

# Commercial and Industrial Wiring

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## Instructional/Task Analysis

**Related Information: What the Student Should Know**

**Application: What the Student Should Be Able to Do**

### Unit 1: Blueprint Reading and Load Calculations

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|---|---|
| 1. Terms and definitions                        | 15. Select participants and describe their functions at a construction site           |
| 2. Mechanical symbols                           | 16. Construct an electrical blueprint   |
| 3. Plumbing symbols                             | 17. Perform load calculations and determine overcurrent protection and conductor size |
| 4. Structural symbols                           | 18. Compute lighting loads  |
| 5. Architectural symbols                        | 19. Determine maximum numbers of conductors in conduit                                |
| 6. Electrical symbols                           | 20. Determine wire sizes to prevent excessive voltage drop                            |
| 7. Panel, circuit, and other electrical symbols |   |
| 8. Types of blueprint lines                     |   |
| 9. Typical electrical specifications            |   |
| 10. Minimum requirements for electrical devices |   |
| 11. Determining motor-circuit wire sizes        |   |
| 12. Load calculations                           |   |
| 13. Voltage drop                                |   |
| 14. Types of blueprints                         |   |

### Unit 2: Tools and Equipment

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| 1. Terms and definitions               | 9. Describe a tool, and suggest changes to increase its efficiency |
| 2. Types of conduit benders            | 10. Bend, cut, ream, and thread 1/2-inch rigid metal conduit       |
| 3. Wire termination tools              | 11. Bend EMT stub-ups  |
| 4. Wire and cable pulling equipment    | 12. Make back-to-back bends on 1/2-inch EMT                        |
| 5. Conduit cutting and threading tools | 13. Make offset bends on 1/2-inch EMT                              |
| 6. Knockout cutters                    | 14. Bend and install 1/2-inch EMT                                  |
| 7. Power actuated tools                | 15. Bend a three-point saddle on 1/2-inch EMT                      |
| 8. Types of excavation equipment       | 16. Bend a four-point saddle on 1/2-inch EMT                       |
|  | 17. Cut, ream, offset, and install connectors on 1/2-inch PVC      |

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### Unit 3: Service

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|---|---|
| 1. Terms and definitions                                    | 9. Install an overhead raceway with service entrance conductors to a meter base |
| 2. <i>NEC</i> requirements for drop clearance and laterals  | 10. Connect meter base assembly to load center or panel                         |
| 3. Switch boards and disconnects                            |   |
| 4. <i>NEC</i> exceptions for overcurrent protection devices |   |
| 5. Grounding electrodes and ground fault                    |   |
| 6. Service entrance devices                                 |   |
| 7. Emergency and standby systems                            |   |
| 8. Procedure for balancing loads                            |   |

### Unit 4: Transformers

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| 1. Terms and definitions                                   | 10. Analyze utility company methods for delivering electrical power                           |
| 2. Basic types of transformers                             | 11. Draw a three-phase wye-delta transformer  |
| 3. Diagrams of the two most commonly used voltage systems  | 12. Locate and list two exceptions on transformer room construction for dry type transformers |
| 4. <i>NEC</i> requirements for dry type transformers       | 13. Locate and list two exceptions concerning oil-insulated transformers                      |
| 5. <i>NEC</i> requirements for oil-filled transformers     | 14. Given amperes, calculate KVA on a three-phase system                                      |
| 6. <i>NEC</i> requirements for askarel-filled transformers | 15. Test transformer turn ratios  |
| 7. Function of a buck and boost transformer                | 16. Test transformer insulation resistance  |
| 8. Transformer locations                                   | 17. Connect transformer primary and secondary windings in a delta-wye configuration           |
| 9. Installation and termination of transformers            | 18. Test and compare primary apparent power of a transformer to secondary apparent power      |

### Unit 5: Rough-In

1. Terms and definitions
2. Branch circuit and feeder installation
3. Devices used in special circuit installations
4. Requirements for cable tray systems
5. Steps for determining the number of conductors allowed in a conduit, based on cross-sectional area

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#### Unit 5: Rough-In (continued)

