

# **Basics of Industrial Electricity and Troubleshooting Electrical Control Circuits**

## **Course Details**

- Date: January 28 – January 31, 2019
- Time: 8:00 A.M. - 4:30 P.M.
- Capacity: 12 attendees
- Provider: National Technology Transfer, Inc. (NTT Training)

## **Estimated Enrollment Fee**

### **In-House @ SCPPA**

- \$1,710/ per person (minimum 10 attendees), or
- \$1,450/ per person (assuming 12 attendees)

## **Course Overview**

Learn how to effectively diagnose electrical control circuit problems. Attendees will experience live circuit faults in a real world scenario. Become a confident and safe troubleshooter from techniques presented. Understand the basics of electricity generation and delivery. Learn to safely use the proper measurement instruments and tools to understand the characteristics and properties of electrical signals. Work hands-on with the same control circuits and devices commonly used on HVAC systems, pump systems, hydraulics, conveyors and automated machines.

## **Who Should Attend?**

This training is ideal for skill levels from the apprentice electricians just starting out, journeymen wishing to upgrade their skills, or any engineering, maintenance, operations, or management personnel who come into contact with electrical control systems in the course of their daily activity.

- Electricians
- Mechanics
- Environmental health & safety personnel
- Apprentice and experienced HVAC technicians



Course: Basics of Industrial Electricity and Troubleshooting Electrical Control Circuits – 4 day  
 Code: EYMC

## Timed Agenda \ Syllabus

Time	Subject / Break
<b>Day 1</b> 8:00 – 9:30 a.m.	<b>BASIC ELECTRICITY</b> <ul style="list-style-type: none"> <li>• Current, voltage, and resistance</li> <li>• Ohm’s Law and calculations</li> <li>• Series-parallel circuits</li> <li>• Kirchhoff’s Laws and corollaries</li> </ul> <b>BASICS OF MULTIMETERS</b> <ul style="list-style-type: none"> <li>• Analog and digital multimeters</li> <li>• Solenoid meters</li> <li>• Accessories</li> </ul>
9:30 – 12:00 p.m.	<b>ELECTRICAL SAFETY</b> <ul style="list-style-type: none"> <li>• Basic safety guidelines</li> <li>• Lockout/tagout</li> <li>• Test safety equipment</li> </ul> <b>COMMON WIRING DEVICES</b> <ul style="list-style-type: none"> <li>• Measure voltage receptacles</li> <li>• Types/grades of current</li> <li>• Voltage check*</li> <li>• Using the probe*</li> <li>• Probing a circuit</li> <li>• Hot and grounding reversed</li> <li>• GFCI connections*</li> <li>• Hot reversed with neutral and open</li> <li>• Problem receptacles*</li> <li>• Switch loops</li> <li>• Dimmer and double-pole switches</li> <li>• Installing a switch*</li> <li>• 4-way switches*</li> <li>• 3-way switches*</li> <li>• Installing 3- and 4-way switches*</li> </ul>
12:00 – 12:30 p.m.	Lunch Break
12:30 – 2:30 p.m.	<b>LIGHTING AND HEATING</b> <ul style="list-style-type: none"> <li>• Types of lamps</li> <li>• Preheat, rapid start, and instant start</li> <li>• Series resistance*</li> <li>• Parallel resistance*</li> <li>• Series/parallel resistance*</li> </ul> <b>CONDUCTORS AND RACEWAYS</b> <ul style="list-style-type: none"> <li>• Solid and stranded</li> <li>• Cables and conduit</li> </ul>



