub Total	**69**	**35**	**34**
S3218: Instrumentation Controls I				
S3218.1	Final Control Elements	16	10	6
S3218.2	Control System Fundamentals	30	15	15
S3218.3	Valve Positioners	10	4	6
S3218.4	Troubleshoot Control Valves	7	2	5
	Sub Total	**63**	**31**	**32**
S3219: Discrete Control				
S3219.1	Introduction to Discrete Control	6	6	0
S3219.2	Control System Electrical Schematics	2	2	0
S3219.3	Discrete Control Wiring	19	8	11
	Sub Total	**27**	**16**	**11**
S3220: Computer Control Systems				
S3220.1	Introduction to PLC, DCS and Supervisory Control and SCADA Systems	8	4	4
S3220.2	Electrical Circuits and Ladder Programs	13	4	9
S3220.3	Configuration and Programming	14	3	11
S3220.4	Control System Troubleshooting	10	2	8
S3220.5	System Configuration, Interfacing and Communications	3	2	1
	Sub Total	**48**	**15**	**33**
	Level 2 Totals	**240**	**123**	**117**

Number:	S3216		
Title:	**Electrical Theory and Applied Trade Calculations II**		
Duration:	Total Hours: 33	Theory: 26	Practical: 7
Content:	S3216.1	Principles of Magnetism	
	S3216.2	Magnetic Devices	
	S3216.3	Capacitance	
	S3216.4	Capacitors, Inductors and Resistive Devices	
	S3216.5	Motors and Generators	
Evaluation & 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.		

Number:	S3216.1		
Title:	**Principles of Magnetism**		
Duration:	Total Hours: 6	Theory: 4	Practical: 2
Cross-Reference to Training Standard: 6551.05, 6551.07, 6551.10; 6552.01, 6552.04, 6552.05, 6552.06; 6556.05			

General Learning Outcomes

Upon successful completion the apprentice is able to describe magnetic principles and solve problems as applied to the operation of transformers.

Learning Outcomes and Content

1.1 Define the principles of permanent magnetism

- define and observe characteristics of permanent magnetism
  - properties of permanent magnets
  - action of magnetic poles
  - magnetic fields
  - magnetic properties

1.2 Define the principles of electromagnetism

- define and observe characteristics of electromagnetism
  - properties of electromagnets
  - action of magnetic fields around a conductor
  - principles of induced voltage
  - effects of motion on induced voltage
  - factors that affect induced voltage
  - define Lenz's Law
  - describe the creation and effects of eddy currents
- describe magnetic flux and flux density
- explain Ohm's Law as applied to magnetic circuits

1.3 Solve problems associated with magnetic energy as related to transformers

- power ratings
- turns ratio
- frequency effects

Number:	S3216.2		
Title:	**Magnetic Devices**		
Duration:	Total Hours: 6	Theory: 6	Practical: 0
Cross-Reference to Training Standard: 6557.01			

General Learning Outcomes

Upon successful completion the apprentice is able to describe the operation and perform inductance calculations related to magnetic devices including but not limited to solenoids and relays according to manufacturer's recommendations.

Learning Outcomes and Content

2.1 Describe operating characteristics of magnetic devices including but not limited to:
- solenoids
- relays
- Linear Voltage Differential Transformers (LVDTs)

2.2 List and explain the factors that affect the magnitude and direction of induced EMF in single conductors and in coils.
- tack weld assembly with prescribed process

2.3 Describe factors that affect inductance and perform related calculations
- inductance
- RL circuits
- impedance

Number:	S3216.3		
Title:	**Capacitance**		
Duration:	Total Hours: 3	Theory: 3	Practical: 0
Cross-Reference to Training Standard: 6557.01			

General Learning Outcomes

Upon successful completion the apprentice is able to describe the operation and function of capacitors as used in RC circuits.

Learning Outcomes and Content

3.1 List and explain the factors that affect capacitance

3.2 Perform related calculations in capacitor circuits
- capacitance
- RC circuits

Number:	S3216.4		
Title:	**Capacitors, Inductors and Resistive Devices**		
Duration:	Total Hours: 13	Theory: 8	Practical: 5

Cross-Reference to Training Standard: 6551.05, 6551.06, 6551.07, 6551.10; 6552.01, 6552.04, 6552.05, 6552.06; 6553.05; 6556.04, 6556.05

General Learning Outcomes

Upon successful completion the apprentice is able to describe, build and test resonant (RLC) circuits as applied to DC and AC motors, impedance networks and polyphaser circuits.

Learning Outcomes and Content

4.1	Describe the effects of alternating voltage and current in a resistive device
4.2	Describe the characteristics of a coil connected to an AC circuit
4.3	Describe the inductance and characteristics of a coil connected to a DC circuit
4.4	Describe capacitance and characteristics of a capacitor connected to a DC circuit
4.5	Describe the characteristics of a capacitor connected to an AC circuit
4.6	Describe and explain resonant circuits (RLC)

Number:	S3216.5		
Title:	**Motors and Generators**		
Duration:	Total Hours: 5	Theory: 5	Practical: 0
Cross-Reference to Training Standard: 6556.05, 6556.08; 6557.01, 6557.03			

General Learning Outcomes

Upon successful completion the apprentice is able to describe the operating characteristics of motors and generators according to manufacturer's recommendations and specifications.

Learning Outcomes and Content

5.1 Describe the operating characteristics, construction and applications of DC machines

- explain the operation and characteristics of DC motors and generators
- identify parts including but not limited to commutator, mainframe, pole pieces and armature
- identify types of windings including but not limited to series, shunt and compound
- describe the relevant name plate information
- explore the operating characteristics of various DC motors and generators

5.2 Explain the fundamentals, applications and operating principles of AC machines

- identify terms including but not limited to motor action, rotating magnetic field, armature rotation, simple AC motor
- identify single phase components including but not limited to housings, rotors, windings, bearings, bushings and springs
- identify components used in 3 phase motors
- describe the operating characteristics of AC motors
- define terms related to electromagnetism including but not limited to induction, factors that determine induced EMF strength, effects of motion on direction of current
- describe the construction features of AC alternators including but not limited to windings, field poles, slip rings, armature, brushes, springs and holders
- explain the operating principles of AC alternators including but not limited to direction of induced voltage, Fleming's right hand rule, induced voltage and current, voltage output waveform and commutation

Number:	S3217		
Title:	**Instrumentation II**		
Duration:	Total Hours: 69	Theory: 35	Practical: 34
Content:	S3217.1	Instrumentation Test Equipment	
	S3217.2	Pressure Measurement	
	S3217.3	Level Measurement	
	S3217.4	Temperature Measurement	
	S3217.5	Flow Measurement	
	S3217.6	Secondary Process Measurement	
Evaluation & 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.		

