Power Electrician
Level 3

04-2025

Apprenticeship Manitoba

Power Electrician

Unit: C1 Electrical Code for Industrial Applications I

Level: Three

Duration: 60 hours

Theory: 60 hours

Practical: 0 hours

Overview:

This unit is designed to provide the apprentice with introductory knowledge about the electrical code for industrial applications. The unit begins with coverage of industrial wiring methods and devices. Part of the unit covers other industrial components and concepts, including transformers, capacitors, motors, and lightning protection and lighting applications. Finally, the unit covers demand factors for industrial applications, and interpretation of plans, drawings and specifications.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Identify hazards and describe safe work practices pertaining to electrical code for industrial applications.	**5%**
2. Describe industrial wiring methods and practices. a. CEC requirements b. Single conductors, cables, busways and raceways • Ampacities • Derations • Conditions of use • Metallurgy (compatibility of materials) c. Bonding and grounding d. Underground ampacities and installations e. Perform related calculations • Voltage drop calculations • Raceway fill calculations	**15%**
3. Describe industrial wiring devices and applications. a. CEC requirements b. Outlet boxes • Sizes • Types • Applications • Box fill calculations c. Receptacles	**15%**

d. Switches and disconnects
e. Specialty outlets

4. Describe industrial lighting applications. 5%

a. CEC requirements
b. Types, including:
   - Incandescent
   - Fluorescent
   - High-intensity discharge (HID)
   - Light emitting diode (LED)
c. Considerations in lamp selection
   - Colour rendition
   - Efficacy
   - Maintenance
   - Purpose and location
d. Control options

5. Describe transformers and capacitors. 20%

a. CEC requirements
b. Transformer types
   - Dry
   - Liquid-filled
   - High voltage
c. Transformer installations
   - Single phase
   - Three phase
d. Perform related calculations
e. Grounded and ungrounded systems
   - Ground fault detection
f. Unit substation
   - Medium voltage installation

6. Describe the installation of single motors and groups of motors. 15%

a. CEC requirements
b. Single phase AC
c. Three phase AC
d. DC
e. Various duty cycles
   - Continuous
   - Intermittent
   - Varying
   - Periodic
   - Short-time
f. Perform related calculations (including tap conductors)

7. Describe welder installations. 5%

a. CEC requirements
b. Perform related calculations

8. Describe demand factors for industrial applications. 10%

a. Single phase voltage drop
b. Three phase voltage drop

c. Continuous loading
d. Conductor derating
e. System voltages

9. Describe electrical bus networks. **10%**

a. Purpose
b. Types and applications
c. Electrical clearances
d. Insulators
e. Connections and terminations
f. Sizing and ampacity considerations and installation applications

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Apprenticeship Manitoba

Power Electrician

Unit: C2 Three-Phase Circuit Analysis and Transformers

Level: Three

Duration: 90 hours

Theory: 85 hours

Practical: 5 hours

Overview:

This unit is designed to provide the apprentice with the knowledge and skills about three phase circuit analysis and transformers. The unit starts by covering three phase systems and loads in wye and delta configurations, and power draw and power ratings of three phase loads and sources. Later the unit covers power transformers, instrument transformers and special transformer connections. Part of the unit covers three phase transformers and transformer banks. Finally, the unit covers transformer testing and connection techniques.

Objectives and Content: **Percent of Unit Mark (%)**

1. Identify hazards and describe safe work practices pertaining to three-phase circuit analysis and transformers. **5%**

2. Define and describe three phase systems in wye and delta configurations. **10%**

a. Relationship between phase and line
- Voltage
- Current

b. Vector (phasor) relationship
- Phasor diagram

c. Connections

3. Define and describe three phase loads in wye and delta configurations. **10%**

a. Perform related calculations
- Balanced and unbalanced loads

b. Draw and interpret vector (phasor) diagrams
- Unity and non-unity power factor loads

c. Effects of a broken neutral

4. Determine the power draw and power ratings of three phase loads and sources. **15%**

a. Power factor

b. Perform related calculations
- Balanced and unbalanced loads
- Power factor correction
- Power measurement (two and three wattmeter method)

5. Describe principles of transformers. **20%**

a. Purpose
b. Basic components
c. Operation and maintenance
   - Transformer action
   - Regulated and non-regulated transformers
   - Cooling methods
d. Nameplate data
e. Types and application
   - Isolation
   - Auto transformer
f. Transformer polarities
   - Inductive kick test
   - Low voltage polarity test
g. Efficiencies
   - Types of losses
h. Perform related calculations
   - Percent impedance and fault current
   - Rated primary and secondary currents (based on nameplate data)
   - Efficiency calculations
   - Determine primary and secondary currents under various loads
i. Perform testing calculations
   - Winding resistance (temperature coefficient)
   - Ratio
   - Capacitance bridge theory

