Apprenticeship and Industry Training

Instrumentation and Control Technician Apprenticeship Course Outline

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Alberta

Apprenticeship and Industry Training

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Instrumentation and Control Technician: apprenticeship course outline

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Instrumentation and Control Technician
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Course Outline

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Apprenticeship

Apprenticeship is post-secondary education with a difference. Apprenticeship begins with finding an employer. Employers hire apprentices, pay their wages and provide on-the-job training and work experience. Approximately 80 per cent of an apprentice's time is spent on the job under the supervision of a certified journeyperson or qualified tradesperson. The other 20 per cent involves technical training provided at, or through, a post-secondary institution – usually a college or technical institute.

To become certified journeypersons, apprentices must learn theory and skills, and they must pass examinations. Requirements for certification—including the content and delivery of technical training—are developed and updated by the Alberta Apprenticeship and Industry Training Board on the recommendation of Instrumentation and Control Technician Provincial Apprenticeship Committee.

The graduate of the Instrumentation and Control Technician apprenticeship program is a certified journeyperson who will be able to:

- Have an understanding of operating processes as it relates to instrumentation.
- Have a thorough knowledge of precision measurement and calibration.
- Service and repair electronic equipment.
- Apply the principles of Electronics, Pneumatics, Hydraulics, Mechanics and Chemistry.
- Understand the monitoring processes involved in process quality control.
- Service, repair, fabricate and assemble trade related electronic, mechanical, pneumatic, hydraulic, components and process connections.
- Maintain and apply Occupational Health and Safety codes and standards
- Perform assigned tasks in accordance with quality and production standards required by industry.

Apprenticeship and Industry Training System

Industry-Driven

Alberta's apprenticeship and industry training system is an industry-driven system that ensures a highly skilled, internationally competitive workforce in more than 50 designated trades and occupations. This workforce supports the economic progress of Alberta and its competitive role in the global market. Industry (employers and employees) establishes training and certification standards and provides direction to the system through an industry committee network and the Alberta Apprenticeship and Industry Training Board. The Alberta government provides the legislative framework and administrative support for the apprenticeship and industry training system.

Alberta Apprenticeship and Industry Training Board

The Alberta Apprenticeship and Industry Training Board provides a leadership role in developing Alberta's highly skilled and trained workforce. The Board's primary responsibility is to establish the standards and requirements for training and certification in programs under the Apprenticeship and Industry Training Act. The Board also provides advice to the Minister of Advanced Education on the needs of Alberta's labour market for skilled and trained workers, and the designation of trades and occupations.

The thirteen-member Board consists of a chair, eight members representing trades and four members representing other industries. There are equal numbers of employer and employee representatives.

Industry Committee Network

Alberta's apprenticeship and industry training system relies on a network of industry committees, including local and provincial apprenticeship committees in the designated trades, and occupational committees in the designated occupations. The network also includes other committees such as provisional committees that are established before the designation of a new trade or occupation comes into effect. All trade committees are composed of equal numbers of employer and employee representatives. The industry committee network is the foundation of Alberta's apprenticeship and industry training system.

Local Apprenticeship Committees (LAC)

Wherever there is activity in a trade, the board can set up a local apprenticeship committee. The board appoints equal numbers of employee and employer representatives for terms of up to three years. The committee appoints a member as presiding officer. Local apprenticeship committees:

- monitor apprenticeship programs and the progress of apprentices in their trade, at the local level
- make recommendations to their trade's provincial apprenticeship committee (PAC) about apprenticeship and certification in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- make recommendations to the board about the appointment of members to their trade's PAC
- help settle certain kinds of disagreements between apprentices and their employers
- carry out functions assigned by their trade's PAC or the board

Provincial Apprenticeship Committees (PAC)

The board establishes a provincial apprenticeship committee for each trade. It appoints an equal number of employer and employee representatives, and, on the PAC's recommendation, a presiding officer - each for a maximum of two terms of up to three years. Most PACs have nine members but can have as many as twenty-one. Provincial apprenticeship committees:

- Make recommendations to the board about:
    - standards and requirements for training and certification in their trade
    - courses and examinations in their trade
    - apprenticeship and certification
    - designation of trades and occupations
    - regulations and orders under the Apprenticeship and Industry Training Act
- monitor the activities of local apprenticeship committees in their trade
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- consult with other committees under the Apprenticeship and Industry Training Act about apprenticeship programs, training and certification and facilitate cooperation between different trades and occupations
- consult with organizations, associations and people who have an interest in their trade and with employers and employees in their trade
- may participate in resolving certain disagreements between employers and employees
- carry out functions assigned by the board

Instrumentation and Control Technician PAC Members at the Time of Publication

Mr. Ken Adams	Red Deer	Presiding Officer
Mr. Shannon Lozinski	Edmonton	Employer
Mr. David MacLean	Drayton Valley	Employer
Mr. Robert Matfin	Edmonton	Employer
Mr. Bruce Carson	Edmonton	Employee
Mr. Carl Jarvis	Grande Prairie	Employee
Mr. Wade McNenly	Fort Saskatchewan	Employee
Mr. Shawn Fortier	Calgary	Employee

Alberta Government

Alberta Advanced Education works with industry, employer and employee organizations and technical training providers to:

- facilitate industry's development and maintenance of training and certification standards
- provide registration and counselling services to apprentices and employers
- coordinate technical training in collaboration with training providers
- certify apprentices and others who meet industry standards

Apprenticeship Safety

Safe working procedures and conditions, incident/injury prevention, and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of government, employers, employees, apprentices and the public. Therefore, it is imperative that all parties are aware of circumstances that may lead to injury or harm.

Safe learning experiences and healthy environments can be created by controlling the variables and behaviours that may contribute to or cause an incident or injury. By practicing a safe and healthy attitude, everyone can enjoy the benefit of an incident and injury free environment.

Alberta Apprenticeship and Industry Training Board Safety Policy

The Alberta Apprenticeship and Industry Training Board (board) fully supports safe learning and working environments and emphasizes the importance of safety awareness and education throughout apprenticeship training- in both on-the- job training and technical training. The board also recognizes that safety awareness and education begins on the first day of on-the-job training and thereby is the initial and ongoing responsibility of the employer and the apprentice as required under workplace health and safety training. However the board encourages that safe workplace behaviour is modeled not only during on-the-job training but also during all aspects of technical training, in particular, shop or lab instruction. Therefore the board recognizes that safety awareness and training in apprenticeship technical training reinforces, but does not replace, employer safety training that is required under workplace health and safety legislation.

The board has established a policy with respect to safety awareness and training:

> **The board promotes and supports safe workplaces, which embody a culture of safety for all apprentices, employers and employees. Employer required safety training is the responsibility of the employer and the apprentice, as required under legislation other than the *Apprenticeship and Industry Training Act.***

The board's complete document on its 'Apprenticeship Safety Training Policy' is available at www.tradesecrets.alberta.ca; access the website and conduct a search for 'safety training policy'.

Implementation of the policy includes three common safety learning outcomes and objectives for all trade course outlines. These common learning outcomes ensure that each course outline utilizes common language consistent with workplace health and safety terminology. Under the title of 'Standard Workplace Safety', this first section of each trade course outline enables the delivery of generic safety training; technical training providers will provide trade specific examples related to the content delivery of course outline safety training.

Occupational Health and Safety

A tradesperson is often exposed to more hazards than any other person in the work force and therefore should be familiar with and apply the Occupational Health and Safety Act, Regulations and Code when dealing with personal safety and the special safety rules that apply to all daily tasks.

Occupational Health and Safety (a division of Alberta Human Services) conducts periodic inspections of workplaces to ensure that safety regulations for industry are being observed.

Additional information is available at www.humanservices.alberta.ca

Technical Training

Apprenticeship technical training is delivered by the technical institutes and colleges in the public post-secondary system throughout Alberta. The colleges and institutes are committed to delivering the technical training component of Alberta apprenticeship programs in a safe, efficient and effective manner. All training providers place a strong emphasis on safety that complements safe workplace practices towards the development of a culture of safety for all trades.

The technical institutes and colleges work with Alberta's Apprenticeship and Industry Training Board, industry committees and Alberta Advanced Education to enhance access and responsiveness to industry needs through the delivery of the technical training component of apprenticeship programs across the Province. They develop curriculum from the course outlines established by industry and provide technical training to apprentices.

The following institutions deliver Instrumentation and Control Technician apprenticeship technical training:

Grande Prairie Regional College	First Period
Lakeland College	First Period, Second Period, Third Period
Northern Alberta Institute of Technology	All Periods
Red Deer College	All Periods
Southern Alberta Institute of Technology	All Periods

Procedures for Recommending Revisions to the Course Outline

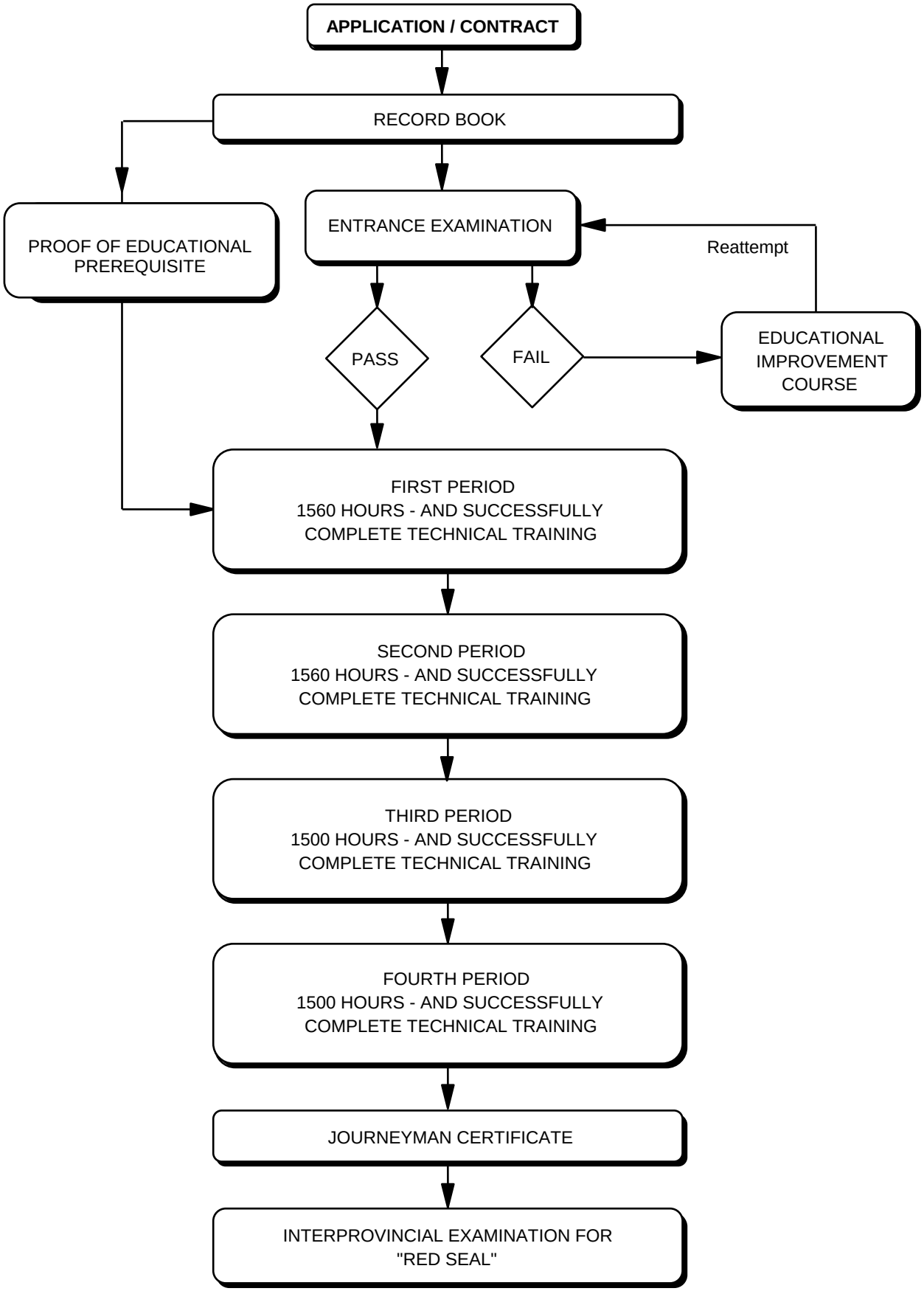
Advanced Education has prepared this course outline in partnership with the Instrumentation and Control Technician Provincial Apprenticeship Committee.