Number:	S3217.1		
Title:	**Instrumentation Test Equipment**		
Duration:	Total Hours: 5	Theory: 1	Practical: 4

Cross-Reference to Training Standard: 6551.05, 6551.06, 6551.07, 6551.09, 6551.10; 6552.01, 6552.03, 6552.04, 6552.05, 6552.06, 6552.07, 6552.08; 6553.01, 6553.02, 6553.04; 6554.04; 6556.01, 6556.02, 6556.04, 6556.05; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05, 6557.06

General Learning Outcomes

Upon successful completion the apprentice is able to configure/calibrate process measuring devices using prescribed test equipment according to manufacturer's recommendations and specifications.

Learning Outcomes and Content

1.1 Identify the types and application of instrumentation test equipment including but not limited to:
- process calibrator
- calibration standards

1.2 Describe the operational features of instrumentation test equipment

1.3 Calibrate process measuring devices using prescribed instrumentation test equipment

Number:	S3217.2		
Title:	**Pressure Measurement**		
Duration:	Total Hours: 10	Theory: 5	Practical: 5

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.08, 6551.09, 6551.10; 6552.01, 6552.02, 6552.03, 6552.04, 6552.05, 6552.06, 6552.07, 6552.08; 6553.01, 6553.02, 6553.03; 6556.01, 6556.02, 6556.04, 6556.05; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05, 6557.06

General Learning Outcomes

Upon successful completion the apprentice is able to wire, connect, test, configure/calibrate and troubleshoot pressure measurement devices as applied to instrumentation according to manufacturer's recommendations.

Learning Outcomes and Content

2.1 Describe the fundamentals and characteristics of pressure measurement
- explain important considerations in pressure measurement
- define Charles', Pascal's and Boyle's gas laws and the combined gas law

2.2 Explain the operating principles of pressure measuring devices
- list and describe isolation methods
- identify means of protecting pressure sensors from hazardous environments

2.3 Install, configure/calibrate and troubleshoot pressure measuring instruments using calibration standards
- perform instrumentation calibration for pressure measuring devices
- install pressure measuring devices
- configure pressure transmitters
- document calibration results

Number:	S3217.3		
Title:	**Level Measurement**		
Duration:	Total Hours: 12	Theory: 6	Practical: 6

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.09, 6551.10; 6552.01, 6552.03, 6552.04, 6552.05, 6552.06, 6552.07, 6552.08; 6553.01, 6553.02, 6553.03, 6553.08; 6556.01, 6556.02, 6556.04, 6556.05; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05, 6557.06

General Learning Outcomes

Upon successful completion the apprentice is able to wire, connect, test, configure/calibrate and troubleshoot level measurement devices as applied to instrumentation according to manufacturer's recommendations.

Learning Outcomes and Content

3.1 Describe the fundamentals and characteristics of level measurement including but not limited to:

- ultrasonic
- radar
- laser
- nuclear
- weight systems including but not limited to strain gauges and load cells
- buoyancy

3.2 Explain the operation principles of level measuring devices

- identify means of protecting level sensors from hazardous environments
- explain factors that affect level measurement including but not limited to specific gravity, equipment location and pressure
- explain important considerations in level measurement applications
- describe weight systems used for level measurement including but not limited to strain gauges and load cells

3.3 Install, configure/calibrate and troubleshoot level measuring instruments using appropriate standards

- perform instrumentation calibration for level measuring devices
- install level measuring instruments
- configure level transmitters
- document calibration results

Number:	S3217.4		
Title:	**Temperature Measurement**		
Duration:	Total Hours: 12	Theory: 6	Practical: 6

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.09, 6551.10; 6552.01, 6552.03, 6552.04, 6552.05, 6552.06, 6552.07, 6552.08; 6553.01, 6553.02, 6553.03; 6556.04, 6556.05; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05, 6557.06

General Learning Outcomes

Upon successful completion the apprentice is able to wire, connect, test, configure/calibrate and troubleshoot temperature measuring devices as applied to instrumentation according to manufacturer's recommendations.

Learning Outcomes and Content

4.1 Describe the fundamentals and characteristics of temperature measurement

- define the common units of heat energy
- explain the specific heat of a liquid
- explain latent heat
- describe the temperature scales and their relationships

4.2 Explain the operating principles of temperature measuring devices

- explain the physics of infrared radiation thermometers and disappearing filament pyrometers
- explain the operating principles of temperature measuring elements including but not limited to:
  - thermocouples
  - RTDs
  - thermistors
  - filled systems
  - semi-conductor
  - bimetallic

4.3 Explain the operating principles of temperature measuring devices

- explain the physics of infrared radiation thermometers and disappearing filament pyrometers
- explain the operating principles of temperature measuring elements including but not limited to:
  - thermocouples
  - RTDs
  - thermistors
  - filled systems
  - semi-conductor
  - bimetallic
- describe the function and use of thermowells
- describe thermocouple measurement circuits
- explain considerations in the use of different types of temperature elements in various applications
- explain important considerations in temperature measurement applications
- list and describe accessory isolation methods

4.4 Install, configure/calibrate and troubleshoot temperature measuring instruments using calibration standards

- perform instrumentation calibration for temperature measuring devices
- install temperature measuring instruments
- configure temperature transmitters
- document calibration results

Number:	S3217.5		
Title:	**Flow Measurement**		
Duration:	Total Hours: 20	Theory: 12	Practical: 8

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.09, 6551.10; 6552.01, 6552.03, 6552.04, 6552.05, 6552.06, 6552.07, 6552.08; 6553.01, 6553.02, 6553.03, 6553.07, 6553.08, 6553.09; 6556.01, 6556.02, 6556.04, 6556.05; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05, 6557.06

General Learning Outcomes

Upon successful completion the apprentice is able to wire, connect, test, configure/calibrate and troubleshoot flow measuring devices as applied to instrumentation according to manufacturer's recommendations.