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|---|---|
| 6. Acceptable wiring methods for commercial and industrial projects     | 8. Determine the number of conductors allowed to be added to an existing conduit      |
| 7. Optional calculations for additional loads to existing installations | 9. Rough-in a wood framed wall  |
|   | 10. Install outlet boxes on steel rods  |
|   | 11. Install outlet boxes on steel studs using caddy metal stud clips for switch boxes |
|   | 12. Install masonry boxes in a block wall   |

#### Unit 6: Lighting

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| 1. Terms and definitions                             | 10. Locate articles in the <i>NEC</i> concerning lighting requirements |
| 2. Basic types of lighting                           | 11. Change a two lamp ballast in a fluorescent fixture                 |
| 3. Characteristics of incandescent lighting          | 12. Change sockets in a fluorescent fixture                            |
| 4. Characteristics of fluorescent lighting           | 13. Change an HID ballast  |
| 5. Characteristics of high intensity discharge lamps | 14. Change a quartz lamp   |
| 6. Characteristics of ballast                        |  |
| 7. Methods of calculating light                      |  |
| 8. Calculating branch circuits and voltage           |  |
| 9. Switching systems                                 |  |

#### Unit 7: Motors and Controllers

1. Terms and definitions
2. Required motor nameplate information
3. Direct current motor theory of operation
4. Types of DC motors
5. Single-phase motor theory of operation
6. Types of single-phase motors
7. Three-phase motor theory of operation
8. Types of three-phase motors
9. Procedure for reversing a three-phase motor
10. Typical supply voltage for three-phase motors
11. Schematics and terminal connections for delta- and wye-wound three-phase motors
12. Motor problems and their typical symptoms

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### Unit 7: Motors and Controllers (continued)

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|--|---|
| 13. Remedies for motor problems  | 25. Interpret nameplate information   |
| 14. Safety rules to observe when working around motors                               | 26. Describe remedies for common motor problems                             |
| 15. Parts of a magnetic contactor  | 27. Use the <i>NEC</i> to answer questions about motor control circuits     |
| 16. Electrical devices or circuits controlled by contactors                          | 28. Distinguish between motor starters and contactors                       |
| 17. Parts of a manual motor starter  | 29. Answer questions about uses of contactors and motor starters            |
| 18. Types of motor starters  | 30. Disassemble, inspect, and clean a motor                                 |
| 19. Parts of magnetic motor starters   | 31. Identify run, common, and start terminals on hermetically sealed motors |
| 20. Uses of magnetic motor starters  | 32. Test capacitors with an ohmmeter  |
| 21. Comparison of parts in magnetic contactors with parts in magnetic motor starters | 33. Wire a three-phase motor for dual voltages                              |
| 22. Reasons a contactor cannot be used to control a motor                            | 34. Perform maintenance on a magnetic contactor                             |
| 23. Purposes of a coil assembly  |   |
| 24. Parts of a coil assembly   |   |

### Unit 8: Electrical Diagrams and Symbols

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| 1. Terms and definitions                        | 7. Construct a basic ladder diagram                |
| 2. Characteristics of wiring diagrams           | 8. Identify electrical symbols in a wiring diagram |
| 3. Characteristics of ladder diagrams           |  |
| 4. Characteristics of one-line diagrams         |  |
| 5. Wiring and ladder diagram symbols            |  |
| 6. Major steps in constructing a ladder diagram |  |

### Unit 9: Two and Three Wire Controls

1. Terms and definitions
2. Typical two-wire pilot devices
3. Advantages of two-wire controls
4. Basic rule for three-wire controls
5. Advantages of three-wire controls
6. Operation of a two-wire control system
7. Operation of a three-wire control system

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### Unit 9: Two and Three Wire Controls (continued)

8. Complete a ladder and a wiring diagram of a two-wire control using a thermal switch
9. Draw a ladder diagram of a three wire control with an "on" indicating pilot light
10. Draw a ladder and a wiring diagram of a three-wire control with an "off" indicating pilot light
11. Determine the number and size of conductors needed to operate a two-wire control system
12. Determine the number and size of conductors needed to operate a three-wire control system
13. Wire a two-wire control
14. Wire two float switches to operate a starter (series connection)
15. Wire two float switches to operate a starter (parallel series)
16. Wire a pressure switch to operate a starter with "on" and "off" pilot lights
17. Wire a three-wire control system
18. Wire a multiple station three-wire control
19. Wire a multiple station three-wire control with "on" and "off" pilot lights