This course outline was approved on December 16, 2016 by the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. The valuable input provided by representatives of industry and the institutions that provide the technical training is acknowledged.

Any concerned individual or group in the province of Alberta may make recommendations for change by writing to:

Instrumentation and Control Technician Provincial Apprenticeship Committee
c/o Industry Programs and Standards
Apprenticeship and Industry Training
Advanced Education
10th floor, Commerce Place
10155 102 Street NW
Edmonton AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used. Recommendations for change will be placed on the agenda for regular meetings of the Instrumentation and Control Technician Provincial Apprenticeship Committee.



Instrumentation and Control Technician Training Profile
FIRST PERIOD
(8 Weeks 30 Hours per Week – Total of 240 Hours)

SECTION ONE

SAFETY, SHOP PRACTICES, THEORY AND LABORATORY
50 HOURS

A	B	C
Safety Legislation, Regulations & Industry Policy in the Trades 2 Hours	Climbing, Lifting, Rigging and Hoisting 2 Hours	Hazardous Materials & Fire Protection 3 Hours
D	**E**	**F**
Apprenticeship Training Program 2 Hours	Tools and Equipment 4 Hours	Tube Bending and Joining 16 Hours
G	**H**	**I**
Pipe Threading and Joints 9 Hours	Mounting and Support Hardware 6 Hours	Precision Measurement 2 Hours
J		
Electrical and Electronic Connections 4 Hours		

SECTION TWO

ELECTRICAL THEORY AND SAFETY
84 HOURS

A	B	C
Resistors 4 Hours	Current, Voltage, Resistance and Power 8 Hours	Characteristics of Conductors 2 Hours
D	**E**	**F**
Series Resistive Circuits 6 Hours	Parallel Resistive Circuits 6 Hours	Series-Parallel Resistive Circuits 6 Hours
G	**H**	**I**
Cells and Batteries 4 Hours	Magnetism, Electromagnetism and Electromagnetic Induction 5 Hours	Fundamentals of Alternating Current (ac) 3 Hours
J	**K**	**L**
Inductance and Capacitance 5 Hours	Time Constants 4 Hours	Inductive Reactance and Capacitive Reactance 5 Hours
M	**N**	**O**
Alternating Current (ac) Circuit Properties 3 Hours	Regulations 3 Hours	Area Classifications 6 Hours
P		
Electrical Equipment in Hazardous Locations 14 Hours		

SECTION THREE

BASIC MEASUREMENTS AND CALIBRATION
32 HOURS

A	B	C
Pressure Measurement 5 Hours	Link and Lever Systems 4 Hours	Pressure Gauges 3 Hours
D	**E**	**F**
Pneumatic Components and Feedback Systems 5 Hours	Pressure Regulators 5 Hours	Pressure Transmitters 6 Hours
G		
Chart Recorders 4 Hours		

SECTION FOUR

FINAL CONTROL ELEMENTS

34 HOURS

A	B	C
Reciprocating Control Valves 6 Hours	Rotary Control Valves 6 Hours	Actuators 8 Hours
D	**E**	**F**
Valve Positioners 4 Hours	Control Valve Selection 4 Hours	Control Valve Servicing 6 Hours

SECTION FIVE

RELATED APPLIED PHYSICS AND CALCULATIONS

40 HOURS

A	B	C
SI and Imperial Units and Basic Calculations 4 Hours	Motion and Force 6 Hours	Work and Power 5 Hours
D	**E**	**F**
Energy 4 Hours	Fluid Principles 7 Hours	Heat and Temperature 7 Hours
G	**H**	
Laws of Perfect Gases 3 Hours	Solids 4 Hours	

SECOND PERIOD
(8 Weeks/30 Hours Per Week –Total Of 240 Hours)

SECTION ONE

MEASUREMENT INSTRUMENTS

68 HOURS

A	B	C
Temperature Measurement 8 Hours	Thermometers and Filled Thermal Systems 4 Hours	Thermocouples 8 Hours
D	**E**	**F**
Resistance Temperature Detector (RTD's) 8 Hours	Non-Contact Temperature Measurement 4 Hours	Flow Measurement Fundamentals 3 Hours
G	**H**	**I**
Analog Differential Pressure Measurement 4 Hours	Analog Differential Pressure Flow Measurement 9 Hours	Variable Area Meters / Weirs / Flumes / Flow Switches 4 Hours
J	**K**	
Level Measurement 9 Hours	Analog Differential Pressure Level Measurement 7 Hours	

SECTION TWO

CONTROL INSTRUMENTS

36 HOURS

A	B	C
Introduction to Automatic Control 6 Hours	On-Off Controllers 4 Hours	Proportional Integral Derivative Control (PID) 14 Hours
D		
Pneumatic Controller Tuning 12 Hours		

SECTION THREE

ELECTRICAL AND DIGITAL FUNDAMENTALS

59 HOURS

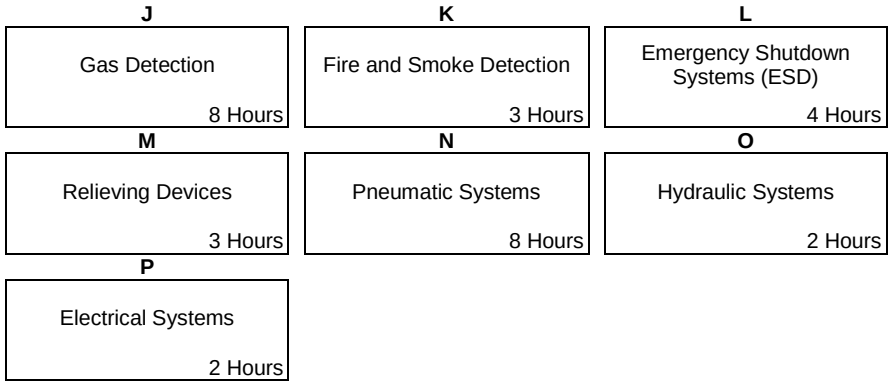
A	B	C
Electrical Theory 7 Hours	Power Supplies 6 Hours	Introduction to Digital 5 Hours
D	**E**	**F**
Logic Gates 3 Hours	Microprocessor and Memory 2 Hours	Introduction to Programmable Logic Controllers (PLC) 20 Hours
G	**H**	
Introduction to Data Communications 10 Hours	Introduction to Personal Computers and Software Applications 6 Hours	

SECTION FOUR

PROCESS EQUIPMENT AND ENERGY SYSTEMS

77 HOURS

A	B	C
Drawings and Symbols 8 Hours	Gas Compression 8 Hours	Liquid Pumping 4 Hours
D	**E**	**F**
Solids and Liquids 4 Hours	Heat Transfer and Evaporation 5 Hours	Drying, Humidification and Dehumidification 5 Hours
G	**H**	**I**
Distillation and Fractionation 3 Hours	Boilers and Direct Fired Heaters 3 Hours	Production and Processing Plants 7 Hours



THIRD PERIOD
(10 Weeks 30 Hours per Week – Total of 300 Hours)

SECTION ONE

ELECTRONIC INSTRUMENT LOOPS

44 HOURS

A	B	C
Analog Loops 10 Hours	Grounding and Shielding Methods 8 Hours	Analog to Digital (ADC) and Digital to Analog (DAC) Conversion 4 Hours
D	**E**	**F**
Signal Conditioning 6 Hours	Smart Instruments 10 Hours	Single Loop Digital Controllers (SLDC) / Stand Alone Controllers (SAC) 6 Hours

SECTION TWO

MEASUREMENT

79 HOURS

A	B	C
Accuracy and Repeatability 9 Hours	Measurement Traceability 4 Hours	Differential Pressure Using Smart Technology 4 Hours
D	**E**	**F**
Nuclear 3 Hours	Ultrasonic and Radar 6 Hours	Capacitance, Thermal Dispersion, Optical and Magnetostrictive 5 Hours
G	**H**	**I**
Solids 2 Hours	Viscosity 2 Hours	Flow Measurement 4 Hours
J	**K**	**L**
Differential Pressure Elements 4 Hours	Magnetic Flowmeters 4 Hours	Turbine Flowmeters 6 Hours
M	**N**	**O**
Vortex Flowmeters 4 Hours	Ultrasonic Flowmeters 4 Hours	Mass Flowmeters 6 Hours
P	**Q**	
Positive Displacement Flowmeters 6 Hours	Flow Computers 6 Hours	

SECTION THREE

PHYSICAL PROPERTIES

58 HOURS

A	B	C
Matter 9 Hours	Inorganic Compounds 8 Hours	Chemical Calculations 8 Hours
D	**E**	**F**
Chemical Reaction 12 Hours	Organic Chemistry 15 Hours	Metallurgy 6 Hours

SECTION FOUR

PROCESS ANALYZERS

50 HOURS

A	B	C
Process Analyzers 6 Hours	Analyzer Sampling Systems 10 Hours	Gas Analyzers 12 Hours
D	**E**	**F**
Liquid Analyzers 12 Hours	Physical Property Analyzers 6 Hours	Vibration Monitoring 4 Hours

SECTION FIVE

PROCESS CONTROL

69 HOURS

A	B	C
Closed Loop Analysis 14 Hours	Process Loop Dynamics 14 Hours	Closed Loop Control 14 Hours

D	E	F
Digital Controller Tuning 10 Hours	Cascade Control 10 Hours	Selective Control 7 Hours

FOURTH PERIOD
(10 Weeks/30 Hours Per Week –Total Of 300 Hours)

SECTION ONE

ADVANCED PROCESS CONTROL
78 HOURS

A	B	C
Multivariable Control 8 Hours	Ratio Control 8 Hours	Feedforward Control 10 Hours
D	**E**	**F**
Split Range Control 6 Hours	Distillation Control 12 Hours	Boiler Control 12 Hours
G	**H**	
Compressor Control 12 Hours	Safety Instrumented Systems (SIS) 10 Hours	

SECTION TWO

COMMUNICATION
57 HOURS

A	B	C
Signal Transmission Systems 6 Hours	Communication Signal Converters 6 Hours	Protocols 14 Hours
D	**E**	
Industrial Networks 15 Hours	Supervisory Control and Data Acquisition (SCADA) 16 Hours	

SECTION THREE

CONTROL SYSTEMS
104 HOURS

A	B	C
Programmable Logic Controllers (PLC) 50 Hours	Distributed Control Systems (DCS) 40 Hours	Variable Speed Drives(VSD) 6 Hours
D		
Human Machine Interfaces (HMI) 8 Hours		

SECTION FOUR

PROCESS ANALYZERS, MAINTENANCE, WORKPLACE COACHING SKILLS
61 HOURS

A	B	C
Process Chromatography 12 Hours	Mass Spectrometry 6 Hours	Environmental Monitoring 8 Hours
D	**E**	**F**
Spectroscopic Analyzers 3 Hours	Infrared Analyzers 6 Hours	Ultraviolet Analyzers (UV) 6 Hours
G	**H**	**I**
Chemiluminescence 4 Hours	Maintenance Planning 10 Hours	Workplace Coaching Skills 2 Hours
J	**K**	
Alberta's Industry Network 2 Hours	Interprovincial Standards Red Seal Program 2 Hours	

NOTE: The hours stated are for guidance and should be adhered to as closely as possible. However, adjustments must be made for rate of apprentice learning, statutory holidays, registration and examinations for the training establishment and Apprenticeship and Industry Training.