Learning Outcomes and Content

5.1 Describe the fundamentals and characteristics of flow measurement

- define the common units of flow measurement
- head, magnetic and mechanical flow meters
- positive displacements

5.2 Explain the operating principles of flow measuring devices

- explain important considerations in flow measurement applications
- list and describe accessory signal conditioning devices
- identify means of protecting flow sensors from hazardous environments
- explain factors that affect fluid flow including but not limited to viscosity, meter location and fluid medium
- explain the function and use of impulse lines and isolation manifolds

5.3 Install, configure/calibrate and troubleshoot flow measuring instruments using calibration standards

- perform instrumentation calibration for flow measuring devices
- install flow measuring instruments
- configure flow transmitters
- document calibration results

Number:	S3217.6		
Title:	**Secondary Process Measurement**		
Duration:	Total Hours: 10	Theory: 5	Practical: 5

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.09, 6551.10; 6552.01, 6552.03, 6552.04, 6552.05, 6552.06, 6552.07, 6552.08; 6553.04, 6553.05, 6553.06, 6553.07, 6553.08, 6553.09; 6554.01, 6554.02, 6554.03, 6554.04; 6555.01; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05, 6557.06

General Learning Outcomes

Upon successful completion the apprentice is able to wire, connect, test, configure/calibrate and troubleshoot secondary process measurement as applied to instrumentation according to manufacturer's recommendations.

Learning Outcomes and Content

6.1 Describe the fundamentals and characteristics of secondary process measurement including but not limited to:

- density
- viscosity
- weight
- vibration
- turbidity
- opacity
- moisture and humidity
- speed
- position
- consistency
- pH

6.2 Explain the operating principles of secondary process measurement

- list and describe accessory signal conditioning devices
- identify means of protecting sensors from hazardous environments

6.3 Install, configure/calibrate and troubleshoot secondary process measurement instruments using calibration standards

- perform instrumentation calibration for secondary process measurement devices
- install secondary process measurement instruments
- configure secondary process measurement transmitters
- document calibration results

Number:	S3218		
Title:	**Instrumentation Controls I**		
Duration:	Total Hours: 63	Theory: 31	Practical: 32
Content:	S3218.1	Final Control Elements	
	S3218.2	Control System Fundamentals	
	S3218.3	Valve Positioners	
	S3218.4	Troubleshoot Control Valves	
Evaluation & 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.		

Number:	S3218.1		
Title:	**Final Control Elements**		
Duration:	Total Hours: 16	Theory: 10	Practical: 6

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.09, 6551.10; 6552.01, 6552.03, 6552.04, 6552.05, 6552.06, 6552.07, 6552.08; 6556.01, 6556.02, 6556.03, 6556.04, 6556.05, 6556.06, 6556.07, 6556.08; 6557.04, 6557.05, 6557.06; 6558.01, 6558.02, 6558.03, 6558.04, 6558.05, 6558.06, 6558.07, 6558.08

General Learning Outcomes

Upon successful completion the apprentice is able to disassemble, assemble, stroke, size and select various types of valves according to manufacturer's recommendations.

Learning Outcomes and Content

1.1 Identify various types and applications of control valves and actuators

- control valve bodies and their process applications
- valve trim and their process applications
- valve packing and their process applications
- valve guiding
- I/P
- self-regulating valves including but not limited to:
  - temperature
  - pressure
- valve actuators including but not limited to:
  - diaphragm
  - piston
  - electric and electro-hydraulic
- describe the advantages and limitations of various types of valve actuators

1.2 Disassemble and assemble control valve assemblies

1.3 Stroke control valve assemblies

1.4 Size and select control valves for various applications

- explain the meaning of valve coefficient (CV)

Number:	S3218.2		
Title:	**Control System Fundamentals**		
Duration:	Total Hours: 30	Theory: 15	Practical: 15

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.09, 6551.10; 6552.04, 6552.05, 6552.07, 6552.08; 6559.01, 6559.02, 6559.03, 6559.04, 6559.05

General Learning Outcomes

Upon successful completion the apprentice is able to wire, connect and tune on/off control systems and proportional, integral and derivative control systems (PID).

Learning Outcomes and Content

2.1 Explain the principles of on/off control and identify the four basic elements of a control system
- process control principles and limitations

2.2 Identify the fundamentals and applications of controllers
- identify terminology that applies process controllers
- identify and become familiar with the various types of controllers
- define PID control modes
  - proportional
  - integral
  - derivative

2.3 Identify various controller options
- identify control device adjustment procedures for various types of controllers
- identify indicators for various types of controllers

2.4 Define and explain the principle of proportional, integral and derivative control

2.5 Explain the advantages and limitations of using proportional, integral and derivative control
- process control principles and limitations

2.6 Wire, connect and tune and on/off control system

2.7 Wire, connect and tune and PID control system

Number:	S3218.3		
Title:	**Valve Positioners**		
Duration:	Total Hours: 10	Theory: 4	Practical: 6

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.09, 6551.10; 6552.01, 6552.03, 6552.04, 6552.05, 6552.06, 6552.07, 6552.08; 6556.01, 6556.02, 6556.03, 6556.04, 6556.05, 6556.06, 6556.07, 6556.08; 6557.04, 6557.05, 6557.06; 6558.01, 6558.02, 6558.03, 6558.04, 6558.05, 6558.06

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate the ability, install, calibrate and troubleshoot various types of control valve positioners according to manufacturer's recommendations and specifications.

Learning Outcomes and Content

3.1 Identify various types and applications of valve positioners
- describe the characteristics of valve positioners
- pneumatic positioners
- electric positioners
- digital smart positioners

3.2 Explain the operating principles of valve positioners
- pneumatic valve positioner operation
- electronic positioner operation
- digital smart positioner operation

3.3 Install and calibrate various valve positioners
- determine calibration values for positioners used in split range applications

Number:	S3218.4		
Title:	**Troubleshoot Control Valves**		
Duration:	Total Hours: 7	Theory: 2	Practical: 5

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.09, 6551.10; 6552.01, 6552.03, 6552.04, 6552.05, 6552.06, 6552.07, 6552.08; 6556.01, 6556.02, 6556.03, 6556.04, 6556.05, 6556.06, 6556.07, 6556.08; 6557.04, 6557.05, 6557.06; 6558.01, 6558.02, 6558.03, 6558.04, 6558.05, 6558.06

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate the ability to troubleshoot common valve problems according to manufacturer's recommendations.

