ELECTRICAL TECHNOLOGY 3
March 2008

I. Course Description

The purpose for this course is to instruct potential electricians in the skills necessary for entry into the job market.

During this course, the students are introduced to basic electricity, wiring methods, conduit installation and bending, current interrupting devices, motors, manual and magnetic motor starters, and transformers.

The course is designed to give students experience in job skills with hands on assignments and basic theory assignments.

Upon completion of this course, the students will be able to approach a prospective employer job skills which are in demand in the electrical industry.

II. Course Objectives

1.) Conduit Bending

A.) Utilizing the Gain
1.) Define the term gain as it applies to conduit.
2.) Calculate the gain of a 90 degree bend.

B.) Three and Four Bend Saddles
1.) Identify a three bend and a four bend saddle.
2.) State the purpose for a three bend saddle.
3.) State the purpose for a four bend saddle.
4.) Bend a three bend saddle to a measurement.
5.) Bend a four bend saddle to a measurement.

C.) Bending with Hickeys (Concentric conduit runs)
1.) Identify the term hickey.
2.) Define concentric bends.
3.) Bend three concentric bends to a measurement.

D.) Rolling Offsets
1.) Define the term rolling offset.

E.) Conduit Runs on the Flat
1.) Identify the proper way to install conduit floor to ceiling.

F.) Conduits in Concrete Slabs/Stubs

1.) Identify methods of conduit installation in a slab.
2.) Define compound bend.
3.) Bend a compound bend to a measurement.
4.) Define cradling a conduit run.
5.) Identify methods of entering a partition obliquely.

G.) Bending Surface Metal Raceway
1.) Bend an offset to a measurement using wiremold.
2.) Bend a stub to a measurement using wiremold.

H.) Bending PVC Conduit
1.) List three ways to bend PVC conduit
2.) Bend an offset to a measurement using PVC conduit.
3.) Bend a stub to a measurement using PVC conduit.

I.) Chicago, Hydraulic, and Electric Benders
1.) Discuss and explain how bending formulas apply to all types of benders.
2.) Bend a stub to a measurement using an electric bender.

J.) Types of Hand Benders
1.) Describe two position foot pedal benders.
2.) State the benefit of a two position foot pedal bender.

2.) Industrial Controls

A.) Time Delay Circuits
1.) Define the function of an ON-delay timer.
2.) Define the function of an OFF-delay timer.
3.) Define the function of a one shot timer.
4.) Define the function of a recycle timer.
5.) Identify a graph timing function for:
a.) ON-delay
b.) Off-delay
c.) one shot
d.) recycle
6.) Connect an ON-delay timer into a control circuit.
7.) Connect an OFF-delay timer into a control circuit.
8.) Connect a recycle timer into a control circuit.
9.) Program a programmable timer.

B.) Liquid Level Controls
1.) Connect a level control for pump operation.
2.) Connect a level control for sump operation.
3.) Connect a solid state level control with a control relay for level control.
4.) Add a timer into a control circuit for back spin and surge control.

5.) Add a selector switch into a circuit for surge control.
6.) Indicate the correct connection of a voltmeter into the circuit for troubleshooting the level control circuit.

C.) Circuit Reversal

1.) Connect two magnetic starters for forward and reversing a three phase motor.
2.) Connect a selector switch into a circuit for forward and reversing a three phase motor.
3.) Add additional pushbuttons into the control circuit for forward and reversing.
4.) State the three main types of interlocking used with forward and reversing circuits.
5.) Add pilot lights into a control circuit to indicate motor direction.
6.) Add limit switches into a circuit to stop the motor in either direction.

D.) Transformers in Power Distribution Systems

1.) Connect transformers for a WYE to WYE system.
2.) Connect transformers for a WYE to DELTA system.
3.) Connect transformers for a DELTA to WYE system.
4.) Connect transformers for a DELTA to DELTA system.
5.) State the relationship of voltage, current and power in a WYE system.
6.) State the relationship of voltage, current and power in a DELTA system.
7.) Using a voltmeter, measure the voltage in a transformer system and determine the type of system it is.
8.) Identify the correct connections for a high voltage primary connection.
9.) Identify the correct connections for a low voltage primary connection.