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2:30 – 4:30 p.m.	<p>WIRES</p> <ul style="list-style-type: none"><li>• Splitbolts and terminal blocks</li><li>• Conductor fill and in parallel</li><li>• Low-voltage circuits</li></ul> <p>ELECTRICIANS' TOOLS AND TEST EQUIPMENT</p> <ul style="list-style-type: none"><li>• Cutting tools</li><li>• Measuring devices</li><li>• Tools for conduit</li><li>• Phase-rotation meter</li><li>• The megohmmeter</li><li>• Voltage and continuity testers</li></ul>
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Time	Subject / Break
<b>Day 2</b> 8:00 – 9:30 a.m.	<b>GENERATORS AND TRANSFORMERS</b> <ul style="list-style-type: none"> <li>DC power sources and voltmeter</li> <li>Measuring DC volts*</li> <li>Series circuit*</li> <li>Parallel circuit*</li> <li>AC generators</li> <li>Generators and sine voltage</li> <li>Current lags/leads wave</li> <li>Transformers</li> <li>Transformer voltages*</li> <li>Wyes and deltas*</li> <li>Measuring a wye or connectors</li> </ul> <b>SOLID-STATE DEVICES</b> <ul style="list-style-type: none"> <li>Resistor color codes</li> <li>Resistor board*</li> <li>Diodes and continuity*</li> <li>Rectifiers</li> <li>Capacitor sine waves</li> <li>Capacitor check*</li> <li>Solid-State switches</li> <li>Checking a solid-state switch*</li> </ul>
9:30 – 12:00 p.m.	<b>PROTECTIVE DEVICES</b> <ul style="list-style-type: none"> <li>Overcurrent</li> <li>Circuit breaker</li> <li>Overload relays</li> <li>Testing fuses*</li> <li>Ground-fault selectivity</li> <li>Coordination and sensors/lights</li> </ul> <b>PUMP BASICS</b> Introduction
12:00 – 12:30 p.m.	Lunch Break
12:30 – 2:30 p.m.	<b>BASIC THEORY</b> <ul style="list-style-type: none"> <li>Ohm's law</li> <li>Series, parallel, and series-parallel</li> <li>Electrical properties and terms</li> <li>Kirchhoff's law</li> <li>AC vs. DC</li> <li>Personal protective equipment (PPE)</li> <li>Safe tools and devices</li> </ul>



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2:30 – 4:30 p.m.	<p>SAFETY</p> <ul style="list-style-type: none"><li>• Lockout/tagout</li><li>• National Electrical Code®</li></ul> <p>MULTIMETERS AND TOOLS</p> <ul style="list-style-type: none"><li>• Types</li><li>• Function</li><li>• Components</li><li>• Accessories</li></ul> <p>GENERATORS AND TRANSFORMERS</p> <ul style="list-style-type: none"><li>• DC power sources</li><li>• Batteries, thermal, piezo, photo, and solar</li><li>• Series and parallel batteries</li><li>• DC generator</li><li>• AC generator (alternator)</li><li>• Single-phase and three-phase</li><li>• Inductance, capacitance, and impedance</li><li>• Transformers</li><li>• Polarity</li><li>• Series and parallel circuits</li></ul>
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Time	Subject / Break
<b>Day 3</b> 8:00 – 9:30 a.m.	<p><b>SOLID-STATE DEVICES</b></p> <ul style="list-style-type: none"> <li>• Resistors</li> <li>• Diodes and rectifiers</li> <li>• Capacitors</li> <li>• Switches</li> </ul> <p>PROTECTIVE DEVICES</p> <ul style="list-style-type: none"> <li>• Fuses and disconnect switches</li> <li>• Circuit breakers, panels, and switchgear</li> <li>• Overload devices</li> <li>• Checking protective devices</li> <li>• Ground-fault protection</li> <li>• Grounding and isolating</li> <li>• Phase reversal</li> <li>• Surge protection</li> <li>• Coordination and selectivity</li> </ul> <p>LIGHTING AND HEATING</p> <ul style="list-style-type: none"> <li>• Incandescent and fluorescent</li> <li>• HID lamps</li> <li>• Low voltage</li> <li>• Series, parallel, and series-parallel lamps</li> </ul>
9:30 – 12:00 p.m.	<p>COMMON WIRING DEVICES</p> <ul style="list-style-type: none"> <li>• Receptacles</li> <li>• Specification grade, isolation, and hospital grade</li> <li>• NEMA locking</li> <li>• Wiring a receptacle, troubleshooting receptacles &amp; GFCI</li> <li>• Lighting outlets—switches and dimmers</li> <li>• Switch operation and installation</li> <li>• 3- and 4-way switches</li> <li>• Testing and installing 3- and 4-way switches</li> </ul> <p>CONDUCTORS AND RACEWAYS</p> <ul style="list-style-type: none"> <li>• Insulation and ampacity</li> <li>• Solid and stranded cable</li> <li>• Conduit-metal and nonmetallic</li> <li>• Cable trays</li> <li>• Busways</li> <li>• Splices: wirenuts, crimps, terminal blocks, split bolts and solder</li> <li>• Conductor and box fill</li> <li>• Parallel conductors</li> <li>• 2-, 3-, and 4-wire circuits</li> <li>• Low-voltage applications</li> </ul>



