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## Requirements for Basic Electrical Training for Maintenance Technicians

### Overview:

Cardinal IG uses highly automated machines to produce insulated glass products. Our maintenance technicians must be able to troubleshoot these systems to keep the machines running properly. Frequently the root cause of the problem is mechanical, but the symptoms may be electrical in nature (blown fuses, frequency drive faulting out, etc.). Cardinal IG is looking for a training program to help bring up technician electrical skills to the required level. Technicians who complete the basic electrical program will be expected to understand and troubleshoot common problems found in industrial electrical circuits. These technicians are not expected to be journeyman electricians, perform new electrical installations, or repair circuits at the board level.

If lectures could be done via long distance learning, that would be a plus. Much of the actual learning will occur during lab projects. Cardinal can assist with supervising lab work as needed at our Hood River facility. After safety training is complete, it is desirable that real world circuits, hardware, and voltages be used for lab work as much as possible.

At Cardinal IG, both single phase and three phase circuits are common. Both 24 VDC and 120 VAC control are used. On the three phase side both 240 Delta and 480 Wye power is used.

### Required Knowledge:

- Electrical Safety
- Basics of AC and DC electrical systems.
  - Voltage
  - Current
  - 1 phase and 3 phase systems.
  - 1 phase and 3 phase power calculation.
  - Delta and Wye connections.
  - Simple series circuits.
  - Simple parallel circuits.
- How to use a Digital Multimeter.
  - DMM Safety.
  - Measuring voltage.
  - Measuring current.
- Resistors
  - What is a resistor?
  - Ohms Law.
  - How a resistor affects a circuit.
  - Uses of resistors (braking resistors).

- How to test a resistor.
- Capacitors
  - What is a capacitor?
  - Safety precautions for capacitors.
  - How a capacitor affects a circuit.
  - Uses of Capacitors (drive power conversion).
  - How to test a capacitor.
- Inductors
  - What is an inductor?
  - How an inductor affects a circuit.
  - Common inductive components (Transformers, motors).
  - How to test an inductor.
- Switches.
  - Basic types
    - Light Switch
    - Maintained knob.
    - Momentary push button.
    - Normally open vs. normally closed.
  - Uses of switches (lighting, controls)
- Relays
  - Function of a relay.
  - Basic types of Relays
    - 1 pole, 2 pole
    - Latching vs. standard.
    - Time delay
    - Solid State
  - Uses of Relays
  - How to test a relay.
- Basic wiring practices (inside the panel)
  - Color codes / reserved colors.
  - Marking of wiring.
  - Wire sizing.
  - Making a neat connection.
  - Refresher on safety when working in a panel.
- Fuses
  - Types of fuses.
  - Function of fuses.
  - How to test fuses.
  - Reason fuses fail.
- Sensors
  - Types of sensors
    - Photo-eye
      - Through Beam
      - Diffuse-reflective
    - Ultrasonic
    - Mechanical contact
  - Function of a sensor (switch)
  - How to test sensors.
- Traditional fixed speed electric motors

- Single phase vs. three phase.
- Motor terminology
  - Types
  - Horsepower and KW ratings.
  - Voltage
  - Full Load Amps
  - Frame
  - Speed
  - Service Factor
  - Insulation Class
- How to configure a dual voltage 3 phase motor.
- Motor running direction.
- How to test a three phase motor.
- Traditional Motor Starter circuits.
  - Components of a typical magnetic motor starter
    - Disconnecting means.
    - Short Circuit Protection
    - Overload Protection
    - Contactor
    - Control Elements
  - Typical 2 wire and 3 wire control schemes.
  - Single Phase and dual phase motor starter wiring.
  - Reversing starters (3 phase).
  - How to troubleshoot a motor starter.
- Frequency Drives
  - Basic principles (real basic!).
  - Frequency drive safety.
  - Frequency vs. speed.
  - Using pre-set speeds.
  - Acceleration and deceleration settings.
  - How to troubleshoot common frequency drive problems.
- Servo Motors
  - Basic principles (real basic).
  - Basic components of a servo motor system.
  - Position control concept.
  - Troubleshooting basics.
- Electrical Prints
  - Basic electrical symbols.
  - Reading electrical prints.
- Electrical Troubleshooting
  - Follow the Power!
- PLC Overview
  - What is a PLC.
  - Analog vs. digital signals.
  - Outputs are switches!
  - Inputs are sensors.
  - How to test PLC inputs and outputs.
  - PLC programming is not expected to be covered in this course.

At Cardinal we have done some in house training covering 50 – 60% of this curriculum in the past. Unfortunately we do not have a dedicated training staff to continue to provide this training. Some things we found that worked well:

- Cover the concept in a short lecture in small chunks.

- Have the students build a working circuit demonstrating the new elements introduced each session. Usually in small groups.

- Incorporate elements from previous lessons to reinforce previously learned concepts when appropriate.

- Have students demonstrate good workmanship during lab projects (neat wire routings, label all wires, follow an electrical print, etc.).

- After students have built a working circuit, then move them over to a non-functional circuit to troubleshoot. Common defects such as failed fuses, bad wire terminations, failed relay contacts, etc. were introduced into circuits and students had to understand how the circuit worked to correctly troubleshoot it.