3.) Motors

A.) System Familiarization

1.) Determine the basic motor safety procedures including matching the motor size to the load.
2.) Be aware that the basic process of checking a motor includes checking the nameplate specifications for ambient temperature, voltage ratings and type of duty.
3.) Describe some of the basic items of a typical maintenance plan such as lubrication, cleaning, and testing the insulation resistance.
4.) Identify the motors, instrumentation, and other components included in the Industrial Motors Trainer.

B.) AC Motor Familiarization

1.) Interpret the information on a motors nameplate.
2.) Disassemble the three phase induction motor and identify the main parts.
3.) Disassemble a single phase motor and identify the main parts.
4.) Classify AC motors according to horsepower, internal construction and the way the motor starts.
5.) Calculate the synchronous speed of an AC motor.

C.) Motor Mounting, Load Coupling, and Shaft Alignment
1.) Identify some types of mechanical couplers used in light, medium, and heavy duty applications.
2.) Identify the misalignment problems that couplings can correct.
3.) Identify the codes used with Vee- belts.
4.) Align a motor coupled to the load with an L-type coupler.
5.) Align a belt drive system.
6.) Use a Vee-belt tension tester.

D.) AC Three Phase Induction Motors
1.) Connect a dual voltage three phase motor for the proper voltage.
2.) Learn how to reverse a three phase motor.
3.) Connect resistors for reduced voltage starting.
4.) Detect a single phasing condition using a voltmeter and an ammeter.

E.) AC Single Phase Induction Motors: Two Speed, Split-Phase
1.) Connect a split phase motor for low and high speed operation.
2.) Reverse the direction of rotation.
3.) Observe the relationship between motor speed and power out.

F.) AC Single Phase Induction Motors: Capacitor-Start and Permanent Capacitor
1.) Connect a capacitor-start motor for forward and reverse operations with low and high voltages.
2.) Test a capacitor for capacitance value and component integrity.
3.) Observe starting and running torque for the split phase, capacitor start, and permanent capacitor motors.

G.) DC Motor Familiarization
1.) Disassemble and assemble a DC motor.
2.) Interpret nameplate information.
3.) Make resistance measurements on the windings.
4.) Draw a wiring diagram.

H.) DC Motor Types
1.) Wire a shunt motor for forward and reverse, measure the percent of speed regulation, and demonstrate field control.

2.) Wire for series operation for both directions of rotation and determine the percent of speed regulation.
3.) Wire for compound operation for both directions of rotation, determine the percent of regulation, and demonstrate field control.

I.) Universal Motor
1.) Disassemble and then assemble a universal motor.
2.) Identify the parts of the motor.
3.) Check for brush alignment and proper length.
4.) Connect the motor for AC and DC operation.
5.) Understand several methods of speed control.

J.) Maintaining AC and DC Motors
1.) Know the forces that can degrade a motor and know the corrective action to maintain the motor.
2.) Know standard maintenance procedures.
3.) Perform standard maintenance tests.
4.) Maintain maintenance records.

K.) Troubleshooting AC and DC Motors
1.) Use a systematic approach to troubleshoot AC and DC motors.
2.) Use flowcharts in the troubleshooting procedure.
3.) Use voltage, current and resistance measurements to identify specific failures.
4.) Relate failures to electrical, mechanical or environmental causes.

4.) Electrical Motor Controls

A.) Control Devices
1.) To list three parts of an industrial pushbutton.
2.) To list five different operations used with pushbuttons.
3.) To make a target table for a selector switch.
4.) To name the two main parts of a limit switch.
5.) To list four main types of actuators used with limit switches.
6.) To explain how to set the pressure differential on a pressure switch.
7.) To list four ways of actuating temperature switches.
8.) To identify what set of contacts to use for a sump pump application using a float switch.
9.) To read an operational diagram for a logic module.
10.) To explain troubleshooting procedures for control devices.

B.) Reversing Motor Circuits
1.) To explain the difference between a three phase wye and a three phase delta motor.
2.) To explain how to reverse a three phase motor.
3.) To explain how to reverse a single phase motor.

4.) To explain how to reverse a DC motor.
5.) To list the three types of interlocking used when reversing motors.
6.) To explain where DC motors are commonly used.
7.) To explain how to reverse a motor using a manual starter.
8.) To explain how to reverse a motor using a magnetic starter.
9.) To explain how to reverse a motor using a drum switch.
10.) To explain troubleshooting procedures for reversing circuits.