Learning Outcomes and Content

4.1 Identify common control valve problems

4.2 Perform troubleshooting procedures to diagnose common control valve problems

Number:	S3219		
Title:	**Discrete Control**		
Duration:	Total Hours: 27	Theory: 16	Practical: 11
Content:	S3219.1	Introduction to Discrete Control	
	S3219.2	Control System Electrical Schematics	
	S3219.3	Discrete Control Wiring	
Evaluation & 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.		

Number:	S3219.1		
Title:	**Introduction to Discrete Control**		
Duration:	Total Hours: 6	Theory: 6	Practical: 0
Cross-Reference to Training Standard: 6552.01, 6552.04, 6552.05; 6556.04, 6556.05; 6559.01			

General Learning Outcomes

Upon successful completion the apprentice is able to identify and describe discrete control devices and circuits used in the Instrumentation and Control Industry.

Learning Outcomes and Content

1.1 Explain the fundamentals of discrete on/off control

- input devices including but not limited to:
  - limit/reed switches
  - selector switches
  - control relays
  - temperature switches
  - pressure switches
  - level switches
  - timers
- output devices including but not limited to:
  - starters
  - solenoids
  - relays

1.2 Identify limit control devices including but not limited to high/low alarms

1.3 Describe the timing and sequencing circuits in conjunction with control devices

- limit/reed switches
- selector switches
- control relays
- temperature switches
- pressure switches
- level switches
- timers

1.4 Interpret manufacturer’s data sheets and specifications

Number:	S3219.2		
Title:	**Control System Electrical Schematics**		
Duration:	Total Hours: 2	Theory: 2	Practical: 0
Cross-Reference to Training Standard: 6552.01, 6552.04, 6552.05; 6556.05; 6559.01			

General Learning Outcomes

Upon successful completion the apprentice is able to read, interpret and draw control system electrical schematics for electrical control circuits that interface with electric controls.

Learning Outcomes and Content

2.1 Read and interpret electrical schematic and wiring diagrams associated with complex control operations i.e. timing and sequencing

2.2 Draw electrical schematic and wiring diagrams associated with complex control operations i.e. timing and sequencing

Number:	S3219.3		
Title:	**Discrete Control Wiring**		
Duration:	Total Hours: 19	Theory: 8	Practical: 11

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.09, 6551.10; 6552.04, 6552.05, 6552.06, 6552.07; 6553.01, 6553.02, 6553.03, 6553.05, 6553.06; 6555.01, 6555.03, 6555.04, 6555.05; 6556.04, 6556.05; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05, 6557.06

General Learning Outcomes

Upon successful completion the apprentice is able to install and connect discrete controls using various devices.

Learning Outcomes and Content

3.1 Install and connect timing and sequencing circuits in conjunction with devices including but not limited to:

- limit/reed switches
- selector switches
- control relays
- temperature switches
- pressure switches
- level switches
- timers

3.2 Install and connect discrete control components

Number:	S3220	
Title:	**Computer Control Systems**	
Duration:	Total Hours: 48	Theory: 15 Practical: 33
Content:	S3220.1	Introduction to PLC, DCS and Supervisory Control and SCADA Systems
	S3220.2	Electrical Circuits and Ladder Programs
	S3220.3	Configuration and Programming
	S3220.4	Control System Troubleshooting
	S3220.5	System Configuration, Interfacing and Communications
Evaluation & 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.	

Number:	S3220.1		
Title:	**Introduction to Programmable Logic Controllers (PLC) Distributed Control Systems (DCS) and Supervisory Control and Data Acquisition (SCADA) Systems**		
Duration:	Total Hours: 8	Theory: 4	Practical: 4
Cross-Reference to Training Standard: 6551.07, 6551.10; 6552.04, 6552.05, 6552.08; 6559.01, 6559.02, 6559.07, 6559.10, 6559.16			

General Learning Outcomes

Upon successful completion the apprentice is able to describe Programmable Logic Controllers (PLC), Distributed Control Systems (DCS), Supervisory Control and Data Acquisition (SCADA) and related communication systems.

Learning Outcomes and Content

1.1 Define the following control systems
- Programmable Logic Controllers (PLC)
- Distributed Control Systems (DCS)
- Supervisory Control and Data Acquisition (SCADA)

1.2 Describe the architecture of control systems
- Programmable Logic Controllers (PLC)
- Distributed Control Systems (DCS)
- Supervisory Control and Data Acquisition (SCADA)

1.3 Explain the concept of addressing

1.4 Explain program flow and faults

1.5 Explain trending as used in automated control systems

1.6 Produce a block diagram of a PLC, DCS or SCADA system

1.7 Identify and describe inter-computer communication strategies and hardware used by PLC and DCS's
- Configure operational software for a PLC and/or DCS

Number:	S3220.2		
Title:	**Electrical Circuits and Ladder Programs**		
Duration:	Total Hours: 13	Theory: 4	Practical: 9

Cross-Reference to Training Standard: 6551.07, 6551.10; 6552.04, 6552.05, 6552.08; 6559.01, 6559.02, 6559.07

General Learning Outcomes

Upon successful completion the apprentice is able to interpret electrical circuits; design, program and test ladder programs for Programmable Logic Controllers (PLC).

Learning Outcomes and Content

2.1 Read and interpret ladder programs

2.2 Design, build and test ladder programs

Number:	S3220.3		
Title:	**Configuration and Programming**		
Duration:	Total Hours: 14	Theory: 3	Practical: 11

Cross-Reference to Training Standard: 6551.05, 6551.07, 6551.10; 6552.04, 6552.05, 6552.08; 6559.01, 6559.02, 6559.07

General Learning Outcomes

Upon successful completion the apprentice is able to configure and program Programmable Logic Controllers (PLC) and/or Distributed Control Systems (DCS) according to operating specifications.

Learning Outcomes and Content

3.1 Configure and program discrete control systems

3.2 Configure function blocks

3.3 Program basic logic functions, timing instructions and counters

3.4 Select specified Input and Output modules for a given application

3.5 Upload, download and run programs from computer to PLC and/or DCS

Number:	S3220.4		
Title:	**Control System Troubleshooting**		
Duration:	Total Hours: 10	Theory: 2	Practical: 8

Cross-Reference to Training Standard: 6551.01, 6551.05, 6551.06, 6551.07, 6551.10; 6552.01, 6552.04, 6552.05, 6552.08; 6556.04, 6556.05; 6557.01, 6557.02, 6557.03, 6557.04; 6559.07, 6559.08, 6559.10, 6559.11, 6559.12, 6559.15

General Learning Outcomes

Upon successful completion the apprentice is able to troubleshoot Programmable Logic Controllers (PLC) and Distributed Control Systems (DCS) according to operating specifications.