FIRST PERIOD TECHNICAL TRAINING
INSTRUMENTATION AND CONTROL TECHNICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE:..... SAFETY, SHOP PRACTICES,THEORY AND LABORATORY..... 50 HOURS

A. Safety Legislation, Regulations & Industry Policy in the Trades.....2 Hours

Outcome: ***Apply legislation, regulations and practices ensuring safe work in this trade.***

1. Demonstrate the application of the Occupational Health and Safety Act, Regulation and Code.
2. Describe the employer's and employee's role with Occupational Health and Safety (OH&S) regulations, Worksite Hazardous Materials Information Systems (WHMIS), fire regulations, Workers Compensation Board regulations and related advisory bodies and agencies.
3. Describe industry practices for hazard assessment and control procedures.
4. Describe the responsibilities of worker and employers to apply emergency procedures.
5. Describe tradesperson attitudes with respect to housekeeping, personal protective equipment and emergency procedures.
6. Describe the roles and responsibilities of employers and employees with the selection and use of personal protective equipment (PPE).
7. Maintain required PPE for tasks.
8. Use required PPE for tasks.

B. Climbing, Lifting, Rigging and Hoisting.....2 Hours

Outcome: ***Use industry standard practices for climbing, lifting, rigging and hoisting in this trade.***

1. Describe manual lift procedures.
2. Describe rigging hardware and associated safety factors.
3. Select equipment for rigging loads.
4. Describe hoisting and load moving procedures.
5. Maintain personal protective equipment (PPE) for climbing, lifting and load moving equipment.
6. Use PPE for climbing, lifting and load moving equipment.

C. Hazardous Materials and Fire Protection.....3 Hours

Outcome: ***Apply industry standard practices for hazardous materials and fire protection in this trade.***

1. Describe roles, responsibilities, features and practices related to the Workplace Hazardous Materials Information System (WHMIS) program.
2. Describe three key elements of WHMIS.
3. Describe handling, storing and transporting procedures for hazardous material.
4. Describe venting procedures when working with hazardous materials.
5. Describe hazards, classes, procedures and equipment related to fire protection.

D. Apprenticeship Training Program ..... 2 Hours

Outcome: Manage an apprenticeship to earn journeyman certification.

1. Describe the contractual responsibilities of the apprentice, employer and Alberta Apprenticeship and Industry Training.
2. Describe the purpose of the apprentice record book.
3. Describe the procedure for changing employers during an active apprenticeship.
4. Describe the purpose of the course outline.
5. Describe the procedure for progressing through an apprenticeship.
6. Describe advancement opportunities in this trade.

E. Tools and Equipment ..... 4 Hours

Outcome: Use trade related tools and equipment.

1. Describe various energy isolation procedures and applications to establish zero energy.
2. Describe and apply safe techniques for using various workshop hand tools and power tools.
3. Demonstrate the safe use of hand tools and equipment related to the Instrumentation and Control Technician trade.
4. Demonstrate the safe use of power and specialty tools related to the Instrumentation and Control Technician trade.
5. Maintains and documents calibration, configuration and test equipment.

F. Tube Bending and Joining ..... 16 Hours

Outcome: Perform tube joining and bending.

1. Identify types and sizes of tube and tube fittings.
2. Identify tools and techniques used in tube joining.
3. Identify tools and techniques used in tube bending.
4. Calculate tube bending lengths for various tube configurations and angles.
5. Identify hazards associated with tube and fitting selection and installation.
6. Demonstrate tube bending for instrument installations.
7. Design and install raceway to support tubing.
8. Install tubing and tube fittings.
9. Demonstrate the use of tube joining tools.
10. Demonstrate soft soldering techniques for joining copper tube.

G. Pipe Threading and Joints ..... 9 Hours

Outcome: Perform pipe threading and joining.

1. Identify types and sizes of pipe, fittings and flanges.
2. Explain tools used in pipe joining.
3. Explain how to achieve a pipe installation emphasising threaded pipe joints.
4. Identify hazards associated with pipe and fitting selection and installation.
5. Demonstrate threading of steel pipe with the use of power threaders and hand threaders.

6. Install threaded pipe and fittings for a safe leak tight installation.
7. Install flange connections for a safe leak tight installation.

H. Mounting and Support Hardware ..... 6 Hours

Outcome: ***Install mounting and support hardware.***

1. Describe location considerations and limitations of mounting and support hardware.
2. Identify fasteners used in mounting and support hardware.
3. Identify tools used in mounting and support hardware.
4. Fabricate mounting and support hardware.
5. Install mounting and support hardware.

I. Precision Measurement ..... 2 Hours

Outcome: ***Use precision measuring instruments.***

1. Describe precision measurement used in dimensional measurement.
2. Describe measuring instruments used for precision measurement.
3. Demonstrate techniques for using precision measuring instruments.

J. Electrical and Electronic Connections ..... 4 Hours

Outcome: ***Assemble electrical and electronic connections.***

1. Describe the tools, materials, and techniques used for soldering electronic circuits.
2. Describe static and anti-static devices.
3. Describe methods used in electrical connections.
4. Demonstrate electrical connection techniques.
5. Desolder and remove components from printed circuit boards.
6. Install and solder electronic components onto a printed circuit board.

SECTION TWO: ..... ELECTRICAL THEORY AND SAFETY ..... 84 HOURS

A. Resistors ..... 4 Hours

Outcome: ***Identify types of resistors.***

1. List two categories of resistors.
2. Describe resistor construction.
3. Explain methods used to determine the ratings of fixed resistors.
4. Use colour codes to determine the resistance of a resistor.

B. Current, Voltage, Resistance and Power ..... 8 Hours

Outcome: ***Apply knowledge of voltage, current, resistance and power.***

1. Describe an electric current.
2. Describe the difference between electron current flow and conventional current flow.
3. Describe voltage.
4. Describe resistance and state and apply Ohm’s law.

5. Describe work, energy and power as it relates to current, voltage and resistance.
6. Connect and verify the relationship between voltage, current and resistance according to Ohm's law.
7. Connect an electrical circuit and verify the power formulae.

C. Characteristics of Conductors ..... 2 Hours

Outcome: ***Use conductors, semiconductors and insulators.***

1. Describe the factors affecting resistance.
2. Calculate the resistance of a conductor of specific dimensions.
3. Describe the electrical properties of materials.

D. Series Resistive Circuits ..... 6 Hours

Outcome: ***Analyze series resistive circuits.***

1. Define a series circuit.
2. Calculate current in a series circuit.
3. Calculate resistance in a series circuit.
4. Apply Kirchhoff's voltage law to a series circuit.
5. Perform calculations using ratio and direct proportion.
6. State the relationship between the resistive values of components and their voltage drops.
7. Solve problems using the voltage divider rule.
8. Determine the voltage drop across a closed or open-circuit component in a series circuit.
9. Connect and verify Kirchhoff’s current and voltage laws in a series resistive circuit.

E. Parallel Resistive Circuits ..... 6 Hours

Outcome: ***Analyze parallel circuits.***

1. Define a parallel circuit.
2. Calculate the total resistance of a parallel circuit.
3. Apply Kirchhoff’s current law to a parallel circuit.
4. Describe the effects of open circuits on a parallel circuit.
5. Use the current divider principle to calculate branch currents.
6. Connect and verify Kirchhoff’s current laws in a parallel resistive circuit.

F. Series-Parallel Resistive Circuits ..... 6 Hours

Outcome: ***Analyze series-parallel resistive circuits.***

1. Identify resistors that are in series.
2. Identify resistors that are in parallel.
3. Calculate the total resistance of a series-parallel circuit.
4. Apply Kirchhoff's current law.
5. Apply Kirchhoff's voltage law.
6. Solve problems involving series-parallel circuits.
7. Connect and verify the relationship of current, voltage and resistance in each part of a series/parallel circuit.

G. Cells and Batteries ..... 4 Hours

Outcome: ***Describe cells and batteries.***

1. Define terminology of cells.
2. Describe construction and operation of a basic primary cell.
3. Describe construction and operation of types of lead-acid batteries.
4. Describe construction and operation of a nickel-cadmium battery.
5. Describe construction and operation of a lithium battery.
6. Describe hazards when charging, handling and disposing of batteries.
7. Describe battery performance ratings.
8. Determine the effects of battery internal resistance.

H. Magnetism, Electromagnetism and Electromagnetic Induction ..... 5 Hours

Outcome: ***Describe magnetism, electromagnetism and electromagnetic induction.***

1. Describe the properties of magnetic materials.
2. Define terminology related to magnetism.
3. Describe electromagnetism and basic design considerations for electromagnetic devices.
4. Describe how an induced voltage is generated.

I. Fundamentals of Alternating Current (ac) ..... 3 Hours

Outcome: ***Describe the fundamental characteristics of ac circuits.***

1. Explain the generation of an ac sine wave.
2. Determine the output frequency of an ac generator.
3. Calculate standard ac sine wave values.

J. Inductance and Capacitance ..... 5 Hours

Outcome: ***Apply the concepts of inductance and capacitance and their use in dc circuits.***

1. Describe an inductor.
2. Describe inductance and the factors which affect it.
3. Describe induction and its effects.
4. Define capacitance.
5. Describe the construction of a basic capacitor.
6. Describe dielectric strength and state the unit of measurement for electric charge.
7. Describe capacitor types and applications.

K. Time Constants ..... 4 Hours

Outcome: ***Apply concepts of circuit time constants.***

1. Describe resistor-capacitor circuit time constants and the relationship to the characteristic charge and discharge waveforms.
2. Describe time effects in selected resistor-capacitor circuits.

3. Calculate instantaneous and steady state voltages in resistor-capacitor circuits.
4. Describe time effects of an inductor in a dc circuit.

L. Inductive Reactance and Capacitive Reactance ..... 5 Hours

Outcome: ***Analyze ac inductive and capacitive circuits.***

1. Describe effects of an inductor in an ac circuit.
2. Describe power relationships in an inductive circuit.
3. Describe effects of a capacitor in an ac circuit.
4. Describe power relationships in a capacitive circuit.
5. Analyze an ac inductive circuit.
6. Analyze an ac capacitive circuit.

M. Alternating Current (ac) Circuit Properties ..... 3 Hours

Outcome: ***Apply the properties of ac circuits.***

1. Describe the factors affecting impedance in an ac circuit.
2. Describe the power relationships in an ac circuit.
3. Demonstrate the relationship between sine waves and phasor diagrams.

N. Regulations ..... 3 Hours

Outcome: ***Apply electrical codes and regulations.***

1. Describe the Instrumentation and Control Technician's area of electrical work/responsibility.
2. Describe the role of Safety Codes Act and the Canadian Electrical Code Part 1 and how they relate to the instrumentation field.
3. Describe the role of CSA, NEMA and CUL and how they relate to the instrumentation field.

O. Area Classifications ..... 6 Hours

Outcome: ***Describe the classification of hazardous locations and the general rules that apply to these locations.***

1. Define the specific terms from Section 18 of the Canadian Electrical Code Part 1 that apply to area classifications.
2. Apply general rules regarding installation and maintenance in hazardous locations.
3. Describe an area classification drawing.

P. Electrical Equipment in Hazardous Locations ..... 14 Hours

Outcome: ***Apply protection methods for electrical equipment in hazardous areas.***

1. Define the purpose of explosion proof equipment.
2. Define installation requirements for conduit, seals, fixtures and appliances.
3. Describe maintenance procedures for explosion proof enclosures.
4. Describe non-incendive equipment.
5. Describe an intrinsically safe loop.
6. Describe an intrinsically safe loop drawing.
7. Describe the grounding requirements of an intrinsically safe system.

8. Define the relationship between explosion proof and intrinsically safe systems.
9. Describe maintenance procedures for intrinsically safe systems.
10. Describe the role of purging under the CSA and ISA definition.
11. Describe the role of sealing, potting and encapsulating for electrical safety.
12. Describe arc flash.
13. Demonstrate how to install a secondary seal.
14. Select and install an intrinsically safe barrier.

SECTION THREE: ..... BASIC MEASUREMENTS AND CALIBRATION..... 32 HOURS

A. Pressure Measurement.....5 Hours

Outcome: Apply the principles of pressure and the standards used to measure pressure.

1. Perform calculations for pressure and pressure units.
2. Apply the principles of pressure standards to pressure measurement techniques.
3. Perform pressure calculations for pressure scales and reference points.