### Unit 10: Separate Control Circuits

1. Terms and definitions
2. Reasons for separate control circuits
3. Applications for separate control circuits
4. Sources of separate control circuits
5. Typical control transformer schematics and their voltage ratings
6. Necessary changes that must be made to a starter when using a separate control circuit
7. Read and interpret ladder diagrams using separate control circuits
8. Answer questions about control circuits
9. Determine the size and number of conductors needed to operate a separate control circuit
10. Wire a relay and a load with a separate control circuit
11. Wire a three-phase starter to operate by a separate control circuit

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### Unit 11: Sequence Control

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| 1. Terms and definitions                        | 8. Answer questions related to a sequence control diagram                |
| 2. Purpose of sequence control                  |  |
| 3. Advantages of sequence control               | 9. Answer questions related to an auxiliary contact interlocking diagram |
| 4. Uses of sequence control                     | 10. Wire two starters in sequence  |
| 5. Purpose of auxiliary contact interlocking    | 11. Wire two starters with auxiliary contact interlocking                |
| 6. Advantages of auxiliary contact interlocking |  |
| 7. Uses of auxiliary contact interlocking       |  |

### Unit 12: Jogging Controls

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| 1. Definition of jogging                    | 5. Convert ladder diagrams to wiring diagrams                            |
| 2. Methods of jogging control               | 6. Determine the number of conductors needed to operate jogging controls |
| 3. Advantages of jogging control            | 7. Wire a jog through a lock-stop push button                            |
| 4. Sequence of operation of ladder diagrams | 8. Wire a jog through a two-position selector switch                     |
|   | 9. Wire a jog through a two-circuit push button                          |
|   | 10. Wire a jog through a control relay                                   |

### Unit 13: Reversing Starters

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|---|---|
| 1. Terms and definitions                                | 6. Describe the sequence of operation of ladder diagrams  |
| 2. Types of reversing starter construction              |   |
| 3. Types of interlocking methods for reversing starters | 7. Determine the number of conductors needed to operate a reversing control                                       |
| 4. Types of drum controls                               | 8. Wire a reversing starter with a three-position selector switch   |
| 5. Drum switch diagram                                  | 9. Wire a reversing starter with one control station using auxiliary contact and mechanical interlock             |
|   | 10. Wire a reversing starter with one control station using push button interlock and auxiliary contact interlock |
|   | 11. Wire a reversing starter with two control stations  |
|   | 12. Wire drum switches  |
|   | 13. Wire a reversing starter with jog in both directions  |

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#### Unit 14: Special Control Circuits

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|---|--|
| 1. Terms and definitions                          | 10. Build a relay control circuit                          |
| 2. Parts of a control relay                       | 11. Wire a latching relay or contactor                     |
| 3. Uses for control relays                        | 12. Wire a timed "on" circuit                              |
| 4. Parts of a latching relay                      | 13. Wire a timed "off" circuit                             |
| 5. Reason for using latching relays or contactors | 14. Energize three starters in a timed sequential order    |
| 6. Types of timing relays                         | 15. De-energize three starters in a timed sequential order |
| 7. Applications for timing relays                 | 16. Build a ground fault indicator circuit                 |
| 8. How a ground fault indicator works             |  |
| 9. Use of an alarm silencing circuit              |  |

#### Unit 15: Programmable Logic Controllers

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| 1. Terms and definitions   | 13. Match I/O devices with their functions |
| 2. Programmable logic controller functions                         | 14. Convert between numbering systems      |
| 3. Parts of a programmable logic controller                        |  |
| 4. Input devices   |  |
| 5. Output devices  |  |
| 6. Components of a programmable logic controller                   |  |
| 7. States of contacts  |  |
| 8. Types of I/O modules  |  |
| 9. Parts of an optical coupler                                     |  |
| 10. Basic PLC ladder logic symbols                                 |  |
| 11. Why a stop button is wired normally closed                     |  |
| 12. Basic numbering systems used in programmable logic controllers |  |