Electrical Safety & Maintenance

Managing Maintenance Institute (MMI)

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Lansdowne, VA

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TURN KEY
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Overview

- Electricity 101
- Exposure and effects
- Troubleshooting
  - Reading schematics
  - Transformers
  - Voltage drop
- Identifying hazards

Electricity 101

- Definitions
  - Electricity:
    - Flow of an atoms electrons through a conductor
  - Voltage:
    - Fundamental “force” or pressure that causes electricity to flow through a conductor.
  - Resistance:
    - Anything that impedes the flow of electricity
  - Current:
    - Flow of electrons from a source of voltage through a conductor (Measured in amperes (amps))

Electricity 101

- Definitions (continued)
  - Alternating Current (AC):
    - Current flows back and forth (a cycle) through a conductor
  - Direct Current (DC):
    - Current flows in one direction only
  - Ohm's Law:
    - Used to relate voltage, resistance and current (I=V/R)
  - Ground:
    - A conducting connection, whether intentional or not, between an electrical circuit or equipment and the earth or to some conducting body that serves in place of the earth

How Does Electricity Work?

- Electricity always:
  - Travels in completed circuits through the path of least resistance
  - Flows toward the earth
- Conductors (wiring) allow electricity to flow
  - Wire Types- Aluminum and Copper
- Insulators prevent electricity from flowing
  - Types of Insulators (wire insulation and rating)

Electricity Can Kill or Maim

- Treat electricity with the respect it deserves
- Electricity is the most commonly encountered hazard in the workplace
- Death can be caused from direct exposure or injuries after shock

Electricity Can Kill or Maim

- You have to respect electricity

Electrical burn on hand and arm.

Arm with third degree burn from high-voltage line.

Exposure and Effects

Readings		Effects
Safe Current Values	1 mA or less	Causes no sensation - not felt.
	1 mA to 8 mA	Sensation of shock, not painful; Individual can let go at will since muscular control is not lost.

Exposure and Effects

Readings		Effects
Unsafe current values	8 mA to 16 mA	Painful shock; individual can let go at will since muscular control is not lost.
	16 mA to 20 mA	Painful shock; control of adjacent muscles lost; victim can not let go.
	50 mA to 100 mA	Ventricular fibrillation - a heart condition that can result in death - is possible.
	100 mA to 200 mA	Ventricular fibrillation occurs.
	200 mA and over	Severe burns, severe muscular contractions - so severe that chest muscles clamp the heart and stop it for the duration of the shock. (This prevents ventricular fibrillation).

Troubleshooting

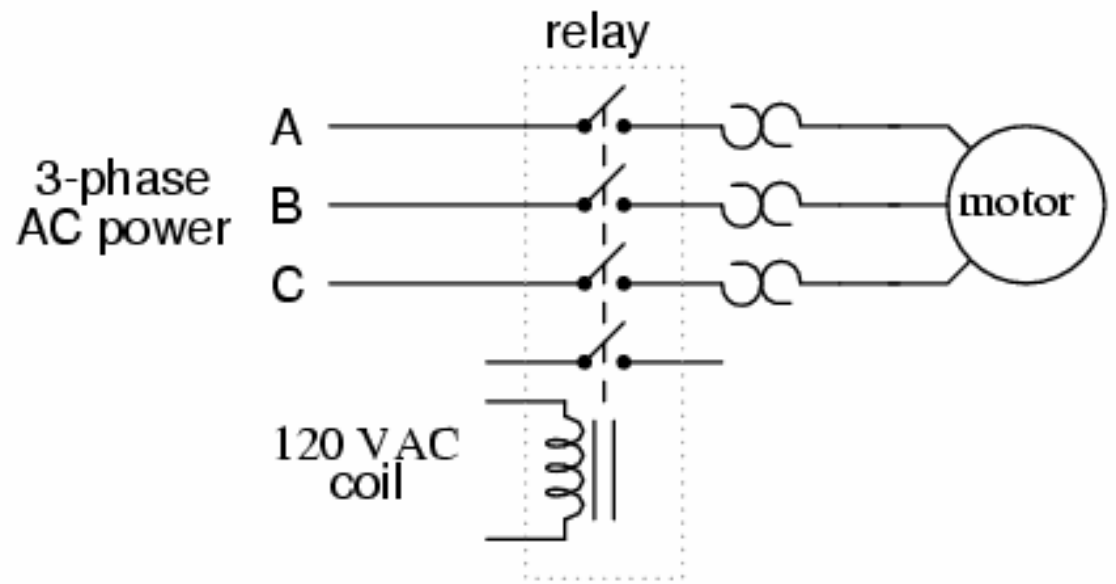
- Systematic approach
  - Preparation
  - Step 1: Observation
  - Step 2: Define problem area
  - Step 3: Identify possible causes
  - Step 4: Determine most probable cause
  - Step 5: Test and repair
  - Follow-up