B. Link and Lever Systems .....4 Hours

Outcome: Calibrate link and lever systems.

1. Define span, angularity, zero, hysteresis, and deadband as they relate to mechanical systems.
2. Perform calibrations of link and lever systems.

C. Pressure Gauges.....3 Hours

Outcome: Select, calibrate, and install pressure gauges.

1. Describe the construction, applications and limitations of pressure gauges.
2. Describe the installation and protection methods for pressure gauges.
3. Demonstrate the methods and standards used to calibrate pressure gauges.
4. Demonstrate a method to protect pressure gauges.

D. Pneumatic Components and Feedback Systems .....5 Hours

Outcome: Select, install, and maintain pneumatic components and feedback systems.

1. Describe the operation and construction of flapper nozzles.
2. Describe the operation and construction of pneumatic pilots.
3. Describe the operation and construction of pneumatic relays.
4. Describe the applications for pneumatic relays.
5. Explain different types of negative feedback systems used in pneumatic instruments.
6. Describe safety considerations of pneumatic instruments.
7. Describe specifications of pneumatic instruments.
8. Describe benefits and disadvantages of pneumatic instruments.
9. Describe alternate gas supplies used in pneumatic instruments and related hazards.
10. Demonstrate the calibration of a feedback system.

E. Pressure Regulators ..... 5 Hours

Outcome: ***Select, install, and maintain pressure regulators.***

1. Describe the operating principles and applications of regulators.
2. Illustrate the design and differences between: spring-loaded, weight- loaded, and pilot operated regulators.
3. Identify hazards associated with pressure regulator selection and installation.
4. Describe maintenance procedures for pressure regulators.
5. Service a pressure regulator.

F. Pressure Transmitters ..... 6 Hours

Outcome: ***Select, install, and maintain pressure transmitters.***

1. Describe the function and construction of pressure transmitters.
2. Describe the applications and installation requirements for pressure transmitters.
3. Describe analog signal standards.
4. Describe the calibration process and the application of input/output calculations for pressure transmitters.
5. Calibrate pressure transmitters.

G. Chart Recorders ..... 4 Hours

Outcome: ***Select, install, and maintain chart recorders.***

1. Describe the function and construction of chart recorders.
2. Describe applications and installation requirements for chart recorders.
3. Describe calibration procedures used on chart recorders.
4. Describe and interpret charts and recording methods for chart recorders.
5. Calibrate chart recorders.

SECTION FOUR: ..... FINAL CONTROL ELEMENTS ..... 34 HOURS

A. Reciprocating Control Valves ..... 6 Hours

Outcome: ***Install and service reciprocating control valves.***

1. Describe applications and construction of reciprocating control valves.
2. Identify hazards associated with reciprocating control valves.
3. Describe servicing procedures used on reciprocating control valves.
4. Install a reciprocating control valve.
5. Service a reciprocating control valve.

B. Rotary Control Valves ..... 6 Hours

Outcome: ***Install and service rotary control valves.***

1. Describe rotary control valves applications and construction.
2. Identify rotary control valves hazards.
3. Describe rotary control valves servicing.

4. Install a rotary control valve.
5. Service a rotary control valve.

C. Actuators ..... 8 Hours

Outcome: Install and service valve actuators.

1. Describe applications and selection of actuators and accessories.
2. Identify hazards associated with servicing valve actuators.
3. Describe servicing procedures used on valve actuators.
4. Demonstrate how to service and setup various valve actuators.

D. Valve Positioners ..... 4 Hours

Outcome: Install and service valve positioners.

1. Describe the applications and selection of valve positioners.
2. Describe the features of positioners.
3. Describe valve positioner servicing procedures.
4. Demonstrate the operation and calibration of pneumatic valve positioners.

E. Control Valve Selection ..... 4 Hours

Outcome: Explain the variables used in selecting and maintaining control valves.

1. Describe the principles of friction, and the coefficient of friction, associated with fluids in motion.
2. Describe flow characteristics, valve C_V, cavitation, flashing, erosion, corrosion, and specialized trim.
3. Describe procedures and considerations when determining valve sizes and construction materials.
4. Identify the required “Fail Safe” mode and flow direction when selecting valves for a given application.
5. Describe valve packing materials and applications.

F. Control Valve Servicing ..... 6 Hours

Outcome: Prepare control valves for installation and maintenance.

1. Describe the OH&S requirements for energy isolation.
2. Identify hazards associated with removing a control valve from service.
3. Describe methods used in isolating control valves for maintenance.
4. Demonstrate how to isolate a control valve for maintenance.
5. Install actuator, perform bench set and adjust valve stroke.

SECTION FIVE: ..... RELATED APPLIED PHYSICS AND CALCULATIONS ..... 40 HOURS

A. SI and Imperial Units and Basic Calculations ..... 4 Hour

Outcome: Solve trade related calculations.

1. Describe SI units, prefixes, and conversions between the SI system and the imperial system.
2. Transpose and solve equations involving: fractions, ratios, proportions, percentages, exponents, algebra, trigonometry and logarithms.

3. Describe units of angular measurement, right angles, obtuse angles, isosceles triangles, equilateral triangles, and the application of Pythagoras Theorem to right angled triangles.
4. Calculate the perimeter, area, and volume of various objects.

B. Motion and Force.....6 Hours

Outcome: Solve problems related to motion and force.

1. Describe velocity, acceleration, displacement, average velocity, average acceleration, momentum, gravitational acceleration, scalar vector quantities, force, and mass.
2. Describe Newton's three laws of motion, and the law of conservation of motion or momentum.
3. Solve problems related to force, mass and acceleration.
4. Describe moment of force, moment of torque, balancing of forces on a beam, equilibrium of a lever system, effort, and mechanical advantage.
5. Solve problems related to force balance about a point, and the mechanical advantage of a beam.
6. Describe the mechanical advantage or velocity ratio in terms of diameter or radius of wheels, axles, pulleys, and gears.
7. Solve problems related to speed or rotation of pulleys and gears based on diameter or radius as well as the mechanical advantage of a block and tackle system.

C. Work and Power .....5 Hours

Outcome: Solve problems related to work and power.

1. Describe the terms work, power and efficiency and their associated units.
2. Express efficiency in terms of output versus input work and power.
3. Solve problems related to work done based on force and distance data.
4. Solve problems related to power based on force, distance, and time data.

D. Energy.....4 Hours

Outcome: Solve problems related to energy.

1. Describe energy, potential energy, kinetic energy, and the units of energy.
2. Describe the forms of energy and their formulae.
3. Describe the relationship between potential and kinetic energy and the laws of conservation of energy.
4. Solve problems related to potential energy based on force and height data, and kinetic energy based on mass and velocity data.

E. Fluid Principles.....7 Hours

Outcome: Solve problems related to fluids and the flow of fluids.

1. Describe atom, molecule, element, molecular attraction, cohesion, adhesion, capillary action, compressibility, thermal expansion, density, relative density, and specific volume.
2. Solve problems related to the mass, density, and relative density of liquids and solids.
3. Describe Pascal's Law and pressure head.
4. Solve problems related to pressure, density, and height of a liquid column.
5. Describe Archimedes principle and concept of buoyancy.
6. Solve problems related to objects submerged in liquids.

7. Describe turbulent flow, laminar flow, and the continuity equation.
8. Describe Bernoulli's equation, resistance to flow, and flow turbulence.

F. Heat and Temperature.....7 Hours

Outcome: Solve problems related to heat and temperature.

1. Describe the relationship between temperature scales.
2. Describe temperature, heat, sources of heat energy, specific heat, and the laws of thermodynamics.
3. Describe the molecular theory of heat and heat transfer, and its significance on the change of state of a substance.
4. Describe the coefficient of linear expansion, volumetric expansion, and surface expansion of liquids and solids.
5. Solve problems related to expansion of solids, expansion of liquids, and the changes in heat content of liquids.
6. Describe the laws related to heat, conductors, insulators, and the process of heat transfer through: conduction, convection, and radiation.
7. Describe the steam tables and the following properties: sensible heat, latent heat of fusion, latent heat of evaporation, saturation temperature, and superheat.
8. Solve problems related to heat and heat transfer.

G. Laws of Ideal Gases .....3 Hours

Outcome: Solve problems related to ideal gases.

1. Describe Boyle's Law, Charles' Law and the general gas law, in relation to pressure, temperature, and volume.
2. Solve problems involving gas laws.
3. Describe the principles of gas compressibility and volumetric expansion.

H. Solids.....4 Hours

Outcome: Solve problems related to solids.

1. Define elasticity, stress, strain, Hooke's Law, and Young's Modulus of Elasticity.
2. Define the relationship between elastic limit, yield point, ultimate strength, breaking strength, safe working stress, and factor of safety.
3. Define tensile, compressive, and shear stresses.
4. Solve problems related to stress, force area, and strain.

SECOND PERIOD TECHNICAL TRAINING
INSTRUMENTATION AND CONTROL TECHNICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE:.....MEASUREMENT INSTRUMENTS..... 68 HOURS

A. Temperature Measurement.....8 Hours

Outcome: Describe temperature measurement.

1. Explain why and where temperature measurement is used in industry.
2. Define terms that apply to temperature measurement.
3. Convert temperature readings between scales.
4. Define coefficient of linear, coefficient of area and coefficient of volume expansion.
5. Solve problems involving linear and volumetric expansion of materials.
6. Describe thermal contact and its effect on accuracy and response time.
7. Describe thermowell requirements and applications.
8. Describe direct and indirect temperature measurement.
9. Describe thermal time constants.

B. Thermometers and Filled Thermal Systems.....4 Hours

Outcome: Install, and maintain thermometers and filled thermal systems.

1. Describe the operation and characteristics of thermometers and filled thermal systems.
2. Describe the construction and operating principle of a bimetallic thermometer.
3. Describe a filled thermal system as it relates to temperature measurement.
4. Define full compensation and case compensation.
5. List advantages and disadvantages of Scientific Apparatus Makers Association (SAMA) classifications.
6. Describe applications using case and full compensation.
7. Describe installation effects, including head elevation, thermowells and transmission lag.

C. Thermocouples.....8 Hours

Outcome: Install, and maintain thermocouples.

1. Explain the principle of operation of a thermocouple element.
2. Identify thermocouples and state the materials used for each type and the colour codes used for identification.
3. Perform calculations required to measure the temperature at the thermocouple using a meter and the temperature versus thermocouple referenced tables.
4. Describe the operation of a thermocouple circuit with reference junction compensation, using the battery equivalent for each point of emf generation.
5. Perform the calculations required to calibrate a reference junction compensated transmitter using a mV source and the table referenced to 0°C.

6. State the characteristics of each type of thermocouple including their advantages, limitations and application.
7. Describe methods of thermocouple fabrication.
8. Describe effects of grounded and ungrounded junctions.
9. Describe methods and components used for thermocouple installation.
10. Demonstrate the fabrication and installation of a thermocouple.
11. Calibrate and verify the accuracy of an analog thermocouple temperature transmitter.

D. Resistance Temperature Detector (RTD's) ..... 8 Hours

Outcome: Install, and maintain Resistance Temperature Detectors (RTD's) and thermistors.

1. Explain the principle of operation of an RTD.
2. Describe characteristics of each type of RTD's including their advantages, limitations and application.
3. Calculate the measured temperature given the resistance of an RTD.
4. Describe two, three and four wire RTD measuring circuits.
5. Describe the principle of operation of thermistors.
6. Compare positive and negative temperature coefficients.
7. Describe the characteristics of each type of thermistor including their advantages, limitations and application.
8. Describe the calibration procedure for an RTD transmitter.
9. Configure and verify the accuracy of an analog RTD temperature transmitter.

E. Non-Contact Temperature Measurement ..... 4 Hours

Outcome: Install and maintain non-contact temperature measurement devices.

1. Describe the principle of operation of a diode used as a temperature detecting device.
2. Describe applications of transistors in temperature measurement.
3. Explain the purpose of non-contact temperature measuring devices.
4. Define terms used in radiation pyrometers.
5. Describe the operating principle of non-contact pyrometers.
6. List advantages and limitations of non-contact temperature measuring devices.
7. Determine emissivity of various surfaces.