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12:00 – 12:30 p.m.	Lunch Break
12:30 – 2:30 p.m.	<p><b>ELECTRICAL DRAWING AND SYMBOLS</b></p> <ul style="list-style-type: none"> <li>• Drawing symbols</li> <li>• Blueprints</li> <li>• One-line drawings</li> <li>• NEMA symbols</li> <li>• Schematics</li> <li>• Ladder diagrams</li> <li>• Physical layout</li> </ul> <p><b>INDUSTRIAL WIRING DEVICES RELAYS</b></p> <p><b>MOTORS</b></p> <ul style="list-style-type: none"> <li>• Single-phase, three-phase and DC</li> <li>• Connection diagrams</li> <li>• Motor construction</li> <li>• Theory of operation</li> </ul>
2:30 – 4:30 p.m.	<p><b>BASICS OF INDUSTRIAL ELECTRICITY HANDS-ON LAB EXERCISES</b></p> <ul style="list-style-type: none"> <li>• Basic trainer set up series circuit</li> <li>• Parallel circuit</li> <li>• Series-parallel circuits</li> <li>• DC voltage transformers</li> <li>• Resistors</li> <li>• Capacitor</li> <li>• Rectifiers</li> <li>• Problem receptacles single-pole switch multiple-way switches</li> </ul> <p><b>ELECTRICAL SCHEMATICS</b></p> <ul style="list-style-type: none"> <li>• Power circuits</li> <li>• Control circuits</li> </ul> <p><b>MAPPING CONTROL CIRCUITS— LADDER DIAGRAMS</b></p> <ul style="list-style-type: none"> <li>• Power rails and wire colors</li> <li>• Control element arrangement</li> <li>• Load arrangement</li> <li>• Circuit protection arrangement</li> <li>• Line numbers</li> <li>• Wire numbers</li> <li>• Tag names and common electrical symbol abbreviations</li> </ul>