Troubleshooting - Preparation

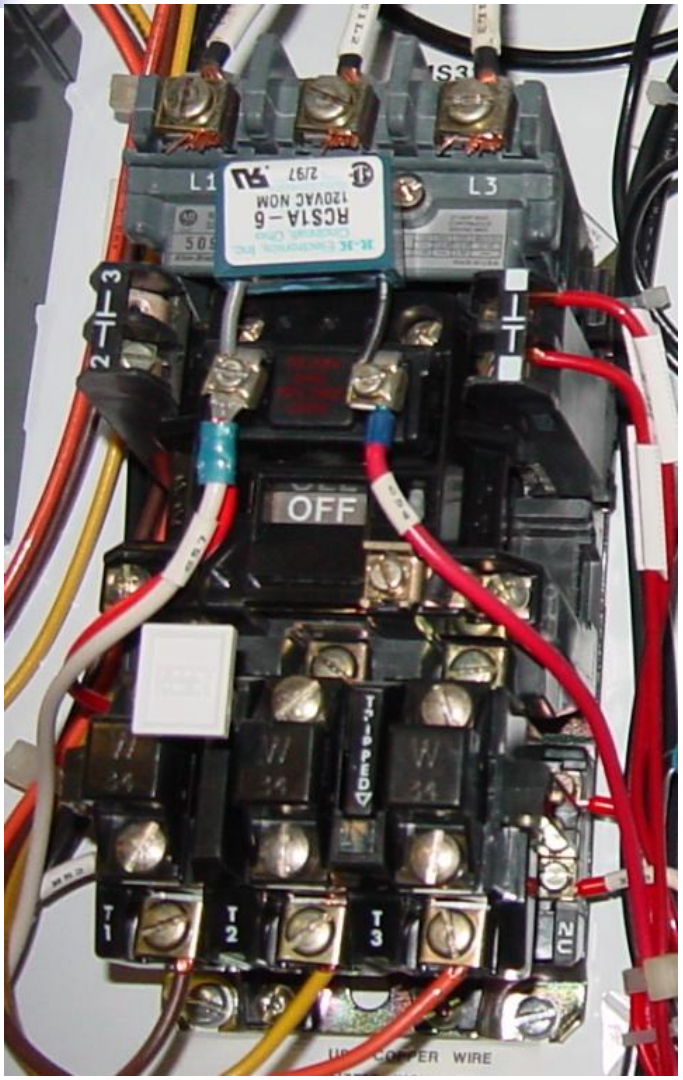
- Familiarize/follow safety rules
- Gather information about equipment/system
  - Manuals
  - Schematics
  - Equipment history records
  - Work order

Preparation

- Schematics
  - Contactors:



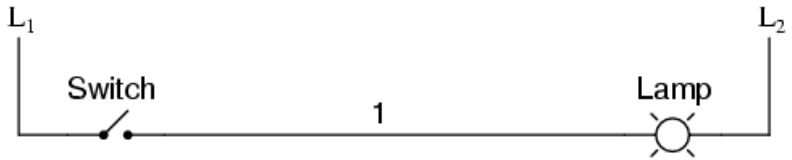
Preparation

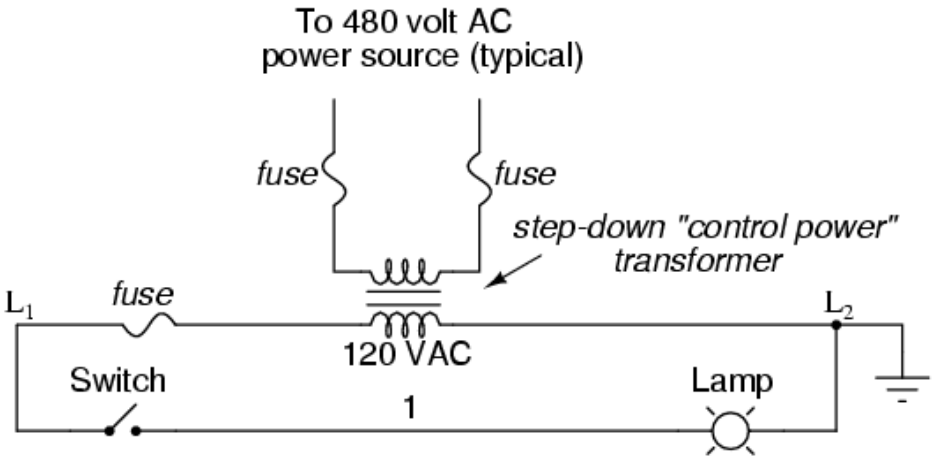


- Motor contactor

Preparation

- Schematics
  - Control diagrams – Ladder diagrams



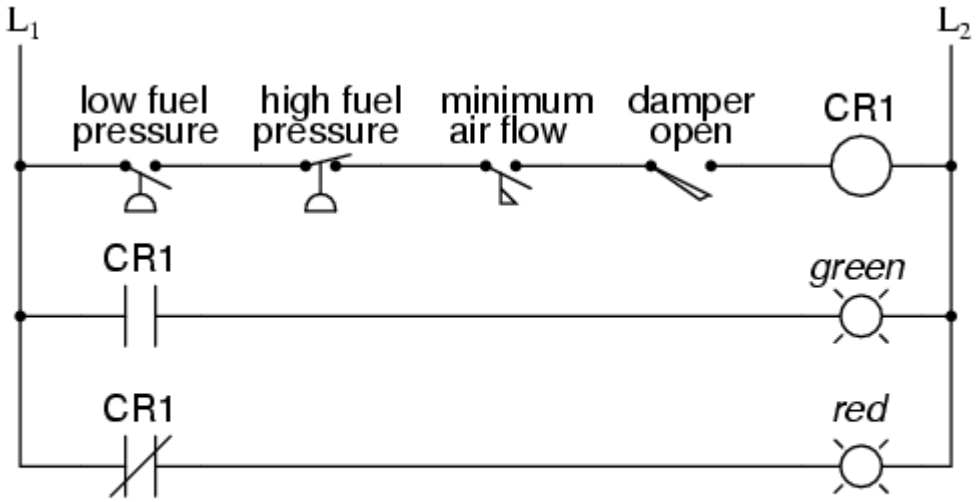


Troubleshooting - Observe

- Look for visual signs
  - Mechanical damage
  - Chafed wires
  - Overheating
- Trust other senses
  - Smell of burnt insulation
  - Listen to sound of equipment
- Note the state of control circuitry
- Test operation of equipment

Troubleshooting - Define

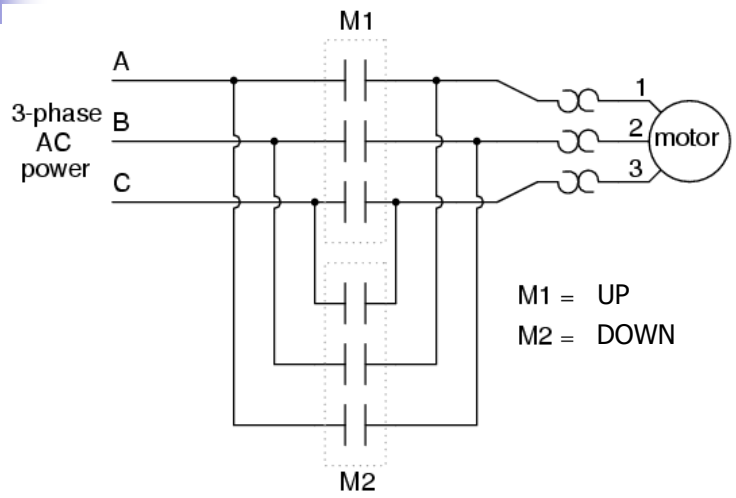
- Burner control logic example – burner green light will not illuminate

