Construction Electrician
Level 3

Apprenticeship Manitoba

Construction Electrician

Unit: C1 Industrial Electrical Code

Level: Three

Duration: 80 hours

Theory: 80 hours

Practical: 0 hours

Overview:

This unit is designed to provide the apprentice with the knowledge about the industrial electrical code. The unit begins with coverage of industrial wiring methods and devices. Part of the unit covers other industrial components and concepts, including overcurrent and lightning protection and lighting applications. Finally, the unit covers main service and feeder sub-panel requirements, and interpretation of plans, drawings and specifications.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Identify hazards and describe safe work practices pertaining to industrial electrical code applications.	**5%**
2. Describe industrial wiring methods and practices.	**15%**
a. CEC requirements	
b. Single conductors, cables, busways, and raceways (including underground)	
• Ampacities	
• Derations	
• Conditions of use	
• Metallurgy (compatibility of materials)	
c. Bonding and grounding	
d. Perform related calculations	
• Voltage drop calculations	
• Raceway fill calculations	
e. Grounded and ungrounded systems	
3. Describe industrial wiring devices and applications.	**10%**
a. CEC requirements	
b. Outlet boxes	
• Sizes	
• Types	
• Applications	
• Box fill calculations	
c. Receptacles	
d. Switches and disconnects	
e. Specialty outlets	

4. Describe industrial overcurrent protection. **5%**

a. CEC requirements
b. Breaker fundamentals
   - Low and medium voltage breakers
   - Characteristics and operation (ARC Extinguishing media)
   - Selective coordination
c. Fuse fundamentals
   - Types and applications
   - Characteristics and operation
   - Selective coordination
d. Short circuit calculation

5. Describe metal clad switch gear. **5%**

a. CEC requirements
b. Breaker installations
c. Switch gear breaker characteristics

6. Describe lightning protection. **5%**

a. CEC requirements
b. Describe the lightning process
c. Identify the requirements for protecting a building
d. List lightning safety rules

7. 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

8. Describe transformers and capacitors. **15%**

a. CEC requirements for transformer and capacitor installations
   - Dry
   - Liquid-filled
   - Single phase
   - Three phase
b. Perform related calculations

9. 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. Hermetic motor compressors (for HVAC and refrigeration applications)

f. Various duty cycles
   - Continuous
   - Intermittent
   - Varying
   - Periodic
   - Short-time

g. Perform related calculations (including tap conductors)

10. Describe main service and feeder sub-panel requirements. 15%

a. CEC requirements
b. Installation and maintenance
c. Perform main service and feeder sub-panel calculations (single and three phase)
   - Small industrial buildings
   - Schools
   - Hospitals
   - Motels/Hotels

11. Describe welder installations. 5%

a. CEC requirements.
b. Perform related calculations

****

Apprenticeship Manitoba

Construction Electrician

Unit: C2 Three Phase Theory 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 about three phase theory and transformers. The unit begins with coverage of three phase systems and loads in wye and delta configurations. Part of the unit covers transformers and transformer connections. 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 theory and transformers.	**5%**
2. Define and describe three phase systems in wye and delta configurations. a. Relationship between phase and line • Voltage • Current b. Vector relationship (current and voltage) c. Connections	**10%**
3. Define and describe three phase loads in wye and delta configurations. a. Perform related calculations • Balanced and unbalanced loads b. Draw and interpret vector diagrams • Unity and non-unity power factor loads c. Effects of a broken neutral	**15%**
4. Determine the power draw and power ratings of three phase loads and sources. a. Power factor b. Perform related calculations • Balanced and unbalanced loads • Power factor correction • Power measurement (two or three single-phase wattmeter and single three-phase wattmeter methods)	**10%**
5. Describe principles of transformers. a. Purpose	**20%**

b. Basic components
c. Operation
   - Transformer action
   - Automatic and manual tap changing for voltage regulation
   - Cooling methods
d. Nameplate data
e. Types, application and maintenance
   - Isolation
   - Auto transformer
f. Transformer polarity
   - Inductive kick test
   - Low voltage polarity test
g. Paralleling
   - Percent impedance
   - Polarity
h. Efficiency
   - Types of losses
i. 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

6. Describe instrument transformers. 5%

a. Current transformers (CT)
   - Connection and safety
b. Potential transformers (PT)
   - Connection
c. Perform related calculations for metering