C.) Power Distribution Systems

1.) To name the major source for electrical energy.
2.) To explain how to connect transformers for a wye connection.
3.) To explain how to connect transformers for a delta connection.
4.) To list the six functions of a sub station.
5.) To list the three categories of switchboards.
6.) To list the three characteristics of panelboards.
7.) To explain the function of a motor control center.
8.) To name two types of busways.
9.) To state the reason for grounding an electrical system.
10.) To discuss the electron flow generator rule.
11.) To explain how motor control centers are connected in a system.
12.) To explain how switchboards and panelboards are different.
13.) To explain troubleshooting procedures for fuses.
14.) To explain troubleshooting procedures for breakers.

D.) Solid State Electronic Control Devices

1.) To identify parts of a PC board.
2.) To explain the semiconductor theory and how it relates to semiconductor devices.
3.) To explain the difference between N type and P type material.
4.) To identify two types of rectification of alternating current.
5.) To explain the operation of a zener diode.
6.) To explain the operation of a photovoltaic cell.
7.) To identify the construction and application of a LED.
8.) To identify two types of transistors and their operation within a system.
9.) To explain the operation of an SCR and discuss it's application.
10.) To identify the two basic types of electronic signals.
11.) To identify the four most common gates used in digital electronics and their function.
12.) To explain the use of fiber optics.
13.) To explain how IC's operate within their system.
14.) To explain troubleshooting procedures for solid state devices.

E.) Electromechanical and Solid State Relays

1.) To list and discuss the three types of electromechanical relays.
2.) To list five ways of actuating a reed relay.

3.) To list four types of solid state relays.
4.) To list five advantages of solid state relays over electromechanical relays.
5.) To list five advantages of electromechanical relays over solid state relays.
6.) To explain how relay contacts are described.
7.) To list the abbreviations for relay contacts.
8.) To describe contact life.
9.) To discuss how temperature affects SSR's.
10.) To explain troubleshooting procedures for relays.

F.) Photoelectric and Proximity Controls
1.) To list the six scanning techniques used in photoelectric applications.
2.) To explain the function of the sensitivity adjustment on a photo eye.
3.) To name the two types of light sources available in photoelectric control.
4.) To list five types of Hall effect sensors.
5.) To list three methods used to activate a Hall effect sensor.
6.) To explain how fiber optics may be used to control light.
7.) To explain the difference between modulated and unmodulated light.
8.) To explain how proximity switches detect the presence of objects.
9.) To explain how proximity sensors are installed.
10.) To explain troubleshooting procedures for photoelectric and proximity switches.

G.) Programmable Controllers
1.) To list the major advantages of using programmable controllers.
2.) To list the two major application areas in which programmable controllers are used.
3.) To explain the difference between a programmable controller and a computer.
4.) To list the four basic parts of the programmable controller and discuss the function of each.
5.) To list the difference between discrete and data inputs and outputs.
6.) To list the steps that must occur before entering a program into the programmable controller.
7.) To list and discuss the advantages of using a multiplexing system.
8.) To identify and describe the basic logic functions of AND, OR, NOT, NOR, and NAND.
9.) To explain how PLC's are used to increase production and discuss how they improve overall plant efficiency in industry.
10.) To explain troubleshooting procedures for PLC's.

H.) Reduced Voltage Starting

1.) To list the five reduced voltage starting methods.
2.) To explain the need for reduced voltage starting.
3.) To explain how DC motors are constructed.
4.) To explain how AC motors are constructed.
5.) To calculate motor starting current.
6.) To calculate motor running current.
7.) To calculate motor speed.
8.) To explain advantages and disadvantages of the different types of reduced voltage starting.
9.) To explain solid state starting.
10.) To explain troubleshooting procedures for reduced voltage starting.

I.) Accelerating and Decelerating Methods

1.) To explain how braking is accomplished.
2.) To calculate braking torque.
3.) To explain the advantages and disadvantages of friction brakes.
4.) To explain how plugging may be used for braking motors.
5.) To explain how electric braking operates.
6.) To calculate work performed.
7.) To calculate torque produced.
8.) To calculate motor torque developed.
9.) To calculate horsepower produced.
10.) To explain the relationship between speed, torque, and horsepower.
11.) To list and explain NEMA design of motors.
12.) To calculate the diameter of pulleys.