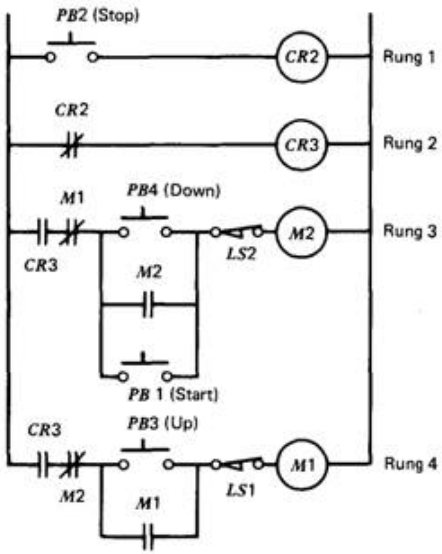


Green light = *conditions met: safe to start*

Red light = *conditions not met: unsafe to start*

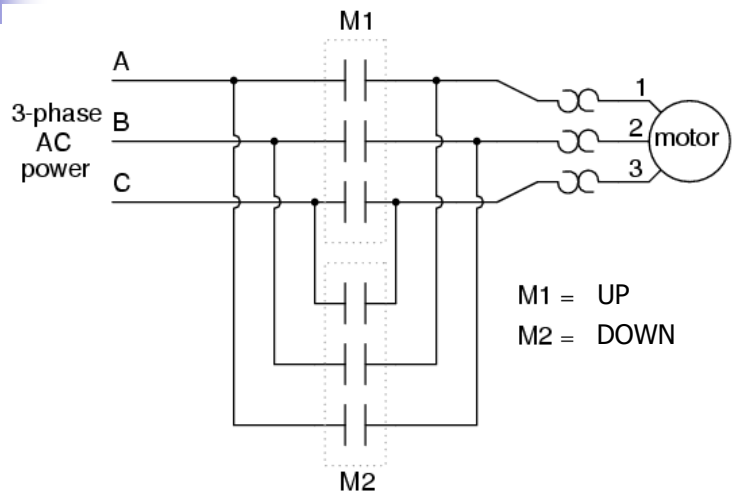
Troubleshooting - Identify

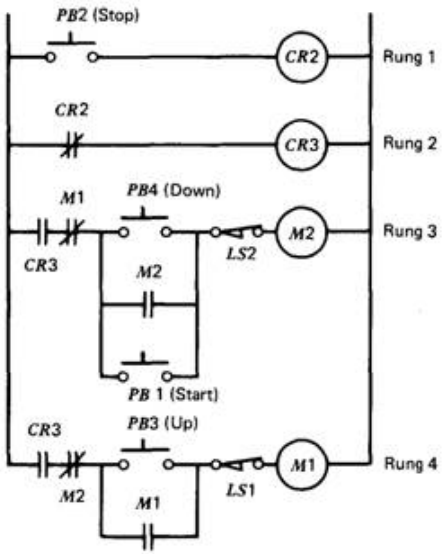




- Reversing motor for a lift
  - Lift is stuck in up position
- Output Elements
  - Ml = Motor to drive the lift UP
  - M2 = Motor to drive the lift DOWN
- Input Elements
  - LS1 = NC limit switch to indicate UP position
  - LS2 = NC limit switch to indicate DOWN position
  - START = NO push-button for START
  - STOP = NO push-button for STOP
  - UP = NO push-button for UP command
  - DOWN = NO push-button for DOWN command

Troubleshooting – Determine Cause

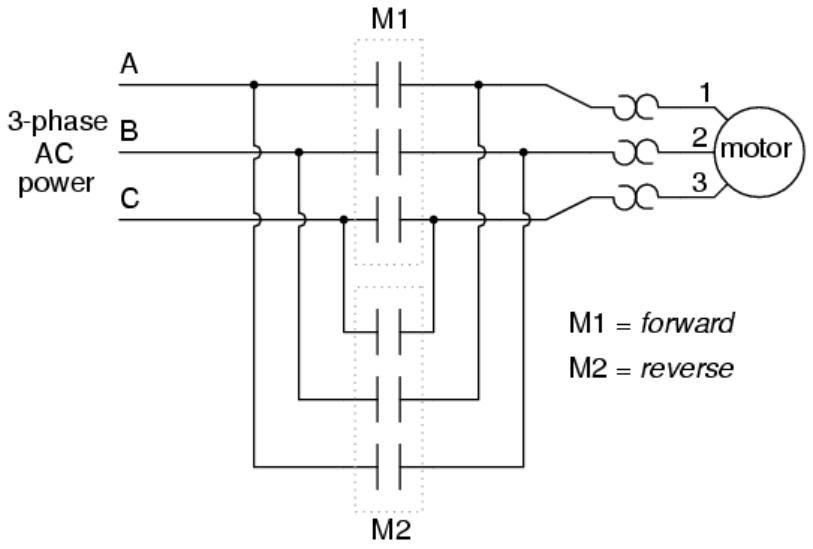




- Prioritize probable causes
- Recommended priorities:
  - Components that burn out or wear out (mechanical switches (LS1, contacts)
  - Check coils, motors, transformers
  - Check connections
  - Check for defective wiring

Troubleshooting – Determine Cause

- Symptom: Overloads keep tripping out
- Potential problems:
  - Bad overload heaters
  - Improperly sized overload heaters
  - Low voltage
  - Other?