F. Flow Measurement Fundamentals ..... 3 Hours

Outcome: Describe flow measurement.

1. Describe the application of flow measurement.
2. Describe measurement units and terms used in flow measurement.
3. Explain the difference between laminar and turbulent flow.
4. Explain the significance of the Reynolds number used to describe flow.
5. Explain the effect of pulsating flow and dampening.

G. Analog Differential Pressure Measurement ..... 4 Hours

Outcome: ***Apply analog differential pressure measurement.***

1. Describe the theory and application of differential pressure measurement.
2. Describe devices used for differential pressure measurement.
3. Calibrate a differential pressure device.

H. Analog Differential Pressure Flow Measurement ..... 9 Hours

Outcome: ***Install, and maintain differential pressure flow measurement devices on orifice plates.***

1. Describe the relationship between differential pressure and flow measurement.
2. Define the terms velocity head, pressure head, elevation head and discharge coefficient.
3. Calculate flow using a continuity equation and Bernoulli's equation.
4. Describe the principle of operation, application, and installation of differential pressure flow elements.
5. Describe the requirements for square root extraction and integration.
6. Calculate the flow coefficient for an orifice plate.
7. Remove, inspect and reinstall an orifice plate in an online orifice fitting installation.

I. Variable Area Meters / Weirs / Flumes / Flow Switches ..... 4 Hours

Outcome: ***Install, and maintain variable area meters, weirs, flumes and flow switches.***

1. Describe the application and principle of operation of variable area meters.
2. Describe the installation requirements.
3. Describe useful range and accuracy with comparison to fixed area orifice meters.
4. Describe the application and principle of operation of weirs and flumes.
5. Describe the application and principle of operation of flow switches.

J. Level Measurement ..... 9 Hours

Outcome: ***Install, and maintain level measurement devices.***

1. Describe the application of level measurement.
2. Differentiate between point level and continuous level detection.
3. Differentiate between direct and inferential methods of level measurement.
4. Describe types, limitations and applications of level gauges.
5. Describe principles and differences between floats and displacers.
6. State Archimedes' principle as applied to floats and displacers.
7. Calculate buoyancy of a float.
8. Describe the application of a float used for point and continuous level measurement.
9. Calculate buoyant force of a displacer.
10. Describe the principle of a torque tube.
11. Describe the operation of a displacer element for detecting liquid level and interfaces.
12. Describe the application of a displacer used for point and continuous level measurement.

13. List advantages and disadvantages of float and displacer type level devices.
14. Connect and calibrate a displacer type instrument for continuous level measurement.

K. Analog Differential Pressure Level Measurement.....7 Hours

Outcome: Install, and maintain differential pressure level measurement devices.

1. Calculate hydrostatic head pressure.
2. Describe characteristics of purge fluids and seal fluids.
3. Compare methods of measuring level in atmospheric and pressurized vessels.
4. Define the terms zero elevation and zero suppression and range elevation and range suppression.
5. Describe a calibration procedure for a zero elevation application and calculate span and elevation settings.
6. Describe a calibration procedure of a zero suppression application and calculate span and elevation settings.
7. Describe a bubbler level system including the required supply pressure settings.
8. Describe purge systems used in bubbler level measurement.
9. Connect and calibrate a pneumatic differential pressure transmitter in atmospheric and pressurized vessels.

SECTION TWO:.....CONTROL INSTRUMENTS ..... 36 HOURS

A. Introduction to Automatic Control.....6 Hours

Outcome: Describe the fundamentals of automatic control and control terminology.

1. Explain why automatic control is necessary in process industries.
2. Define the terms used in automatic control.
3. Illustrate and describe feedback control and controller action selection.
4. Describe the methodology of transferring between auto and manual control.
5. Describe the application of auto/manual stations and bumpless transfer.
6. Demonstrate the effect of controller action.

B. On-Off Controllers .....4 Hours

Outcome: Install, and maintain on-off control.

1. Describe an on-off controller.
2. Describe the applications of on-off control.
3. Describe the operation of a differential gap controller.
4. Construct and commission an on-off control application.

C. Proportional Integral Derivative (PID) Control.....14 Hours

Outcome: Install and maintain PID controllers.

1. Define the terms used in PID control.
2. Perform controller output calculations for a proportional only controller.
3. Describe the operation of a pure proportional controller.
4. Describe bias and offset as applied to proportional control.

5. Explain the effect of gain on offset.
6. Perform controller output calculations for a PI controller.
7. State the purpose and application of integral in a controller.
8. Describe the effect of integral in a controller.
9. Explain reset wind-up on a controller.
10. Explain anti-reset wind-up and where it must be incorporated.
11. Perform controller output calculations for a PD and PID controller.
12. State the purpose and applications of derivative in a controller.
13. Perform controller output calculations for direct acting and reverse acting controllers.
14. State the guidelines to select the correct PID mode.

D. Pneumatic Controller Tuning ..... 12 Hours

Outcome: Tune pneumatic controllers.

1. Explain the term quarter amplitude decay.
2. Describe open loop methods used for controller tuning.
3. Describe the closed loop methods used for controller tuning.
4. Explain critically damped tunings.
5. Describe controller modes used on typical processes.
6. Describe pneumatic controller alignment.
7. Determine controller action and settings for a proportional only controller.
8. Perform a pneumatic controller alignment.
9. Determine controller action and settings for a PI controller and perform a bumpless transfer.

SECTION THREE: ..... ELECTRICAL AND DIGITAL FUNDAMENTALS ..... 59 HOURS

A. Electrical Theory ..... 7 Hours

Outcome: Apply electrical concepts to circuit analysis.

1. Describe the relationship between resistance, current and voltage.
2. Determine the value of various components using color codes and numerical identifiers.
3. Calculate the resistances, voltages, and currents in both series and parallel ac and dc circuits using Ohm's Law, voltage divider and Kirchoff's Laws.
4. Perform power calculations for a circuit, given any three of the following: resistance, current, voltage or power.
5. Determine the frequency, period, and voltages of various waveforms from both graphical representations and an oscilloscope display.
6. Evaluate and solve series/parallel circuits containing ac sources, dc sources, resistors, capacitors, and inductors.
7. Describe the characteristics and operation of conductors, insulators, semiconductors, and PN junctions.
8. Describe characteristics of forward and reverse biased Zener diodes in various circuit configurations.
9. Describe transistors as used for digital I/O sensing and switching.

B. Power Supplies ..... 6 Hours

Outcome: Install and maintain power supplies.

1. Explain the load vs. voltage characteristics of a transformer and how it applies to power supply sizing.
2. Define and illustrate the components of an UPS system.
3. Define the operation and applications of various power supplies and uninterruptable power supplies (UPS).
4. Define power supply output quality and quantity.
5. Troubleshoot power supply output qualities.

C. Introduction to Digital ..... 5 Hours

Outcome: Apply the fundamentals of digital electronics.

1. Describe the application of digital circuitry in measurement and control instrumentation, and how they differ from analog devices.
2. Describe the implications of electrostatic protection when servicing electronic devices.
3. Describe the application, similarities and the base conversion methods for decimal, binary, binary coded decimal (BCD), and hexadecimal number systems.
4. Solve basic arithmetic operations on decimal, binary, BCD, and hexadecimal number systems.

D. Logic Gates ..... 3 Hours

Outcome: Describe digital logic gates, their schematic symbols, and their Boolean functions.

1. Describe the purpose of digital logic gates.
2. Show the truth tables for various logic gates.
3. Explain the Boolean equations and the truth tables for various logic gates.

E. Microprocessors and Memory ..... 2 Hours

Outcome: Describe the basic elements of a microprocessor and application of memory devices.

1. Explain memory addressing and device selection/enabling methods.
2. Describe Random Access Memory (RAM) and Read Only Memory (ROM) and their applications.
3. Describe the components of a microprocessor.
4. Describe types of mass storage devices.
5. Describe different microprocessor peripheral Input / Output (I/O) devices.
6. Describe types of memory.

F. Introduction to Programmable Logic Controllers (PLC) ..... 20 Hours

Outcome: Explain the operation of a PLC running a ladder logic program.

1. Describe the symbols and conventions used in relay ladder logic diagrams.
2. Describe the components of a modular PLC.
3. Describe discrete and analog I/O card types and addressing used by modular PLC's.
4. Derive a PLC ladder logic program from a relay ladder logic diagram or a Boolean logic diagram.
5. Describe troubleshooting techniques and safety considerations when working on PLC's.

6. Commission a PLC that uses discrete and analog I/O.
7. Connect and program a PLC using ladder logic and discrete I/O.
8. Connect and program a PLC using ladder logic and analog I/O.

G. Introduction to Data Communications ..... 10 Hours

Outcome: Verify data communication between devices.

1. Describe terms used in data communication.
2. Explain serial data stream frame structure.
3. Explain the characteristics and applications of various protocols.
4. Explain the characteristics and applications of various transmission media.
5. Describe the purpose and application of modems.
6. Describe NULL modem and straight through cabling.
7. Connect two data communication devices and verify communication between them.

H. Intoduction to Personal Computers and Software Applications ..... 6 Hours

Outcome: Use software applications of a personal computer including office and industrial software.

1. Identify the hardware components of a computer.
2. Explain the purpose of data communication hardware.
3. Describe office and industrial software.
4. Describe software used in maintenance and reliability management.
5. Describe security measures as they apply to industrial instrumentation.
6. Demonstrate the ability to copy files, view and organize directories and backup data.
7. Demonstrate the use of word processing package applications.
8. Demonstrate the use of spread sheet package applications.
9. Demonstrate the use of data base package applications.
10. Demonstrate the use of the internet to research technical information.
11. Demonstrate the installation, upgrading and removal of industrial software.

SECTION FOUR: .....PROCESS EQUIPMENT AND ENERGY SYSTEMS..... 77 HOURS

A. Drawing and Symbols ..... 8 Hours

Outcome: Develop a Piping and Instrument Diagram (P&ID) drawing.

1. Define symbols used by International Society of Automation (ISA).
2. Describe the ISA identification system used in instrument drawings.
3. Define SAMA symbols.
4. Describe the SAMA identification system used for boiler control drawings.
5. Interpret P&ID drawings.
6. Interpret Process Flow Diagram (PFD) drawings.
7. Develop a P&ID drawing.

B. Gas Compression ..... 8 Hours

Outcome: ***Develop P&ID drawing of a compressor and process equipment.***

1. Describe the components of a reciprocating gas compressor.
2. Describe the components of other positive displacement compressors.
3. Describe the components of centrifugal gas compressors.
4. Describe applications of gas compressors.
5. Describe types of drivers used to drive compressors and pumps.
6. Develop and sketch a P&ID of a compressor and the related process equipment.
7. Identify hazards associated with gas compression equipment.

C. Liquid Pumping ..... 4 Hours

Outcome: ***Develop a P&ID of a pump and the related process equipment.***

1. Describe the components of positive displacement pumps.
2. Describe the components of centrifugal pumps.
3. Describe applications of pumps.
4. Describe the use of Variable Speed Drives (VSD) for liquid pumping.
5. Identify hazards associated with pumping equipment.
6. Develop and sketch a P&ID of a pump and the related process equipment.

D. Solids and Liquids ..... 4 Hours

Outcome: ***Describe the basic principles and equipment used for solids size reduction, solids enlargement, solids and liquids separation or mixing.***

1. Define size reduction in regards to crushing, grinding and pulverizing.
2. Explain the process of size enlargement of material.
3. Describe size separation and screening for process materials.
4. Describe the principles and operation of two and three phase separators.
5. Explain auxiliary support equipment/processes.
6. Describe equipment used to maintain material consistency.

E. Heat Transfer and Evaporation ..... 5 Hours

Outcome: ***Describe the principles and application of heat transfer and evaporation.***

1. Describe the terms of heat transfer.
2. Describe heat exchangers.
3. Describe cooling methods.
4. Describe process evaporators.
5. Describe the operation of a multiple effect evaporator.
6. Describe the separation of solids and liquids by crystallization.