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<b>Day 4</b> 8:00 – 9:30 a.m.	<b>LOGICAL CIRCUITS</b> <ul style="list-style-type: none"> <li>• AND—Series circuit</li> <li>• OR—Parallel circuit</li> <li>• Compound and complex circuits</li> <li>• NOT circuit</li> </ul> <b>BASIC ELECTRICAL PRINCIPLES</b> <ul style="list-style-type: none"> <li>• Power sources—transformers</li> <li>• Flow of electricity</li> <li>• Switches—allow or prohibit current flow</li> <li>• Loads</li> </ul> <b>TRANSFORMERS</b> <ul style="list-style-type: none"> <li>• Magnetism</li> <li>• Induction</li> <li>• Primary/secondary</li> <li>• Turn ratio</li> <li>• Grounded vs. floating ground</li> </ul>
9:30 – 12:00 p.m.	<b>DISCONNECTING DEVICES AND SYMBOLOGY</b> <ul style="list-style-type: none"> <li>• Knife switch</li> <li>• Disconnects</li> <li>• Circuit breakers</li> </ul> <b>CONTROL ELEMENTS, SWITCHES AND SYMBOLOGY</b> <ul style="list-style-type: none"> <li>• Relay contacts—normally open, normally closed</li> <li>• Solid-state relays</li> <li>• Timing relays</li> <li>• Overload relays</li> </ul> <b>SUPPLEMENTARY CONTACT SYMBOLS AND TERMS</b> <ul style="list-style-type: none"> <li>• Breaks, poles, throws</li> <li>• Single break, double break</li> <li>• Single pole, double pole</li> <li>• Single throw, double throw</li> </ul> <b>MANUAL SWITCHES—FUNCTIONALITY AND SYMBOLOGY</b> <ul style="list-style-type: none"> <li>• Selector switches</li> <li>• Push buttons</li> <li>• Drum and foot switches</li> </ul>
12:00 – 12:30 p.m.	Lunch Break





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<p>12:30 – 2:30 p.m.</p>	<p><b>AUTOMATIC SWITCHES</b></p> <ul style="list-style-type: none"> <li>• Limit switches</li> <li>• Temperature, pressure, flow, and float switches</li> <li>• Motion switches</li> <li>• Proximity and photo switches</li> </ul> <p><b>TROUBLESHOOTING SUGGESTIONS</b></p> <ul style="list-style-type: none"> <li>• Measuring ohms, voltage, and current</li> <li>• Open faults vs. shorts</li> <li>• Using the proper tools and meters</li> <li>• Logical and sequential troubleshooting methods</li> <li>• Meter categories and types</li> <li>• Safety and precautions</li> </ul> <p><b>GROUND-FAULT &amp; OVERLOAD PROTECTION</b></p> <ul style="list-style-type: none"> <li>• Conductor sizing</li> <li>• Ground-fault protection devices and sizing</li> <li>• Motor starter sizing</li> <li>• Motor overload protection sizing</li> <li>• Disconnect sizing</li> </ul>
<p>2:30 – 4:30 p.m.</p>	<p><b>MOTOR OVERLOAD PROTECTION</b></p> <ul style="list-style-type: none"> <li>• Thermal overloads</li> <li>• Bimetallic overloads</li> <li>• Magnetic overloads</li> <li>• Solid-state overloads</li> </ul> <p><b>APPLICATION SPECIFIC CIRCUITS</b></p> <ul style="list-style-type: none"> <li>• Common pumping circuits</li> <li>• Common heating/cooling circuits</li> <li>• Alarming and latching circuits</li> <li>• Conveyor control circuits</li> </ul> <p><b>SAFETY AWARENESS</b></p> <ul style="list-style-type: none"> <li>• Electrical Safety</li> <li>• Lockout/tagout Procedures</li> <li>• Safe Work Practices</li> <li>• Personal Protective Equipment (PPE)</li> </ul> <p><b>HANDS-ON LAB EXERCISE CIRCUITS</b></p> <ul style="list-style-type: none"> <li>• Two-wire control and hands-off/auto</li> <li>• Three-wire control—start/stop</li> <li>• Jog/inch circuits</li> <li>• Sequencing start and stop circuits</li> <li>• Timing circuits</li> <li>• Automatic sequencing circuits</li> <li>• Forward/reversing circuits</li> <li>• Plug stop and anti-plugging circuits</li> <li>• Two-speed motor control</li> <li>• Reduced voltage starting circuits</li> </ul>

- Supervisors working on or who oversee employees working on 50V or greater equipment
- Linemen & Utility workers
- Owners & managers
- Maintenance Technicians
- Fire Alarm Technicians
- Plant & facility maintenance technicians
- Building engineers
- Building managers & superintendents
- Plant & facility managers
- Stationary engineers
- Safety directors