Low Voltage Condition

- Poor power quality
- Transformer problem
- Voltage drop

Transformers

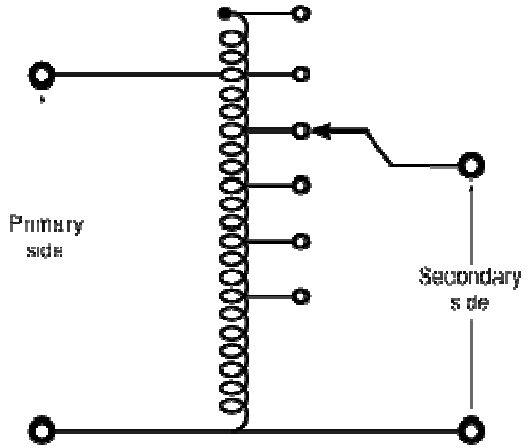
- Voltage changer
- Primary and secondary windings around an ironer core
- Number of turns in each coil will determine voltage transformation.
  - Difference between primary and secondary windings produces voltage change (Turns Ratio)
- Types:
  - Step down
  - Step up
  - Isolation

Transformers - Maintenance

- Visual inspection
  - Burns
  - Loose windings
- Infrared imaging - detect
  - Loose connections
  - Unbalanced loads
  - Faulty wiring
- Shut-down maintenance
  - Wipe down
  - Tap changes
  - Tighten connections

Transformers – Tap Changes

- Multi-tap transformer
- Detect low output voltage
  - Transformer has 4:1 turns ratio (480/120v)
  - Input voltage measured at 456v verses 480v
  - Output voltage = 456volts/4 = 114 volts
  - Reducing turns ratio (auto-transformer) will improve output voltage to acceptable levels



Low Voltage Condition – Voltage Drop

- Motors require voltage within 10% of nameplate voltage
- Recommended voltage drop:
  - Combined voltage drop (feeder **and** branch circuit) < 5%
  - Maximum voltage drop (feeder or branch circuit) < 3%

Voltage Drop

- Why pay attention to Voltage Drop?
  - System efficiency
  - System performance – lights
  - Troubleshooting
  - Load protection – under voltage for inductive loads can cause:
    - Overheating
    - Inefficiency
    - Shorter life span

Voltage Drop

- Calculating voltage drop
- Ohms law method:
  - VD = I x R

    where:
    - I = load in amps
    - R = conductor resistance

Voltage Drop

- Example with Ohms law
- Given:
  - 16 amp, 120 volt load (20 amp breaker)
  - 200’ of 12 AWG THHN wire
    - R = 2 ohms per 1000 ft.

- VD=16A x (2Ω/1000’) x 200’
- VD=16A x 0.4Ω
- VD=6.4V
- 6.4V ÷ 120 V = 5.33%

Voltage Drop

- Calculating voltage drop
- Formula method:
  - Single phase
    - VD = (2 x K x I x D) ÷ CM
  - Three phase
    - VD = (1.732 x K x I x D) ÷ CM

    where:
    - K = DC resistance for 1,000 CM conductor 1,000’ long
      - K = 12.9 ohms for copper
      - K = 21.2 ohms for aluminum
    - I = load in amps
    - D = length of cable
    - CM = circular mils of cable used

Voltage Drop

- Three phase example
- Given:
  - 36kVA, 3Ø load at 208 volts
  - 80’ of 1 AWG THHN aluminum wire

- VD=3.51 volts
- 3.51V ÷ 208 V = 1.69%

Tables

Voltage Drop

- Algebraic variations
- Solve for CM
  - CM = (1.732 x K x I x D) ÷ (Allowable VD)
  - Example:
    - Installing a 15 kVA load (20 hp air compressor)
    - 480 volts, 3Ø
    - Length of cable = 390’ of copper wire
    - Determine what size cable should be used.
- Solve for D to determine maximum distance for a particular cable size
- Solve for I to determine maximum load on a given circuit

Tables

Troubleshooting – Test & Repair

- Prove/disprove theory by testing
- Sample test methods:
  - Use multimeters:
    - Test phase to phase voltage, phase to ground
    - Test control power
    - Test motor leads for continuity and "ohmage" of windings
  - Megohmmeter check on motors
    - Check insulation resistance to ground