J.) Preventive Maintenance and Troubleshooting

1.) To list the five parts of a good preventive maintenance program.
2.) To list eight basic rules for using test instruments.
3.) To explain troubleshooting procedures for a fuse or circuit breaker in a circuit.
4.) To explain how to test a control transformer for open, ground, or short.
5.) To list six causes for motor failure.
6.) To explain how to remark a 3 phase or DC motor.
7.) To explain how to locate a circuit in a switchboard.
8.) To explain how to test for an open or shorted capacitor.
9.) To explain troubleshooting procedures for a good diode or SCR.
10.) To explain troubleshooting procedures for electric motors.

III. Textbooks & Instructional Materials

A.) Bendfield Conduit Bending Manual

2nd. Edition Intertech Publishing Corporation

B.) Digital Multimeter Principles
Glen A. Mazur

C.) Electrical Motor Controls
2nd. Edition Gary Rockis - Glen Mazur

D.) Industrial Controls
Glen Mazur Energy Concepts, Inc.

E.) Industrial Motors
Glen Mazur Energy Concepts, Inc.

F.) National Electrical Code - 1999 edition
National Fire Protection Association

IV. Instructional Strategies

This course will utilize various teaching methods as listed below:

A.) Lecture and class discussion.
B.) Hands on lab activities.
C.) Use of textbooks / workbook.
D.) Use of visual aids.

VI. Evaluation

Requirements for satisfactory completion of this course: 65% = D

Grading Procedure:

Major Tests (Both practical and written)	**60%**
Class work	**10%**
Notebook	**10%**
Shop projects	**10%**
Quizzes (Both practical and written)	**10%**

Scope and Sequence

Skills to be learned:	**12th. Grade**		
	I	**D**	**R**
1.) Work cooperatively and effectively with others.		X	X
2.) Demonstrate an awareness of occupational opportunities	X	X	X

available in the electrical industry.

3.)	Demonstrate knowledge of safety and proper use of hand and power tools.	X	X X
4.)	Understand and demonstrate good habits of electrical safety.	X	X X
5.)	Demonstrate work habits that assure quality, accuracy, and pride in workmanship.	X	X X
6.)	Demonstrate a working knowledge of hand and power conduit benders used in the field.	X	X X
7.)	Demonstrate an awareness of the use of time delay circuits.	X	X X
8.)	Demonstrate an awareness of the use of three phase reversing controllers.	X	X X
9.)	Demonstrate an awareness of various transformer connections.	X	X X
10.)	Demonstrate the ability to interpret motor nameplate information.	X	X X
11.)	Demonstrate an awareness of various types of motors.	X	X X
12.)	Demonstrate an awareness of motor troubleshooting procedures.	X	X X
13.)	Demonstrate an awareness of various types of relays.	X	X X
14.)	Demonstrate an awareness of uses for programmable controllers.	X	X X
15.)	Demonstrate an awareness of the need for reduced voltage motor starters.	X	X X
16.)	Demonstrate an awareness of requirements for plugging a motor.	X	X X
17.)	Demonstrate a knowledge of the five parts of a preventive maintenance program.	X	X X

Overview and Proficiencies

Course Overview

This course will provide the Electrical Technology 3 students with a comprehensive program which includes in depth training in electrical theory, advanced conduit bending, advanced industrial controls, motors, power distribution, and troubleshooting.

Proficiencies

Upon successful completion of the requirements of this course, the students will be able to:

A.) Demonstrate entry level skills required for employment in the electrical industry.
B.) Work cooperatively and effectively with others.
C.) Demonstrate an awareness of occupational opportunities available in the electrical industry.
D.) Demonstrate the knowledge of safety and proper use of hand and power tools.
E.) Understand and demonstrate good habits of electrical safety.
F.) Demonstrate work habits that assure quality, accuracy, and pride in workmanship.
G.) Demonstrate a working knowledge of hand and power conduit benders used in the field.
H.) Demonstrate an awareness of the use of time delay circuits.
I.) Demonstrate an awareness of the use of three phase reversing controllers.
J.) Demonstrate an awareness of various transformer connections.
K.) Demonstrate the ability to interpret motor nameplate information.
L.) Demonstrate an awareness of various types of motors.
M.) Demonstrate an awareness of motor troubleshooting procedures.
N.) Demonstrate an awareness of various types of relays.
O.) Demonstrate an awareness of uses for programmable controllers.
P.) Demonstrate an awareness of the need for reduced voltage motor starting.
Q.) Demonstrate an awareness of requirements for plugging a motor.
R.) Demonstrate the knowledge of the five parts of a preventive maintenance program.