Learning Outcomes and Content

4.1 Identify hardware and/or software problems for PLC and DCS systems

4.2 Troubleshoot PLC and DCS systems

Number:	S3220.5		
Title:	**System Configuration, Interfacing and Communications**		
Duration:	Total Hours: 3	Theory: 2	Practical: 1

Cross-Reference to Training Standard: 6551.05, 6551.07; 6552.04, 6552.05, 6552.08; 6557.01, 6557.02, 6557.03, 6557.04; 6559.07, 6559.08, 6559.10, 6559.11

General Learning Outcomes

Upon successful completion the apprentice is able to commission and troubleshoot computer communication set-up procedures for Programmable Logic Controllers (PLC), Distributed Control Systems (DCS) and related communication systems.

Learning Outcomes and Content

5.1 Set up communications among computers, PLC and DCS

5.2 Set up networks among workstations, multiple PLC and DCS

- Explain Transmission Control Protocol/Internet Protocol (TCP/IP) and its use on computerized systems

Level 3

Reportable Subject Summary – Level 3

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practical
S3221: Applied Circuits				
S3221.1	Solid State Devices	6	6	0
S3221.2	Power Supply, Regulation and Amplifiers	13	5	8
S3221.3	Switching Circuit Devices	6	4	2
S3221.4	Manufacturer's Connection Schematics and Diagrams	7	4	3
S3221.5	Final Control Elements	10	4	6
	Sub Total	**42**	**23**	**19**
S3222: Advanced PLC and DCS				
S3222.1	PLC and DCS Control Systems	40	10	30
S3222.2	PLC/DCS Control Problem Solving Techniques	17	4	13
	Sub Total	**57**	**14**	**43**
S3223: Instrumentation Controls II				
S3223.1	Control Tuning	13	5	8
S3223.2	Control Systems	49	29	20
S3223.3	Industrial Networks and Data Transfer Methods	16	10	6
S3223.4	Troubleshooting Control Systems	6	2	4
S3223.5	Safety Systems	6	6	0
	Sub Total	**90**	**52**	**38**
S3224: Analytical Instrumentation				
S3224.1	Introduction to Analyzers and Analytics Process Measurement	24	24	0
S3224.2	Analyzer Sampling System	6	6	0
S3224.3	Analyzer Calibration and Maintenance	6	2	4
	Sub Total	**36**	**32**	**4**
S3225: Fluid Power Systems				
S3225.1	Fundamentals of Fluid Power Systems	4	4	0
S3225.2	Hydraulic Systems	4	4	0
S3225.3	Pneumatic Systems	7	5	2
	Sub Total	**15**	**13**	**2**
	Level 3 Totals	**240**	**134**	**106**

Number:	S3221		
Title:	**Applied Circuits**		
Duration:	Total Hours: 42	Theory: 23	Practical: 19
Content:	S3221.1	Solid State Devices	
	S3221.2	Power Supply, Regulation and Amplifiers	
	S3221.3	Switching Circuit Devices	
	S3221.4	Manufacturer's Connection Schematics and Diagrams	
	S3221.5	Final Control Elements	
Evaluation & 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.		

Number:	S3221.1		
Title:	**Solid State Devices**		
Duration:	Total Hours: 6	Theory: 6	Practical: 0
Cross-Reference to Training Standard: 6552.04, 6552.05; 6556.05			

General Learning Outcomes

Upon successful completion the apprentice is able to identify symbols and explain the operation of solid state devices.

Learning Outcomes and Content

1.1 Identify the symbols used for solid state devices including but not limited to:
- silicon controlled rectifiers, Triacs
- operational amplifiers
- optocoupler

1.2 Explain the operating principles of solid state devices including but not limited to:
- silicon controlled rectifiers, Triacs
- operational amplifiers
  - explain the operation of a constant current generator
  - explain the term impedance
  - explain the operation of a current source
- optocoupler

Number:	S3221.2		
Title:	**Power Supply, Regulation and Amplifiers**		
Duration:	Total Hours: 13	Theory: 5	Practical: 8

Cross-Reference to Training Standard: 6551.05, 6551.06, 6551.07, 6551.10; 6552.01, 6552.03, 6552.04, 6552.05; 6556.04, 6556.05

General Learning Outcomes

Upon successful completion the apprentice is able to test and troubleshoot power supplies and amplifiers according to manufacturer's recommendations and specifications.

Learning Outcomes and Content

2.1 Describe the function of components of voltage regulators, power supplies and amplifier components

2.2 Explain the operating principles of a power supply regulation circuit
- drill presses
- band saws
- nibblers
- ironworkers
- punching
- notching
- cutting

2.3 Explain the operating principles of operational amplifier circuits including but not limited to:
- constant current source
- inverting
- non-inverting
- voltage followers
- summers
- substracters
- integrator
- differentiator
- PID

2.4 Test and troubleshoot power supplies and power supply regulators

2.5 Test and troubleshoot open collector/emitter outputs

2.6 Test and troubleshoot operational amplifier circuits

Number:	S3221.3		
Title:	**Switching Circuit Devices**		
Duration:	Total Hours: 6	Theory: 4	Practical: 2

Cross-Reference to Training Standard: 6551.05, 6551.06, 6551.07, 6551.10; 6552.01, 6552.03, 6552.04, 6552.05; 6556.04, 6556.05

General Learning Outcomes

Upon successful completion the apprentice is able to test and troubleshoot switching devices according to manufacturer's recommendations and specifications.

Learning Outcomes and Content

3.1 Describe the electrical characteristics of switching circuit devices including but not limited to:
- relays
- opto-devices
- transistors
  - sinking
  - sourcing

3.2 Explain the operating principles of switching circuit devices including but not limited to:
- explain the operation of different types of relays
- explain the operation of different opto-devices used in switching circuits
- explain the operation of transistors used in switching circuits

3.3 Test and troubleshoot switching devices

Number:	S3221.4		
Title:	**Manufacturer's Connection Schematics and Diagrams**		
Duration:	Total Hours: 7	Theory: 4	Practical: 3
Cross-Reference to Training Standard: 6552.04, 6552.05, 6552.08; 6558.07, 6558.08			

General Learning Outcomes

Upon successful completion the apprentice is able to trace and interpret schematics and diagrams for motor drives and process loops according to manufacturer's recommendations and specifications.