Proper Use of Extension Cords, Receptacles and Connectors

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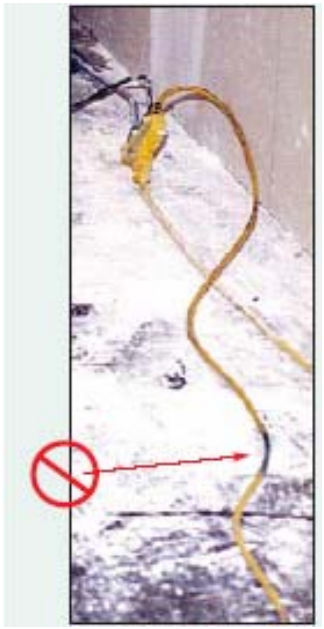
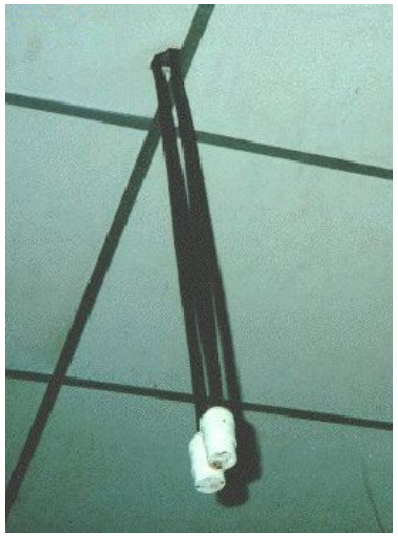
- Extension cords
  - Extension cords are only a temporary solution not "permanent" wiring
  - They are at higher risk of damage than fixed wiring
  - Damaged cords cause shocks and fires
  - They should be checked before shifts start
  - Do not use cords coiled up





Proper Use of Extension Cords, Receptacles and Connectors

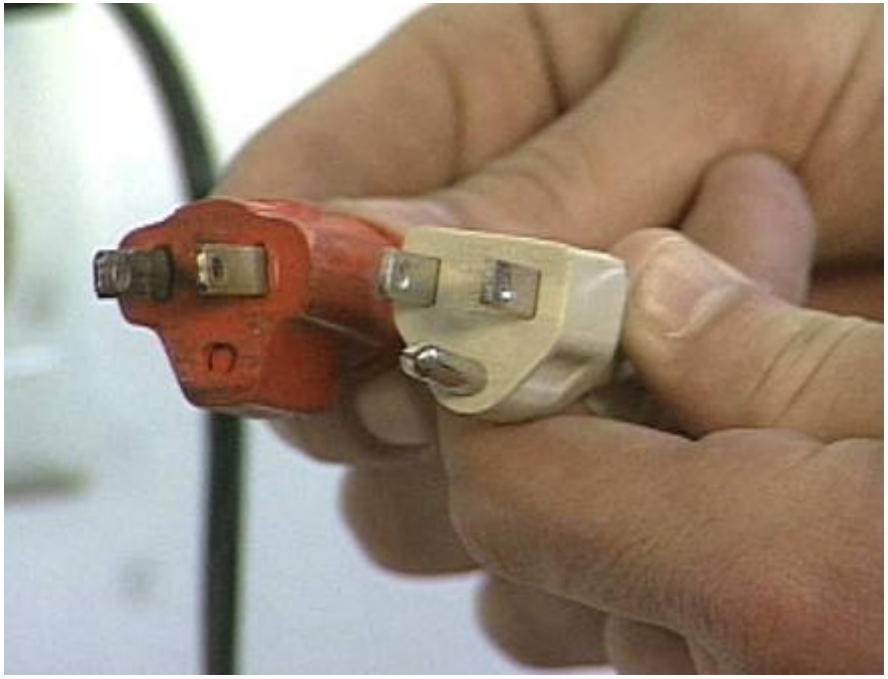
- Receptacles and Connectors
  - Use according to manufacturers specifications
  - Use in proper environment
  - Do not cut off ground
  - Inspect for damage

Grounding Prevents Injuries

- Grounding equipment prevents dangerous electricity from traveling through your body

- Examples are:
  - Three prong plugs
  - Equipment ground

- Machine Grounds
  - Neutral vs. ground



Recognizing Hazards

- Identify hazard

Recognizing Hazards

- Identify hazard(s)

Recognizing Hazards

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