6. Describe instrument transformers. **10%**

a. Purpose
b. Current transformers (CT)
   - Connection and safety
c. Potential transformers (PT)
   - Connection
d. Perform related calculations
e. Hazards

7. Describe and draw three phase transformers and transformer banks. **20%**

a. Connections
   - Wye
   - Delta (3 and 4 wire)
   - Open delta
b. Phase shifting
   - Power flow
   - Paralleling
   - Reflected impedance
   - Dot polarity direction

8. Describe special transformer connections. **5%**

a. Applications
b. Connections
   - Scott
   - T-connection
   - Zig zag (ground bank)

9. Demonstrate connections of three-phase wye and delta transformers and loads. 5%

a. Verify phase and line relationship by connections and measurements
b. Verify power measurement
c. Wye-connected transformer
d. Delta-connected transformer
   - Delta closure test
e. Verify polarity of transformers
   - Inductive kick test
   - Low voltage polarity test
f. Verify primary and secondary voltages

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Unit: C3 Electronic Concepts II

Level: Three
Duration: 50 hours
Theory: 20 hours
Practical: 30 hours

Overview:

This unit, which builds on *B5 Electronic Concepts I*, is designed to provide the apprentice with additional knowledge and skills about electronic concepts. The unit begins with coverage of filtration and percent ripple in a circuit. Part of the unit covers thyristors and transistors. Finally, the unit covers additional applications of electronic concepts.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Review hazards and safe work practices pertaining to electronic concepts.	**5%**
2. Describe filtration and percent ripple in a circuit. a. Perform related calculations	**10%**
3. Describe thyristors. a. Purpose and applications • DC Circuits • AC Circuits b. Types • Silicon-Controlled Rectifier (SCR) • Gate Turn-Off (GTO) • Triode for Alternating Current (TRIAC) c. Phase shifting (voltage controllers) d. Identify the schematic symbols and terminal connections e. Perform related calculations	**30%**
4. Describe a transistor. a. Purpose and applications • Switching • Amplification b. Types • Bi-polar • Junction field effect transistor (JFET) • Depletion and Enhancement MOSFETs • Insulated Gate Bipolar Transistor (IGBTs) c. Identify and label schematic symbols and terminals	**20%**

d. Describe transistor characteristics
   - Operating point
   - Current gain
   - Voltage gain
   - Load lines

e. Perform related calculations

5. Demonstrate and apply electronic concepts. 35%

a. Measure the voltages and verify the percent ripple
b. Test an SCR
c. Connect an SCR to control a DC circuit
d. Connect an SCR to control a single phase AC circuit
e. Analyze the operation of SCR and TRIAC phase control
f. Test a transistor in a circuit and out of a circuit
g. Use an oscilloscope to demonstrate transistor characteristics

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Apprenticeship Manitoba

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Unit: C4 Industrial Control Systems

Level: Three

Duration: 90 hours

Theory: 60 hours

Practical: 30 hours

Overview:

This unit is designed to provide the apprentice with the knowledge and skills about industrial control systems. The unit begins with coverage of industrial control system components, including sensors, detectors and control transformers. Part of the unit covers advanced control circuits and heating, ventilating and air conditioning systems, and variable frequency drives. Finally, the unit covers installation, testing and troubleshooting techniques using wiring diagrams.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Identify hazards and describe safe work practices pertaining to industrial control systems.	**5%**
2. Describe sensors and detectors. a. Purpose and application • Hall effect • Proximity • Photo	**5%**
3. Describe reduced voltage starting methods. a. Purpose and application • Resistor and reactor • Autotransformer • Wye – Delta • Variable frequency drives (VFD)	**5%**
4. Describe control transformers. a. Purpose and application b. Terminal markings c. Turns ratio d. Dual voltage connections	**5%**
5. Describe solenoids and motor operated valves. a. Purpose b. Types and application	**10%**

6. Design and interpret advanced control circuits. 20%

a. Purpose
b. Applications
   - Conveyors
   - Alternating pumps
   - Other automated equipment

7. Describe heating, ventilating and air conditioning (HVAC) systems. 5%

a. Purpose
b Cycle of operations
c. Types and applications
   - Gas furnaces
   - Electric furnaces
   - A/C units
   - Heat recovery ventilator (HRV)

8. Describe variable frequency drives (VFD). 10%

a. Purpose
b. Types and applications
   - AC drives
   - DC drives

9. Describe testing and troubleshooting of control circuits using hand held devices. 10%

a. Purpose
b. Types
   - Ohmmeter
   - Ammeter
   - Voltmeter
   - Megohmmeter
c. Operation and applications
   - Meter selection
   - Meter placement
   - Meter reading
d. Logical testing procedure
e. Grounded and ungrounded control circuits
f. Common circuit problems.