F. Drying, Humidification and Dehumidification ..... 5 Hours

Outcome: ***Describe the principle and application used in the processes of gas humidification, gas drying, and solids drying.***

1. Define drying, humidification and dehumidification.
2. Describe the processes of solids drying.
3. Describe humidification of process gases.
4. Describe dehumidification of process gases.
5. Describe the principles and applications of absorption, desorption and adsorption.
6. Describe the principles of operation of desiccant and chemical dehydration processes.

G. Distillation and Fractionation ..... 3 Hours

Outcome: ***Describe the principles and application used in the process of fractionation and distillation.***

1. Define the terms used in distillation and fractionation processes.
2. Describe the distillation process.
3. Describe the fractionation process.

H. Boilers and Direct Fired Heaters ..... 3 Hours

Outcome: ***Describe the principle and application of boilers and fired heaters.***

1. Describe boilers and auxiliary equipment.
2. Describe boiler operation.
3. Describe burner management.
4. Describe direct fired heaters.
5. Describe current standards and regulations as they apply to gas fired equipment.

I. Production and Processing Plants ..... 7 Hours

Outcome: ***Explain the major components and processes of process facilities using process flow diagrams (PFD).***

1. Use a PFD to explain the major processes, flows and unit operations for gas sweetening and sulphur recovery.
2. Use a PFD to explain the major processes, flows and unit operations for NGL/LPG recovery and fractionation.
3. Use a PFD to explain the major processes, flows and unit operations for a Kraft pulp and paper mill.
4. Use a PFD to explain the major processes, flows and unit operations for an oil upgrading facility.
5. Use a PFD to explain the major processes, flows and unit operations for an oil refinery.
6. Use a PFD to explain the major processes, flows and unit operations for an oil recovery unit.
7. Use a PFD to explain the major processes, flows and unit operations for a water treatment facility.

J. Gas Detection ..... 8 Hours

Outcome: ***Install, and maintain gas detection devices.***

1. Describe applications of personal, portable and fixed gas detectors.
2. Describe applications of toxic gas detectors.

3. Describe applications of combustible gas detectors.
4. Describe the selection of calibration gas for an application.
5. Describe the placement of portable and fixed gas detectors.
6. Calibrate a combustible gas detector selecting calibration gases.
7. Calibrate a H_2S gas detector selecting calibration gases.
8. Perform and document a bump test and calibration of a personal multi-gas monitor.

K. Fire and Smoke Detection ..... 3 Hours

Outcome: ***Install, and maintain fire and smoke detection devices.***

1. Describe applications of fire and smoke detectors.
2. Describe types of fire detectors stating their operating characteristics, advantages and limitations.
3. Describe types of smoke detectors stating their operating characteristics, advantages and limitations.
4. Test a smoke and fire detector.

L. Emergency Shutdown Systems (ESD) ..... 4 Hours

Outcome: ***Describe Emergency Shutdown Systems (ESD).***

1. Explain the need for ESD systems.
2. Describe the components and logic of an ESD System.
3. Explain the applications of ESD systems.
4. Describe the individual responsibility after the activation of an ESD system.

M. Relieving Devices ..... 3 Hours

Outcome: ***Install and maintain relieving devices.***

1. Explain the need for relieving devices.
2. Describe types of relieving devices stating their operating characteristics, advantages and limitations.
3. Describe the documentation and governing body/certification requirements for relieving devices.

N. Pneumatic Systems ..... 8 Hours

Outcome: ***Install and maintain pneumatic supplied systems.***

1. Describe and illustrate types of air compressors and their applications.
2. Describe and illustrate air dryers, air receivers and air distribution piping as part of the overall instrument air system.
3. Describe alternate gas supplies used in pneumatic systems and related hazards.
4. Describe quality, specifications and sizing of an instrument air system.
5. Describe safety considerations of pneumatic systems.
6. Describe benefits and disadvantages of pneumatic systems compared to alternate energy systems.

O. Hydraulic Systems ..... 2 Hours

Outcome: ***Install and maintain hydraulic systems.***

1. Describe and illustrate the specifications and components of a hydraulic system.
2. Describe alternate fluids used in hydraulic systems and related hazards.
3. Describe the benefits and disadvantages of hydraulic systems compared to other energy systems.
4. Describe safety and environmental considerations of hydraulic systems.

P. Electrical Systems ..... 2 Hours

Outcome: ***Install and maintain electrical systems.***

1. Describe safety considerations of electrical energy system.
2. Describe the components of alternate/multiple power sources and associated hazards.
3. Describe benefits and disadvantages of electrical systems compared to other energy systems.

THIRD PERIOD TECHNICAL TRAINING
INSTRUMENTATION AND CONTROL TECHNICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: ..... ELECTRONIC INSTRUMENT LOOPS..... 44 HOURS

A. Analog Loops .....10 Hours

Outcome: Calibrate analog loops.

1. Describe the standard signal levels used in industrial measurement and control loops.
2. Calculate loop output between various standards.
3. Describe why current rather than voltage is primarily used for signal transmission.
4. Illustrate an instrument loop using a 2 wire transmitter.
5. Illustrate an instrument loop using a 4 wire transmitter.
6. Describe the circuits used to test the output of a transmitter without interrupting the current flow.
7. Describe the current to voltage relationships of an analog control loop.
8. Calculate maximum loop resistance for a current loop.
9. Describe test procedures used to calibrate and/or troubleshoot analog loops.
10. Predict how the loop could be affected by common circuit faults.
11. Calibrate an analog loop.

B. Grounding and Shielding Methods .....8 Hours

Outcome: Install grounding and shielding on equipment.

1. Describe the importance of grounding and shielding electronic equipment.
2. Describe the difference between grounding and shielding.
3. Describe methods for grounding electronic equipment.
4. Describe methods for shielding electronic equipment.
5. Install an analog instrument, demonstrate shielding methods and compare unshielded and shielded wiring methods using an oscilloscope.
6. Install an analog instrument, demonstrate grounding methods and compare ungrounded and grounded wiring methods using an oscilloscope and multimeter.

C. Analog to Digital (ADC) and Digital to Analog Conversion (DAC) .....4 Hours

Outcome: Install and maintain analog to digital (ADC) and digital to analog converters (DAC).

1. Describe the purpose and application for both ADC's and DAC's.
2. Describe resolution and calculate the resolution based on the number bits of binary data.
3. Describe multiplexer applications.
4. Explain terms and specifications for both ADC's and DAC's.
5. Perform output calculations of an ADC and DAC for a given input value.

D. Signal Conditioning ..... 6 Hours

Outcome: Install and maintain signal conditioners.

1. Describe the functions and applications of signal transducers.
2. Describe the components, function and application of a current to pressure (I/P) transducer.
3. Identify signal transducers.
4. Install and calibrate an I/P signal transducer.

E. Smart Instruments..... 10 Hours

Outcome: Install and maintain smart instruments.

1. Describe the hardware architecture, features and operation of smart instruments.
2. List the digital communications standards and protocols used with smart instruments.
3. Describe the operation of hand-held and personal computer interfaces used with smart instruments.
4. Describe the advantages of smart instruments in measurement and control loops.
5. Demonstrate a digital waveform imposing an analog signal using an oscilloscope and hand held communicator.
6. Install and configure a smart positioner and capture a valve signature.
7. Configure and verify the accuracy of a smart thermocouple temperature transmitter.
8. Configure and verify the accuracy of a smart RTD temperature transmitter.

F. Single Loop Digital Controllers (SLDC) / Stand Alone Controllers (SAC)..... 6 Hours

Outcome: Install and maintain single loop digital controller (SLDC) / stand alone controllers (SAC).

1. Describe the operation of SLDC/SAC.
2. Describe the functions and applications of SLDC/SAC.
3. Sketch a control loop diagram illustrating controller type, action and valve fail position.
4. Connect and configure a SLDC and / or a SAC for a level control application.

SECTION TWO: ..... MEASUREMENT ..... 79 HOURS

A. Accuracy and Repeatability ..... 9 Hours

Outcome: Verify the accuracy of a measurement system.

1. Describe accuracy and its importance in measurement.
2. Describe repeatability and its importance in measurement.
3. State accuracy statements for analog and digital instruments and calculate their possible range of errors.
4. Describe the correlation of accuracy and repeatability as they relate to measurement uncertainty.
5. Demonstrate the accuracy and repeatability of a given instrument/component from the values measured and then compared to the manufacturer's specifications.
6. Measure and calculate the possible and probable range of errors for a measurement system consisting of several instruments.
7. Verify and compare the accuracy of a thermocouple and a RTD at three points.

B. Measurement Traceability ..... 4 Hours

Outcome: ***Apply regulations on measurement accuracy and traceability.***

1. Describe traceability and its importance in measurement and related certification.
2. Describe the regulatory standards and the governing bodies responsible for measurement accuracy and traceability.
3. Describe how measurement traceability relates to regulatory standards.
4. Apply current regulations on measurement accuracy and traceability.

C. Differential Pressure Using Smart Technology ..... 4 Hours

Outcome: ***Install and maintain differential pressure level and density measurement equipment.***

1. Describe differential pressure methods used in level measurement.
2. Describe differential pressure methods used in density measurement.
3. Describe wet and dry leg level transmitter installations.
4. Describe remote seal level transmitter installations.
5. Calculate the expected zero and span in a wet leg level application, install and configure a smart differential pressure transmitter for a suppressed zero application and verify the calculations.
6. Connect and configure a smart differential pressure transmitter in a wet leg suppressed zero application and determine the density.

D. Nuclear ..... 3 Hours

Outcome: ***Install and maintain nuclear instruments used in density and level measurement.***

1. Describe principles and applications used in nuclear instruments.
2. Describe installation requirements for nuclear instruments.
3. Describe methods used to calibrate nuclear instruments.
4. Describe required safety considerations when working with and around radioactive sources.
5. Describe the regulatory bodies for nuclear sources.

E. Ultrasonic and Radar ..... 6 Hours

Outcome: ***Install and maintain ultrasonic and radar level instruments.***

1. Describe principles and application of ultrasonic level instruments.
2. Describe installation requirements for ultrasonic level instruments.
3. Describe principles and applications of radar level instruments.
4. Describe installation requirements for radar level instruments.
5. Connect and calibrate an ultrasonic or radar level instrument.

F. Capacitance, Thermal Dispersion, Optical and Magnetostrictive ..... 5 Hours

Outcome: ***Install, and maintain capacitance, thermal, optical, and magnetostrictive level instruments.***

1. Describe principles, applications and installation requirements of capacitance level instruments.
2. Describe principles, applications and installation requirements of thermal level instruments.

3. Describe principles, applications and installation requirements of optical level instruments.
4. Describe principles, applications and installation requirements of magnetostrictive level instruments
5. Connect and calibrate a capacitance level instrument.

G. Solids ..... 2 Hours

Outcome: ***Install and maintain solids level instruments.***

1. Describe the principles and application of solids level instruments.
2. Describe the installation requirements for solids level instruments.

H. Viscosity ..... 2 Hours

Outcome: ***Describe viscosity.***

1. Describe absolute viscosity and kinematic viscosity.
2. Describe Newtonian and non-Newtonian liquids.
3. Describe the effect of viscosity on flow measurement.

I. Flow Measurement ..... 4 Hours

Outcome: ***Describe flow measurement.***

1. State the purposes for flow measurement.
2. Compare mass flow and volumetric flow.
3. Describe the regulatory standards and the governing bodies responsible for flow measurement.
4. Describe principles and application of meter proving.
5. Sketch a loop diagram illustrating basic components of a proving measurement system.

J. Differential Pressure Elements ..... 4 Hours

Outcome: ***Install and maintain differential pressure elements focusing on elements other than orifice plates.***

1. Describe principles and applications of differential pressure elements.
2. Describe components of differential pressure elements.
3. Describe installation requirements for differential pressure elements.
4. Describe maintenance and calibration of differential pressure elements.
5. Describe advantages and limitations of differential pressure elements.

K. Magnetic Flowmeters ..... 4 Hours

Outcome: ***Install and maintain magnetic flowmeters.***

1. Describe the principles and applications of magnetic flowmeters.
2. Describe components of a magnetic flowmeter.
3. Describe installation requirements for magnetic flowmeters.
4. Describe maintenance and calibration of magnetic flowmeters.
5. Describe advantages and limitations of magnetic flowmeters.