7. Describe and draw three phase transformers and transformer banks. 15%

a. Connections
   - Wye
   - Delta (3 and 4 wire)
   - Open delta

8. Describe special transformer connections. 5%

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

9. Demonstrate principles of three phase systems in wye and delta configurations. 5%

a. Verify phase and line relationship by connections and measurements.
b. Verify power measurement

10. Perform transformer testing to verify nameplate data. 5%

a. Verify polarity of transformers
   - Low voltage polarity test
b. Verify primary and secondary voltages
c. Startup (commissioning) and shutdown procedures

11. Demonstrate connections of three phase transformer banks. 5%

a. Wye

b. Delta

- Delta closure test

***

Apprenticeship Manitoba

Construction Electrician

Unit: C3 Electronic Concepts II

Level: Three
Duration: 45 hours
Theory: 25 hours
Practical: 20 hours

Overview:

This unit, which builds on *B5 Electronic Concepts I*, is designed to provide the apprentice with additional knowledge 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) • Metal Oxide Semiconductor Field-Effect Transistor (MOSFET) • Insulated Gate Bipolar Transistor (IGBT) 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

***

Apprenticeship Manitoba

Construction Electrician

Unit: C4 Industrial Control Systems

Level: Three

Duration: 95 hours

Theory: 60 hours

Practical: 35 hours

Overview:

This unit is designed to provide the apprentice with the knowledge 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. 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 • Temperature	**5%**
3. Describe reduced voltage starting methods. a. Purpose and application • Resistor and reactor • Autotransformer • Wye – Delta • Variable frequency drives (VFD) • Soft starters • Part winding	**15%**
4. Describe control transformers. a. Purpose and application	**5%**
5. Describe solenoids and motor operated valves. a. Purpose b. Types and application	**5%**

6. Design and interpret advanced control circuits. 10%

a. Purpose
b. Applications (such as conveyors, alternating pumps and other automated equipment)

7. Describe heating, ventilating and air conditioning (HVAC) systems. 20%

a. Purpose
b Cycle of operations
c. Residential, commercial and industrial applications
   - Gas furnaces
   - Electric furnaces
   - Air conditioning (A/C) units
   - Heat recovery ventilator (HRV)
   - Boilers
   - Rooftop units (RTU)
   - Heat pumps

8. Describe testing and troubleshooting of control circuits using handheld 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.
g. Startup (commissioning) and shutdown procedures

9. Describe plugging and braking. 5%

a. Purpose and application
b. Types of plugging
c. Types of braking, including:
   - Dynamic
   - DC injection
   - Mechanical
d. VFDs
   - DC application
   - Dynamic application

10. Perform installation, testing and troubleshooting techniques using schematic or wiring diagrams. 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 reduced voltage starters, such as:
   - VFD

- Soft start
- Autotransformer
- Wye-delta

***

Apprenticeship Manitoba

Construction Electrician

Unit: C5 AC Machines and Maintenance

Level: Three

Duration: 40 hours

Theory: 30 hours

Practical: 10 hours

Overview:

This unit is designed to provide the apprentice with the knowledge about AC machines and maintenance. This unit covers three phase motors, single phase motors and AC generators. Part of the unit covers reactive, preventive and predictive practices for electrical apparatus. Finally, the unit covers insulation tests on electrical systems and apparatus.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Identify hazards and describe safe work practices pertaining to AC machines and maintenance.	**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 • Electronically commutated motor (ECM) • Stepping motors b. Purpose and applications c. Operating characteristics d. Basic construction e. Terminal markings	**25%**

f. Nameplate ratings
g. Perform related calculations

4. Describe AC generators. **15%**

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

5. Describe and compare reactive, preventive and predictive practices for electrical apparatus. **20%**

a. Purpose
b. Considerations
   - Effects of temperature and correction factors
   - Effects of moisture
   - Effects of contamination
c. Procedures for megohmmeter testing
   - Lockout / tag out procedures
   - Equipment grounding
   - Maximum test voltages
   - Meter lead connections
   - Institute of Electrical and Electronics Engineers (IEEE) standards
d. Test methods using a megohmmeter
   - Sixty second test (including for commissioning and decommissioning)
   - Step voltage test
   - Dielectric absorption test
e. Thermal imaging
f. Maintenance schedule and records

6. Perform tests on electrical systems and apparatus. **10%**

a. Sixty second test
b. Ohmmeter test
c. Potential test
d. Startup (commissioning) and shutdown procedures

***