10. Describe plugging, DC injection, dynamic braking and regenerative braking. 5%

a. Purpose and application

11. Perform practical wiring projects. 20%

a. Design and wire advanced control circuits
   - Timing sequence
   - Order of operation
   - Counters
   - Memory circuits
b. Design and wire HVAC systems
c. Design and wire VFD systems

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Unit: C5 Interrupting Equipment

Level: Three

Duration: 20 hours

Theory:	20	hours
Practical:	0	hours

Overview:

This unit is designed to provide the apprentice with the knowledge about interrupting equipment. The unit begins with coverage of breakers, arc and arc-extinguishing media, and fuses. Part of the unit covers disconnects. Finally, the unit covers sizing and ampacity considerations and installation applications.

Objectives and Content: **Percent of Unit Mark (%)**

1. Identify hazards and describe safe work practices pertaining to interrupting equipment. **5%**

2. Describe breakers and automatic circuit reclosers (ACRs). **20%**

a. Purpose and applications
b. Classification
   - Low voltage (any voltage not exceeding 750 V)
   - Medium voltage (any voltage exceeding 750 V but not exceeding 25 kV)
   - High voltage (any voltage exceeding 25 kV)
c. Operating mechanisms
   - Stored energy (springs)
   - Solenoid
   - Hydraulic
   - High pressure air
   - Motor
d. Hazards

3. Describe arc and arc-extinguishing media. **25%**

a. Purpose
b. Types and applications
   - Gas
   - Bulk oil
   - Magna blast
   - Minimum oil
   - Air blast
   - Vacuum

c. Hazards and safe handling procedures
   - Filling and recovery of SF_6 gas and oil

4. Describe fuses. **15%**

a. Purpose
b. Types and applications
c. Co-ordination
d. Perform related calculation
   - Short circuit calculation

5. Describe disconnects. **15%**

a. Purpose
b. Types and applications
   - Centre-break
   - Horizontal and vertical
   - Propeller
   - Single-break
   - Tandem
   - Vacrupters
c. Means of disconnection
   - Manual
   - Motorized
   - Insulated switch stick

6. Describe sizing and ampacity considerations and installation applications. **20%**

a. Breakers
b. Fuses
c. Disconnects

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Unit: C6 AC Machines, Governors and Exciters

Level: Three

Duration: 40 hours

Theory: 40 hours

Practical: 0 hours

Overview:

This unit is designed to provide the apprentice with the knowledge about AC machines, governors, and exciters. This unit covers three-phase and single-phase motors, and AC generators. After covering AC generators, the unit also covers mechanical/hydraulic governor and governor control systems. Part of the unit covers components and controls for speed control and excitation. Finally, the unit covers generator voltage output controls.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Identify hazards and describe safe work practices pertaining to machines, governors and exciters.	**5%**
2. Describe three phase motors. a. Types • Squirrel cage induction motors • Wound rotor induction motors • Synchronous motors b. Purpose and applications c. Operating characteristics d. Basic construction e. Terminal markings f. Nameplate ratings g. Perform related calculations	**25%**
3. Describe single phase motors. a. Types • Split phase induction motors • Alternating current series motors • Shaded pole motors b. Purpose and applications c. Operating characteristics d. Basic construction e. Terminal markings f. Nameplate ratings g. Perform related calculations	**25%**

4. Describe AC generators. **20%**

a. Types and construction details
b. Operating characteristics and losses
c. Paralleling requirements

5. Describe mechanical/hydraulic governor systems. **5%**

a. Purpose
b. Application

6. Describe governor control systems and how they are integrated into the hydraulic governor. **5%**

a. Types
   - Electrical
   - Electronic
   - Digital
b. Applications

7. Describe components and controls for speed control. **5%**

a. Permanent Magnet Generator (PMG) and ball head motor
b. Speeder motor controls
   - Gate limit
   - Best gate
   - Full gate
c. Servos, control rings, and wicket gates

8. Describe components and controls for excitation. **5%**

a. Slip rings and commutators
b. Exciters
   - Electronic
   - Motor generator (MG) set
c. Field breaker

9. Describe generator voltage output controls. **5%**

a. Purpose
b. Types and components
   - Automatic voltage regulator (AVR)
   - Amplidynes
   - Silicon control rectifier (SCR)

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