L. Turbine Flowmeters ..... 6 Hours

Outcome: ***Install and maintain turbine flowmeters.***

1. Describe principles and applications of turbine flowmeters.
2. Describe components of a turbine flowmeter.
3. Describe installation requirements for turbine flowmeters.
4. Describe maintenance and calibration of turbine flowmeters.
5. Describe advantages and limitations of turbine flowmeters.
6. Perform a volumetric prove of a turbine flowmeter calculating the K-factor and configure the totalizer.

M. Vortex Flowmeters ..... 4 Hours

Outcome: ***Install and maintain vortex flowmeters.***

1. Describe the principles and applications of vortex flowmeters.
2. Describe components of a vortex flowmeter.
3. Describe installation requirements for vortex flowmeters.
4. Describe the maintenance and calibration of vortex flowmeters.
5. Describe advantages and limitations of vortex flowmeters

N. Ultrasonic Flowmeters ..... 4 Hours

Outcome: ***Install and maintain ultrasonic flowmeters.***

1. Describe the principles and applications of ultrasonic flowmeters.
2. Describe components of an ultrasonic flowmeter.
3. Describe installation requirements for ultrasonic flowmeters.
4. Describe the maintenance and calibration of ultrasonic flowmeters.
5. Describe advantages and limitations of ultrasonic flowmeters.

O. Mass Flowmeters ..... 6 Hours

Outcome: ***Install and maintain mass flowmeters.***

1. Describe the principles and applications of mass flowmeters.
2. Describe the components of a mass flowmeter.
3. Describe installation requirements for mass flowmeters.
4. Describe maintenance and calibration of mass flowmeters.
5. Describe advantages and limitations of mass flowmeters.
6. Configure a mass flowmeter, perform a master meter prove and calculate the meter factor.

P. Positive Displacement Flowmeters ..... 6 Hours

Outcome: ***Install and maintain positive displacement flowmeters.***

1. Describe principles and applications of positive displacement flowmeters.
2. Describe components of a positive displacement flowmeter.
3. Describe installation requirements for positive displacement flowmeters.

4. Describe maintenance and calibration of positive displacement flowmeters.
5. Describe advantages and limitations of positive displacement flowmeters.
6. Connect and determine meter factor for a positive displacement flowmeter.

Q. Flow Computers ..... 6 Hours

Outcome: Install and maintain flow computers.

1. Describe parameters of a flow computer.
2. Describe principles and applications of flow computers.
3. Describe components of flow computers.
4. Describe advantages and limitations of flow computers.
5. Connect a flow computer for a liquid application to an ultrasonic meter and configure.
6. Install end devices on a gas orifice meter run, connect to a flow computer, configure and calibrate measurement system.

SECTION THREE: ..... PHYSICAL PROPERTIES ..... 58 HOURS

A. Matter ..... 9 Hours

Outcome: Describe the relationship between atomic structure and electron flow.

1. Describe the basic composition of matter.
2. Describe physical and chemical changes to matter.
3. Describe the basic structure of the atom.
4. Describe the periodic table as it applies to properties of matter.
5. Describe nuclear fission and fusion.

B. Inorganic Compounds ..... 8 Hours

Outcome: Describe inorganic compounds.

1. Describe the formation of compounds.
2. Describe oxidation.
3. Describe simple and complex ions.
4. Describe cation/anion combinations.
5. Describe the classifications of compounds.

C. Chemical Calculations ..... 8 Hours

Outcome: Perform chemical calculations.

1. Describe molar mass, mass, number of molecules and number of atoms for a given number of moles in any compound.
2. Calculate the volume of moles of any gas at standard conditions.
3. Calculate the percent mass composition of each element in a compound.
4. Describe concentration of solutions.
5. Balance formulas for chemical reactions.

D. Chemical Reaction ..... 12 Hours

Outcome: Describe chemical reaction.

1. Describe classification of chemical reactions.
2. Describe chemical reactions involving metal and a metal ion.
3. Describe factors that influence rate of chemical reaction.
4. Describe exothermic and endothermic reaction.
5. Describe activation energy and reaction rate.
6. Describe electrical properties of water solutions.
7. Define pH, hydrogen ion concentration, and ionic activity.
8. Describe acids and bases as related to the pH scale.
9. Describe acid/base titration.
10. Describe oxidization and reduction in a chemical reaction.
11. Describe electrochemical cells.

E. Organic Chemistry ..... 15 Hours

Outcome: Describe organic chemistry.

1. Describe carbon bonding.
2. Describe carbon compounds and their molecular formula.
3. Describe organic families.
4. Describe the hydrocarbon chain.
5. Describe the chemical reactions used to refine the hydrocarbon chain.
6. Apply the stoichiometric equation to combustion of hydrocarbons.

F. Metallurgy ..... 6 Hours

Outcome: Select a metal or alloy for a required application.

1. Describe physical and mechanical properties of metals.
2. Describe effects of expansion and contraction.
3. Describe factors that change the properties of metals and alloys.
4. Identify effects of heat treatment on metals.
5. Describe applications and mechanical properties of alloying elements used in steel.
6. Interpret charts and tables to select a metal or alloy for an application.
7. Describe techniques of conditioning and coating of metals and alloys.
8. Describe methods of destructive and non-destructive testing of metals.
9. Describe hydrostatic tests.
10. Describe hardness testing.

SECTION FOUR: ..... PROCESS ANALYZERS ..... 50 HOURS

A. Process Analyzers ..... 6 Hours

Outcome: ***Explain the terminology, technology, and applications of analytical measurements.***

1. Describe process analytical measurement and terminology.
2. Describe applications of process analyzers.
3. Describe analyzer technologies.
4. Describe analyzer tolerances and limitations.
5. Describe environmental considerations for analyzer installations.
6. Describe calibration and calibration interaction of process analyzers.
7. Describe qualitative and quantitative data analysis.
8. Interpret block diagrams used in analyzer documentation.

B. Analyzer Sampling Systems ..... 10 Hours

Outcome: ***Explain analyzer sampling systems, including the system components and materials specifications.***

1. Describe the purpose of a sample system.
2. Define in-situ and extractive sampling, used by continuous analyzers.
3. Describe the purpose and methods of sample conditioning.
4. Define clean and dirty service sample systems.
5. Describe the importance of sample loop time.
6. Describe components, design and limitations of sample systems.
7. Describe common troubleshooting techniques of various sample systems.
8. Describe representative grab sampling and the techniques utilized in grab sampling.

C. Gas Analyzers ..... 12 Hours

Outcome: ***Install and maintain gas analyzers.***

1. Describe applications of gas analyzers.
2. Describe safety concerns when dealing with gas analyzers.
3. Describe principles of analysis and application of relative humidity analyzers.
4. Perform relative humidity calculations using psychrometric charts and tables.
5. Describe operation and calibration for dew point sensors.
6. Describe principles of analysis and application of dew point analyzers.
7. Describe principles of analysis and application of moisture analyzers.
8. Describe combustible chemical reactions.
9. Describe principles of analysis and application of oxygen analyzers.
10. Describe principles of analysis and application of combustion analyzers.
11. Describe combustion parameters measured to determine air to fuel ratio.
12. Describe the relationship between energy conservation, pollution emissions and combustion efficiency.
13. Connect / calibrate a combustion analyzer and demonstrate the effect of changing air / fuel ratios.

D. Liquid Analyzers ..... 12 Hours

Outcome: ***Install and maintain liquid analyzers.***

1. Describe applications of liquid analyzers.
2. Describe safety concerns when dealing with liquid analyzers.
3. Describe principles of analysis and application of pH analyzers.
4. Describe electrochemical process, measurement and reference half-cell reactions.
5. Apply the Nernst equation to pH measurements and determine why temperature correction is required.
6. Describe pH sensor limitations and control problems.
7. Describe similarities and differences between pH, specific ion and ORP measurements.
8. Describe buffer solutions for pH standards.
9. Describe principles of analysis and application of conductivity analyzers.
10. Describe the operation of conductivity cells.
11. Describe principles of analysis and application of turbidity analyzers.
12. Describe the operation of turbidity analyzers.
13. Describe principles of analysis and application of dissolved oxygen analyzers.
14. Describe the operation of dissolved oxygen analyzers.
15. Connect / calibrate a pH analyzer using 3 points and demonstrate the effects of buffer temperature on calibration.

E. Physical Property Analyzers ..... 6 Hours

Outcome: ***Install and maintain physical property analyzers.***

1. Describe principles of analysis and application of distillation (boiling point) analyzers.
2. Describe principles of analysis and application of vapour pressure analyzers.
3. Describe principles of analysis and application of viscosity analyzers.
4. Describe principles of analysis and application of density analyzers.
5. Demonstrate the effect of temperature on vapour pressure.

F. Vibration Monitoring ..... 4 Hours

Outcome: ***Install and maintain vibration monitoring equipment.***

1. Describe vibration as it relates to force and motion.
2. Describe units of measurement related to vibration monitoring.
3. Describe components of vibration monitoring equipment.
4. Describe where vibration monitoring is commonly used.
5. Assemble a probe, cable and amplifier, and use them to determine critical speed.

SECTION FIVE: ..... PROCESS CONTROL ..... 69 HOURS

A. Closed Loop Analysis ..... 14 Hours

Outcome: Analyze loop characteristics.

1. Describe block diagrams and output/input equations for open loop control.
2. Describe the difference between linear and non-linear static gains.
3. Describe the characteristics of an integrating process.
4. Describe the characteristics of a first order process.
5. Describe the characteristics of a dead time process.
6. Describe the characteristics of a multi-capacity process.
7. Perform an open loop test to determine the characteristics of the above processes.

B. Process Loop Dynamics ..... 14 Hours

Outcome: Explain the dynamics of process control loops.

1. Describe the behaviour of an open loop system to a frequency input.
2. Describe the open loop frequency response of a dead time process.
3. Describe the open loop frequency response of an integrating process.
4. Describe the open loop frequency response of a first order.
5. Describe the open loop frequency response of a multi-capacity process.
6. Determine the effect of a frequency input on the gain and phase of a process.

C. Closed Loop Control ..... 14 Hours

Outcome: Explain the principles and applications of closed loop control for process control.

1. Describe the behaviour of a closed loop system to a disturbance.
2. Describe the closed loop response of a first order process.
3. Describe the closed loop response of an integrating process.
4. Describe the closed loop response of a dead time process.
5. Describe the closed loop response of a multi-capacity process.
6. Describe control strategies for non-linear processes.
7. Implement control strategies for the above non-linear processes.

D. Digital Controller Tuning ..... 10 Hours

Outcome: Commission and tune digital controllers.

1. Describe features and functionality of digital controllers versus pneumatic controllers.
2. Calculate the controller settings of a control loop.
3. Determine controller mode selection and initial settings for various process control loops.
4. Verify results of the self-tuning feature of a digital controller.
5. Connect, configure and tune a single loop digital controller in a gas pressure process.
6. Connect, configure and tune a single loop digital controller in a liquid pressure process.

7. Connect, configure and tune a controller in a flow application.
8. Connect, configure and tune a controller in a level application.

E. Cascade Control ..... 10 Hours

Outcome: ***Develop cascade control loop for process control.***

1. Describe advantages and applications for cascade control.
2. Describe failure mode considerations and control action for cascade control loops.
3. Explain how the effective time constant of the inner loop is reduced under cascade control.
4. Describe methods for tuning cascade control systems.
5. Draw a block diagram of a cascade control system.
6. Connect and tune a cascade control loop for a level/flow application.

F. Selective Control ..... 7 Hours

Outcome: ***Develop a selective control loop for process control.***

1. Describe advantages and applications for selective control.
2. Explain how to prevent reset windup on selective control.
3. Describe the methods for tuning selective control systems.
4. Draw a block diagram of a selective control system.
5. Configure and tune a selective control loop.