Learning Outcomes and Content

4.1 Identify manufacturer's connection schematics and diagrams for:
- process loops
- DC drives
- AC drives

4.2 Trace and interpret the circuits of manufacturer's connection schematics and diagrams for:
- Process loops
- DC drives
- AC drives

Number:	S3221.5		
Title:	**Final Control Elements**		
Duration:	Total Hours: 10	Theory: 4	Practical: 6

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.09, 6551.10; 6552.01, 6552.03, 6552.04, 6552.05, 6552.06, 6552.07, 6552.08; 6556.01, 6556.02, 6556.03, 6556.04, 6556.05, 6556.06, 6556.07, 6556.08; 6557.04, 6557.05, 6557.06; 6558.01, 6558.02, 6558.03, 6558.04, 6558.05, 6558.06, 6558.07, 6558.08

General Learning Outcomes

Upon successful completion the apprentice is able to test and troubleshoot switching devices according to manufacturer's recommendations and specifications.

Learning Outcomes and Content

5.1 Describe the construction features of final control elements including but not limited to:
- control valves
- chemical metering pumps
- servomotors
- Variable Frequency Drives (VFDs)

5.2 Explain the operating principles of final control elements including but not limited to:
- control valves
- chemical metering pumps
- servomotors
- Variable Frequency Drives (VFDs)

5.3 Configure, connect and test control wiring for final control elements including but not limited to:
- control valves
- chemical metering pumps
- servomotors
- Variable Frequency Drives (VFDs)

Number:	S3222		
Title:	**Advanced PLC and DCS**		
Duration:	Total Hours: 57	Theory: 14	Practical: 43
Content:	S3222.1	PLC and DCS Control Systems	
	S3222.2	PLC/DCS Control Problem Solving Techniques	
Evaluation & 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.		

Number:	S3222.1		
Title:	**PLC and DCS Control Systems**		
Duration:	Total Hours: 40	Theory: 10	Practical: 30

Cross-Reference to Training Standard: 6551.01, 6551.05, 6551.06, 6551.07, 6551.10; 6552.01, 6552.04, 6552.05, 6552.08; 6556.04, 6556.05; 6557.01, 6557.02, 6557.03, 6557.04; 6559.06, 6559.07, 6559.08, 6559.09, 6559.10, 6559.11, 6559.12, 6559.13, 6559.14, 6559.15

General Learning Outcomes

Upon successful completion the apprentice is able to configure and program Programmable Logic Controllers (PLC) and/or Distributed Control Systems (DCS).

Learning Outcomes and Content

1.1 Describe the architecture and operation of advanced control systems
- Programmable Logic Controllers (PLC)
- Distributed Control Systems (DCS)
- explain the concept of scaling analog signals

1.2 Plan and organize a PLC/DCS project
- select required hardware
- select programming format

1.3 Use Human-Machine Interface (HMI) to display data and control processes

1.4 Configure and program PLC and DCS
- identify the appropriate PLC/DCS I/O
- configure bus structures for the PLC/DCS controllers and I/O modules
- identify and manipulate the numerical information as required for PLC/DCS functions including but not limited to:
  - scaling
  - signal conditioning
- program Graphical User Interfaces (GUI) using various software for a PLC/DCS
- configure PLC/DCS multi-loop control strategies

Number:	S3222.2		
Title:	**PLC/DCS Control Problem Solving Techniques**		
Duration:	Total Hours: 17	Theory: 4	Practical: 13

Cross-Reference to Training Standard: 6551.01, 6551.05, 6551.06, 6551.07, 6551.10; 6552.01, 6552.04, 6552.05, 6552.08; 6556.04, 6556.05; 6557.01, 6557.02, 6557.03, 6557.04; 6559.06, 6559.07, 6559.08, 6559.09, 6559.10, 6559.11, 6559.12, 6559.13, 6559.14, 6559.15

General Learning Outcomes

Upon successful completion the apprentice is able to troubleshoot PLC/DCS system.

Learning Outcomes and Content

2.1 Apply diagnostics software tools to solve PLC/DCS problems

2.2 Troubleshoot PLC/DCS systems

2.3 Troubleshoot industrial PLC control problems

Number:	S3223			
Title:	**Instrumentation Controls II**			
Duration:	Total Hours: 90		Theory: 52	Practical: 38
Content:	S3223.1	Control Tuning		
	S3223.2	Control Systems		
	S3223.3	Industrial Networks and Data Transfer Methods		
	S3223.4	Troubleshooting Control Systems		
	S3223.5	Safety Systems		
Evaluation & 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.			

Number:	S3223.1		
Title:	**Control Tuning**		
Duration:	Total Hours: 13	Theory: 5	Practical: 8
Cross-Reference to Training Standard: 6559.01, 6559.02, 6559.04, 6559.05			

General Learning Outcomes

Upon successful completion the apprentice is able to tune controllers using a variety of methods according to industry standards.

Learning Outcomes and Content

1.1 Identify various methods of controller tuning

1.2 Tune controllers using a variety of tuning methods
- calculate controller settings
- tune controllers using various prescribed methods
- implement auto tune if available

Number:	S3223.2		
Title:	**Control Systems**		
Duration:	Total Hours: 49	Theory: 29	Practical: 20

Cross-Reference to Training Standard: 6551.01, 6551.04, 6551.05, 6551.06, 6551.07, 6551.10; 6552.01, 6552.03, 6552.04, 6552.05, 6552.06, 6552.07, 6552.08; 6553.01, 6553.02, 6553.03, 6553.04, 6553.07, 6553.08; 6554.01, 6554.02, 6554.04; 6655.01, 6655.02, 6655.03, 6655.04; 6556.01, 6556.02, 6556.04, 6556.05, 6556.06, 6556.07; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05; 6558.01, 6558.02, 6558.03, 6558.04, 6558.05, 6558.06, 6558.07, 6558.08; 6559.01, 6559.02, 6559.03, 6559.04, 6559.05, 6559.07, 6559.08, 6559.10, 6559.11, 6559.14, .15, 6559.16

General Learning Outcomes

Upon successful completion the apprentice is able to assemble, commission and tune control systems and components found in industry.

Learning Outcomes and Content

2.1 Identify and describe control system types and applications

- common industry controls including but not limited to:
  - combustion controls
  - Heating Ventilation and Air Conditioning controls (HVAC)
  - boiler controls
  - power plant controls
- computer controls
  - distributed controls
  - supervisory controls
  - data acquisition
  - direct digital controls

2.2 Describe the features and applications of cascade controls

- cascade control features
- cascade control applications
- prepare loop drawings of cascade controls

2.3 Describe the features and applications of ratio controls

- ratio control features
- ratio control applications
- prepare loop drawings of ratio controls

2.4 Describe the features and applications of feed-forward controls
- feed-forward control features
- feed-forward control applications
- prepare loop drawings of feed-forward controls

2.5 Assemble, commission and tune control systems including but not limited to:
- cascade control loop
- ratio control loop

Number:	S3223.3		
Title:	**Industrial Networks and Data Transfer**		
Duration:	Total Hours: 16	Theory: 10	Practical: 6

Cross-Reference to Training Standard: 6551.05; 6552.01, 6552.03, 6552.04, 6552.05, 6552.07, 6552.08; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05, 6557.06; 6559.07, 6559.10, 6559.14, 6559.16

General Learning Outcomes

Upon successful completion the apprentice is able to describe, commission and troubleshoot industrial networks and data transfer methods.

Learning Outcomes and Content

3.1 Network Topologies and Protocols

3.2 Identify various types and limitations of Network Topologies and Protocols

3.3 Commission and troubleshoot communication cables and connectors

3.4 Configure different types of network protocols

Number:	S3223.4		
Title:	**Troubleshooting Control Systems**		
Duration:	Total Hours: 5	Theory: 1	Practical: 4

Cross-Reference to Training Standard: 6551.01, 6551.04, 6551.05, 6551.06, 6551.07, 6551.10; 6552.01, 6552.04, 6552.05, 6552.07, 6552.08; 6553.02, 6553.05, 6553.08; 6554.02; 6555 .04; 6556.02, 6556.05, 6556.07; 6557.03, 6557.05; 6558.02, 6558.04, 6558.06, 6558.08; 6559.01, 6559.05, 6559.08, 6559.11, 6559.15, 6559.16

General Learning Outcomes

Upon successful completion the apprentice is able to troubleshoot control systems.

Learning Outcomes and Content

4.1 Troubleshoot control systems

- identify and determine problems using loop diagrams
- recognize symptoms and their causes

Number:	S3223.5		
Title:	**Safety Systems**		
Duration:	Total Hours: 6	Theory: 6	Practical: 0

Cross-Reference to Training Standard: 6551.01, 6551.04, 6551.05, 6551.06, 6551.07, 6551.10; 6552.01, 6552.03, 6552.04, 6552.05, 6552.06, 6552.07, 6552.08; 6553.01, 6553.02, 6553.03, 6553.04, 6553.07, 6553.08; 6554.01, 6554.02, 6554.04; 6555.01, 6555.02, 6555.04; 6556.01, 6556.02, 6556.04, 6556.05, 6556.06, 6556.07; 6557.01, 6557.02, 6557.03, 6557.04, 6557.05; 6558.01, 6558.02, 6558.03, 6558.04, 6558.05, 6558.06, 6558.07, 6558.08; 6559.01, 6559.02, 6559.03, 6559.04, 6559.05, 6559.07, 6559.08, 6559.10, 6559.11, 6559.14, 6559.15, 6559.16

General Learning Outcomes

Upon successful completion the apprentice is able to assemble, commission and tune control systems and components found in industry.

Learning Outcomes and Content

5.1 Identify and describe control system types and applications

- common industry controls including but not limited to:
  - combustion controls
  - Heating Ventilation and Air Conditioning controls (HVAC)
  - boiler controls
  - power plant controls
- computer controls
  - distributed controls
  - supervisory controls
  - data acquisition
  - direct digital controls

5.2 Describe the features and applications of cascade controls

- cascade control features
- cascade control applications
- prepare loop drawings of cascade controls

5.3 Describe the features and applications of ratio controls

- ratio control features
- ratio control applications
- prepare loop drawings of ratio controls

5.4 Describe the features and applications of feed-forward controls
- feed-forward control features
- feed-forward control applications
- prepare loop drawings of feed-forward controls

5.5 Assemble, commission and tune control systems including but not limited to:
- cascade control loop
- ratio control loop

Number:	S3224	
Title:	**Analytical Instrumentation**	
Duration:	Total Hours: 36	Theory: 32 Practical: 4
Content:	S3224.1	Introduction to Analyzers and Analytics Process Measurement
	S3224.2	Analyzer Sampling System
	S3224.3	Analyzer Calibration and Maintenance
Evaluation & 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.	

Number:	S3224.1
Title:	**Introduction to Analyzers and Analytics Process Measurement**
Duration:	Total Hours: 24 Theory: 24 Practical: 0

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.08, 6551.09, 6551.10; 6552.04, 6552.05; 6554.01, 6554.02, 6554.03, 6554.04; 6555.01, 6555.02, 6555.03, 6555.04

General Learning Outcomes

Upon successful completion the apprentice is able to describe the operating principles of analyzers.

Learning Outcomes and Content

1.1 Describe the principles and operations of analyzers including but not limited to:

- PH/ORP and conductivity
- turbidity
- humidity
- oxygen
- opacity
- chromatography
- spectroscopy
- vibration
- solid moisture
- thermal conductivity
- radiant energy absorption

Number:	S3224.2		
Title:	**Analyzer Sampling System**		
Duration:	Total Hours: 6	Theory: 6	Practical: 0

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.08, 6551.09, 6551.10; 6552.04, 6552.05; 6554.01, 6554.02, 6554.03, 6554.04; 6555.01, 6555.02, 6555.03, 6555.04

General Learning Outcomes

Upon successful completion the apprentice is able to describe the fundamentals of analyzer sampling systems.

Learning Outcomes and Content

2.1 Identify the necessary components for an analyzer sampling system

2.2 Identify the requirements for an appropriate sampling system

2.3 Describe the function of analyser sampling systems

Number:	S3224.3		
Title:	**Analyzer Calibration and Maintenance**		
Duration:	Total Hours: 6	Theory: 2	Practical: 4

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.05, 6551.06, 6551.07, 6551.08, 6551.09, 6551.10; 6552.04, 6552.05; 6554.01, 6554.02, 6554.03, 6554.04; 6555.01, 6555.02, 6555.03, 6555.04

General Learning Outcomes

Upon successful completion the apprentice is able to calibrate a variety of analyzers and describe recommended maintenance procedures.