FOURTH PERIOD TECHNICAL TRAINING
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COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: ..... ADVANCED PROCESS CONTROL..... 78 HOURS

A. Multiariable Control ..... 8 Hours

Outcome: ***Develop a multivariable control loop.***

1. Describe advantages and applications for multivariable control.
2. Draw a block diagram of a multivariable control system.
3. Describe methods for tuning multivariable control systems.
4. Configure and tune a multivariable control loop.

B. Ratio Control ..... 8 Hours

Outcome: ***Develop a ratio control loop.***

1. Describe advantages and applications for ratio control.
2. Draw a block diagram of a ratio control system.
3. Describe methods for tuning ratio control systems.
4. Configure and tune a ratio control using hot and cold streams.

C. Feedforward Control ..... 10 Hours

Outcome: ***Develop a feedforward control loop.***

1. Describe the differences between a feedforward control loop and a feedback control loop.
2. Describe the advantages and applications for feedforward control.
3. Draw a block diagram of a feedforward control system.
4. Describe the methods for tuning feedforward control systems.
5. Configure and tune a feedforward control loop.

D. Split Range Control ..... 6 Hours

Outcome: ***Develop a split range control loop.***

1. Describe the advantages and applications for split range control.
2. Draw a block diagram of a split range control system.
3. Describe the methods for tuning split range control systems.
4. Configure and tune a split range control loop.

E. Distillation Control ..... 12 Hours

Outcome: ***Develop a control strategy for distillation processes.***

1. Define the terms related to distillation process control.
2. Describe control strategies used in the distillation process.

3. Describe problems associated with distillation process control.
4. Demonstrate distillation process control.

F. Boiler Control.....12 Hours

Outcome: Develop a control strategy for boiler control.

1. Define terms related to boiler process control.
2. Describe control strategies used in the boiler process.
3. Describe problems associated with boiler process control.
4. Demonstrate boiler process control.

G. Compressor Control.....12 Hours

Outcome: Develop a control strategy for compressor control.

1. Define terms related to centrifugal compressor control.
2. Describe control strategies used in centrifugal compressor control.
3. Describe problems associated with centrifugal compressor control.
4. Define terms related to reciprocating compressor control.
5. Describe control strategies used in reciprocating compressor control.
6. Describe problems associated with reciprocating compressor control.
7. Demonstrate reciprocating and centrifugal compressor control applications.

H. Safety Instrumented Systems (SIS).....10 Hours

Outcome: Develop a control strategy for safety instrumented systems (SIS).

1. Describe safety instrumented systems (SIS) and it's difference from basic process control systems (BPCS).
2. Describe safety integrity level (SIL) ratings.
3. Describe redundancy as it relates to SIS.
4. Select, configure and verify a SIS system for a specific SIL rating.

SECTION TWO:.....COMMUNICATION..... 57 HOURS

A. Signal Transmission Systems.....6 Hours

Outcome: Install and maintain signal transmission systems.

1. Describe signal transmission systems used for communication.
2. Describe components of signal transmission systems.
3. Describe applications of signal transmission systems.
4. Connect and configure a signal transmission system.

B. Communication Signal Converters .....6 Hours

Outcome: Install and maintain communication signal converters.

1. Describe communication signal converters used for signal transmission.
2. Describe components of signal converters.

3. Describe applications of signal converters.
4. Configure a signal converter.

C. Protocols ..... 14 Hours

Outcome: ***Apply protocols between devices as used in industrial communication systems.***

1. Describe and compare the capabilities of digital field devices to that of analog devices.
2. Compare open and proprietary communication protocols.
3. Describe communication devices and application software.
4. Connect, configure and analyze several different protocol signals between devices.

D. Industrial Networks ..... 15 Hours

Outcome: ***Install and maintain industrial networks.***

1. Describe the different area networks and their applications.
2. Describe network components and characteristics.
3. Describe different transmission techniques of both wired and wireless.
4. Describe the different network topologies.
5. Describe methods of networking PLC's and DCS's.
6. Connect and network PLC's and or DCS's to implement industrial applications.
7. Assemble and configure a wireless network.

E. Supervisory Control and Data Acquisition (SCADA) ..... 16 Hours

Outcome: ***Perform configuration and maintenance of supervisory control and data acquisition systems.***

1. Describe SCADA applications.
2. Describe components and installation considerations of SCADA systems.
3. Describe standards, codes and licenses associated with SCADA systems.
4. Assemble, configure and test a single point to point SCADA system.
5. Assemble, configure and test a SCADA host to multiple remote terminal units (RTU).

SECTION THREE: ..... CONTROL SYSTEMS ..... 104 HOURS

A. Programmable Logic Controllers (PLC) ..... 50 Hours

Outcome: ***Select, configure, troubleshoot and maintain programmable logic controllers (PLC).***

1. Describe PLC ladder logic programs that use timers and counters.
2. Describe PLC ladder logic programs that use math instructions and PID control.
3. Describe PLC function block, sequential logic and structured text programs.
4. Describe PLC programs that use subroutines.
5. Describe PLC mixed language programs.
6. Describe PLC integration to various fieldbus devices.
7. Describe redundancy as it applies to PLC's.

8. Describe safety considerations when making changes online, forcing, disabling and bypassing I/O's.
9. Describe change management as it applies to PLC program changes.
10. Select all components, assemble and configure a PLC for a process control application.
11. Connect and program a PLC using ladder logic for a process control application.
12. Connect and program a PLC using function blocks for a process control application.
13. Connect and program a PLC that uses mixed programming.
14. Add I/O to a PLC; perform a program change and perform a backup.
15. Integrate various fieldbus devices to a PLC.
16. Use a configuration compare tool and update PLC change documentation.

B. Distributed Control Systems (DCS) ..... 40 Hours

Outcome: Select, configure and maintain distributed control systems (DCS).

1. Describe the hardware components and the buses of a DCS
2. Describe the different software programs of a DCS.
3. Describe data flow, scan cycle and databases of a DCS.
4. Evaluate DCS function block programs and communication between blocks.
5. Describe alarm management and history management concepts for a DCS.
6. Describe security and access privileges for a DCS.
7. Describe redundancy as it applies to DCS.
8. Describe change management and audit trail as they apply to a DCS.
9. Describe safety considerations as it applies to a DCS when making changes online, forcing, disabling and bypassing I/O's
10. Perform software configuration for a DCS.
11. Download and commission an analog process control strategy for a DCS.
12. Download and commission a discrete process control strategy for a DCS.
13. Add a smart field device to a DCS.
14. Add I/O to a DCS, perform a program change and perform a backup.
15. Troubleshoot a fault on a DCS using error codes.
16. Use historical logs, error logs and diagnostic tools to verify changes and troubleshoot a DCS.

C. Variable Speed Drives (VSD) ..... 6 Hours

Outcome: Perform configuration and maintenance of variable speed drives (VSD) used in process control.

1. Describe the principles and applications of VSDs.
2. Describe components of VSDs.
3. Describe software versions and updates.
4. Connect and configure a VSD to a PLC to control a process.

D. Human Machine Interfaces (HMI) ..... 8 Hours

Outcome: Perform configuration and maintenance of human machine interfaces (HMI).

1. Describe HMI components and their applications.

2. Describe programming/configuration software used for HMIs.
3. Describe methods of networking HMIs.
4. Describe software versions and updates.
5. Describe change management as it applies to HMI program changes.
6. Connect and program a HMI in a process control application.
7. Configure an HMI for VSD flow control.
8. Perform a program change and perform a backup.

SECTION FOUR:PROCESS ANALYZERS / MAINTENANCE PLANNING / WORKPLACE SKILLS ... 61 HOURS

A. Process Chromatography.....12 Hours

Outcome: Install and maintain chromatographs.

1. Explain the principle of analysis utilized by chromatography.
2. Define the terminology used in chromatography.
3. Describe components of a gas chromatograph.
4. Describe detectors used in gas chromatography.
5. Describe components of a liquid chromatograph.
6. Describe detectors used in liquid chromatography.
7. Describe sample systems and sample conditioning as they apply to chromatography.
8. Explain multi stream sample switching techniques.
9. Describe hazards and safe work practises related to chromatography and their sample systems.
10. Perform a manufacturer's periodic maintenance routine on a gas chromatograph unit.
11. Select a column and assemble sample system components for a given sample stream for a gas chromatograph, run analysis and interpret results.

B. Mass Spectrometry .....6 Hours

Outcome: Describe the principles, terminology, and applications of mass spectrometry.

1. Describe the principles of mass spectrometry.
2. Describe the application of mass spectrometry.

C. Environmental Monitoring .....8 Hours

Outcome: Install and maintain environmental monitoring devices.

1. Describe environmental monitoring and list pollutants that must be monitored and controlled.
2. Describe environmental monitoring with regards to health and safety.
3. Describe the role of government regulatory agencies.
4. Describe regulatory compliance with regard to environmental monitoring and the consequences of noncompliance.
5. Select and assemble sample system and sample conditioning components for a given sample stream for an environmental monitoring system, run analysis and interpret results.

D. Spectroscopic Analyzers ..... 3 Hours

Outcome: ***Install and maintain spectroscopic analyzers.***

1. Describe the electromagnetic spectrum and electromagnetic radiation.
2. Describe absorption and emission spectrums.
3. Describe the principles of analysis and application of spectroscopic analyzers.
4. Describe the use of Beer-Lambert absorption laws for infrared (IR) and ultraviolet (UV) absorption analyzers.
5. Describe fluorescence.

E. Infrared Analyzers (IR) ..... 6 Hours

Outcome: ***Install and maintain infrared analyzers.***

1. Describe the difference between dispersive infrared (DIR) and non-dispersive infrared (NDIR) analyzers.
2. Describe the sources, cells and detectors utilized by NDIR analyzers.
3. Describe negative and positive filtering techniques as applied in industry.
4. Describe process applications for IR analyzers.
5. Demonstrate the operation and calibration of a NDIR analyzer.

F. Ultraviolet Analyzers (UV) ..... 6 Hours

Outcome: ***Install and maintain ultraviolet analyzers.***

1. Describe the principles of analysis and application of ultraviolet analyzers (UV).
2. Describe the components of UV analyzers.
3. Describe UV precautions and hazards.
4. Explain the differences between UV absorption and UV emission (fluorescence) analysis.
5. Demonstrate the operation and calibration of an ultraviolet analyzer.

G. Chemiluminescence ..... 4 Hours

Outcome: ***Install and maintain chemiluminescent analyzers.***

1. Describe the chemical reactions related to chemiluminescence analysis.
2. Describe the components of a chemiluminescence nitric oxide (NO) analyzer.
3. Describe the principles of analysis and application of chemiluminescence analyzers.
4. Demonstrate the operation of a gas sample system for a chemiluminescence analyzer.
5. Demonstrate the operation and calibration of a chemiluminescence analyzer.

H. Maintenance Planning ..... 10 Hours

Outcome: ***Perform maintenance planning.***

1. Describe reactive, preventative and predictive methods of maintenance planning.
2. Describe key performance indicators (KPI) as it relates to reliability.
3. Describe the equipment criticality decision process as it relates to maintenance planning.
4. Describe the inventory control process.
5. Describe estimating, justification and purchasing procedures.

6. Describe maintenance scheduling and record keeping.
7. Describe management of change (MOC) processes and their purpose.

I. Workplace Coaching Skills ..... 2 Hours

Outcome: ***Use coaching skills when training an apprentice.***

1. Describe the process for coaching an apprentice.

J. Alberta's Industry Network ..... 2 Hours

Outcome: ***Describe the role of the network of industry committees that represent trades and occupations in Alberta.***

1. Describe Alberta's Apprenticeship and Industry Training system.
2. Describe roles and responsibilities of the Alberta Apprenticeship and Industry Training Board, the Government of Alberta and post-secondary institutions.
3. Describe roles and responsibilities of the Provincial Apprenticeship Committees (PACs), Local Apprenticeship Committees (LACs) and Occupational Committees (OCs).

K. Interprovincial Standards Red Seal Program ..... 2 Hours

Outcome: ***Use Red Seal products to challenge an Interprovincial examination.***

1. Identify Red Seal products used to develop Interprovincial examinations.
2. Use Red Seal products to prepare for an Interprovincial examination.

Apprenticeship and Industry Training

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