Learning Outcomes and Content

3.1 Describe the maintenance procedures for analyzers

3.2 Calibrate analyzers using prescribed procedures

Number:	S3225			
Title:	**Fluid Power Systems**			
Duration:	Total Hours: 15		Theory: 13	Practical: 2
Content:	S3225.1	Fundamentals of Fluid Power Systems		
	S3225.2	Hydraulic Systems		
	S3225.3	Pneumatic Systems		
Evaluation & 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.			

Number:	S3225.1		
Title:	**Fundamentals of Fluid Power Systems**		
Duration:	Total Hours: 4	Theory: 4	Practical: 0

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.06, 6551.10; 6552.04, 6552.05; 6556.01, 6556.02, 6556.06, 6556.07; 6557.01, 6557.02, 6557.03; 6558.03, 6558.04

General Learning Outcomes

Upon successful completion the apprentice is able to describe the fundamentals and applications, draw symbols and identify the hazards of industrial fluid power systems according to manufacturer's recommendations.

Learning Outcomes and Content

1.1 Define the fundamentals of fluid power systems
- define fluid in terms of energy transmission
- state the advantages and disadvantages of hydraulics and pneumatics
- identify hydraulic servo to control systems

1.2 Identify fluid power system valve symbols to International Organization for Standardization (ISO) and American National Standards Institute (ANSI) standards

1.3 Identify the hazards and safety concerns of fluid power systems

Number:	S3225.2		
Title:	**Hydraulic Systems**		
Duration:	Total Hours: 4	Theory: 4	Practical: 0

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.06, 6551.10; 6552.04, 6552.05; 6556.01, 6556.02, 6556.06, 6556.07; 6557.03; 6558.03, 6558.04

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate the ability to describe the operating principles of industrial hydraulic systems.

Learning Outcomes and Content

2.1 Describe the applications of hydraulic systems

2.2 Describe the operating principles of hydraulic systems and components including but not limited to:

- hydraulic pumps
- hydraulic plungers and cylinders
- hydraulic control valves
- flow control devices
- pressure switches
- pressure gauges
- fans
- storage tanks

Number:	S3225.3		
Title:	**Pneumatic Systems**		
Duration:	Total Hours: 7	Theory: 5	Practical: 2

Cross-Reference to Training Standard: 6551.01, 6551.02, 6551.03, 6551.04, 6551.06, 6551.10; 6552.04, 6552.05; 6556.01, 6556.02; 6557.01, 6557.02, 6557.03; 6558.03, 6558.04

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate the ability to assemble and test industrial pneumatic systems.

Learning Outcomes and Content

3.1 Describe the use and applications of pneumatic systems

- pneumatic system air supply
  - compressors
  - motors
  - filters
  - dryers
  - dew point measurement
- pneumatic system components
  - filters
  - dryers
  - receivers
  - cylinders
  - pressure regulators

3.2 Explain the operating principles of pneumatic systems and components

- air supply systems
- air filtering, drying and oiling
- determine the function and layout of pneumatic circuits

3.3 Assemble and test basic pneumatic systems

APPENDIX A: Tools and Equipment List

Mandatory Equipment List for Training Delivery Agents – Level 1
Minimum Equipment Required

Safety glasses
Steel toe boots – CSA Certified
Variety of PPE as required
Digital Multi-Meter (DMM)
Variable DC power supply – 0 to 40 Vdc
Assorted resistors
Assorted electrical loads (lights, relays, solenoid valves)
Function generators
Various hand tools as required
Minimum software requirements (Word processor, Spreadsheet, CAD, presentation software)
Instrument tubing
Tubing bender, cutter, reamer
Assorted tube fittings, compression fittings, hand valves
Pressure standards – Inclined and U-tube manometers, pressure calibrator + 25%, Dead Weight Tester (DWT) and test gauges
Variety of temperature indicators (glass thermometers, bimetal, IR non-contact)
Variety of temperature elements (thermocouple, RTD, thermistor)
Variety of temperature switches
Variety of temperature transmitters
Flow indicators
Prototype board – Circuit assembly
Clamp-on Ammeter
Assorted transistors
Assorted diodes
Optocouplers
Oscillloscopes
Frequency counters
Pressure Regulating Valve (PRV)
Compressed air supply (2.5 cfm @ 90 psi minimum)
Variety of pressure indicators
Variety of pressure switches
Variety of pressure transmitters
Variety of level switches
Variety of level transmitters
Variety of flow switches
Variety of flow transmitters
DC supply (minimum 24Vdc @ 100mA)
Conduit threading tools and fittings

Mandatory Equipment List for Training Delivery Agents – Level 2
Minimum Equipment Required

Variety of capacitors, inductors, transformers, AC and DC motors
AC source – 120 Vac
Pressure Regulating Valve (PRV)
Variety of automatic control valves
Pneumatic rotary valve (butterfly or ball)
Piston actuators
I/P converters
Pneumatic calibrator
Variety of electronic standalone PID controllers
Proximity switches
Oscilloscope and X10 probe
Permanent magnets
Variety of analyzers
Pneumatic spring and diaphragm globe style
Cage guided control valve
Vane type actuators
Dial indicator
Variety of valve positioners
Variety of switches (SPST, SPDT, DPDT)
Time delay relay
Programmable Logic Controller (PLC) or Distributed Control System (DCS) – minimum 6
discrete inputs, 4 discrete outputs
Variety of input devices
Network cables, hub or router
Personal computer for program entry c/w PLC
software, network card
Variety of output devices
PLC or DCS communication cards

Mandatory Equipment List for Training Delivery Agents – Level 3
Minimum Equipment Required

Variety of diodes, bridge rectifiers, voltage regulators
Operational amplifiers
Variety of relays, contactors
Distributed Control System (DCS) - minimum 6
discrete inputs, 4 discrete outputs, 2 analog inputs, 2 analog outputs
Analytical calibration standards
Pneumatic cylinders
Variety of pneumatic sensors
Variety of final control elements (Triacs, SCRs, VFDs, etc.)
Optocouplers
Programmable Logic Controller (PLC) – minimum
6 discrete inputs, 4 discrete outputs, 2 analog inputs, 2 analog outputs
SMART instrumentation communicators
Manufacturer’s data sheets
Standalone pneumatic controllers and recorders

Resource Materials
Engineering specifications
Manufacturer’s specifications, manuals and charts
Safety manuals
Ontario Health and Safety Act (OHSA) Book

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Instrumentation and Control Technician