Study Guide

CORE

Carrier®

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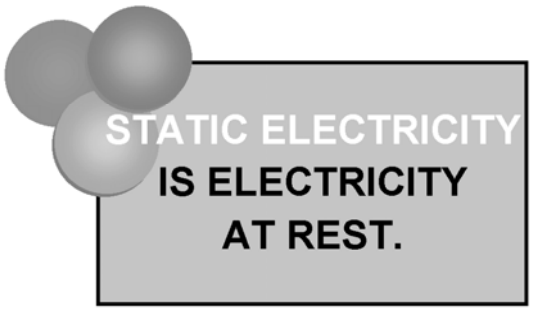
NORTH AMERICAN TECHNICIAN EXCELLENCE

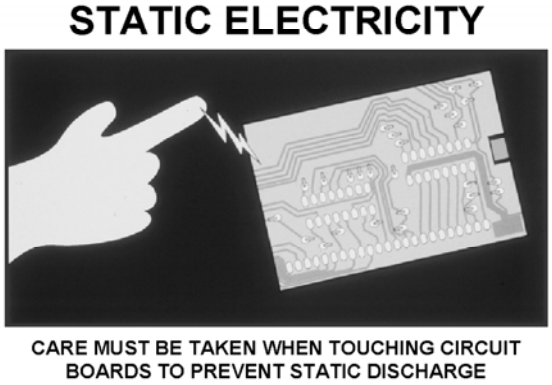
NATE

CORE

1. This refresher course covers topics contained in the **CORE** segment of the North American Technician Excellence (NATE) certification exam.



2. Simply stated, **static electricity** is electricity at rest. Static electricity is either a positive or negative charge. If an object or the atmosphere contains an equal amount of charge it is considered uncharged.

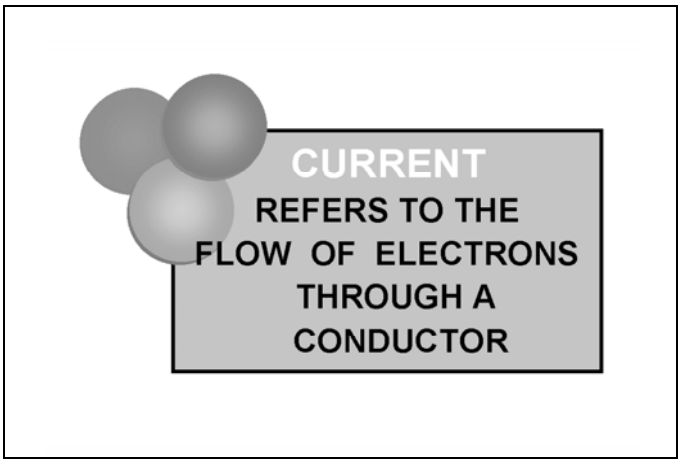


3. Our atmosphere and most objects around us have either a positive or negative charge. For example, a person walking across a carpet may create a negative charge through friction. The atmosphere may build up a static charge due to heat. An electronic device may have a charge that is different than the person handling it.

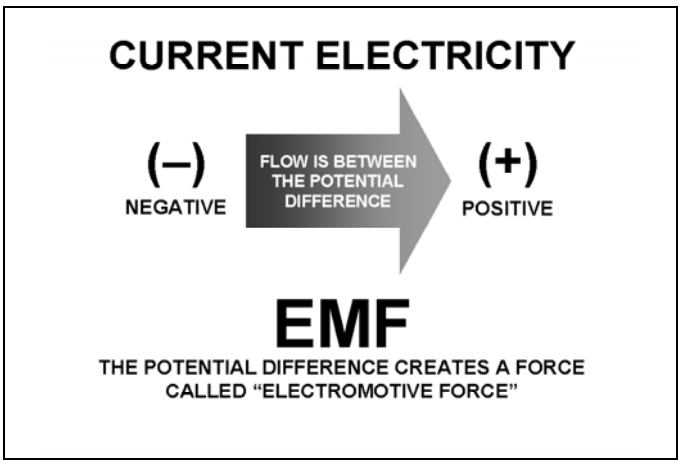
This buildup of energy is often released in the form of static electricity. Lightning is one of the most common forms of static electricity. Touching an object with a less positive charge will cause a spark of high voltage or discharge when static electricity is released.

Raising the humidity can control static electricity. In the air conditioning industry, however, the control of static electricity and the potential dangers from its discharge are often weighed against the need for comfort. During the heating season, it may be necessary to add a humidifier.

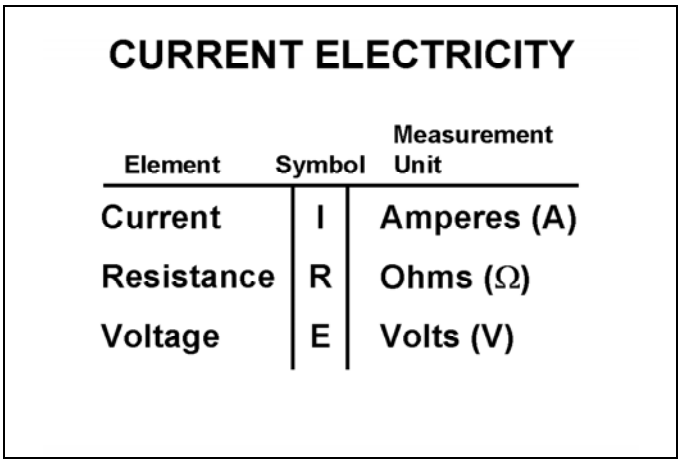
We can remove excess humidity in an A/C system by slowing the blower speed. This allows air to have more contact time with the coil, increasing the delta temperature across the coil and removing more humidity in the process. Care should be taken not to slow the blower speed too much since this may cause freezing.



4. **Current electricity** is electricity in motion. Current is the flow of electrons through a conductor, like a wire, water or air.



5. Current flow must be between a potential difference and will flow from negative to positive. This potential difference creates a force called "Electromotive Force" or **EMF** and is measured in volts.

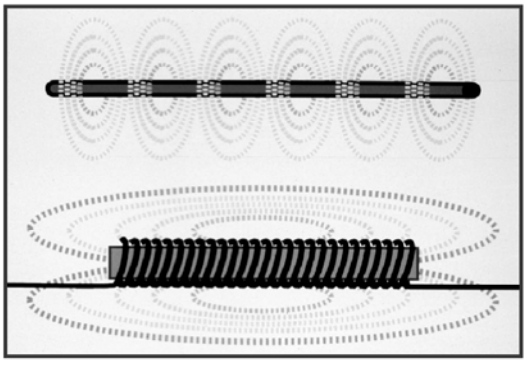


6. The force required to move one ampere through one ohm of resistance is called a **volt**.
The rate of current flow is measured in **amperes** (amps) and depends on the applied voltage.

The ratio of voltage to current flow is the resistance and is measured in ohms (Ω). An **ohm** is the amount of resistance in a circuit that allows one volt to cause one ampere to flow through a circuit. Conductors control the rate of current flow depending on the resistance and physical state.

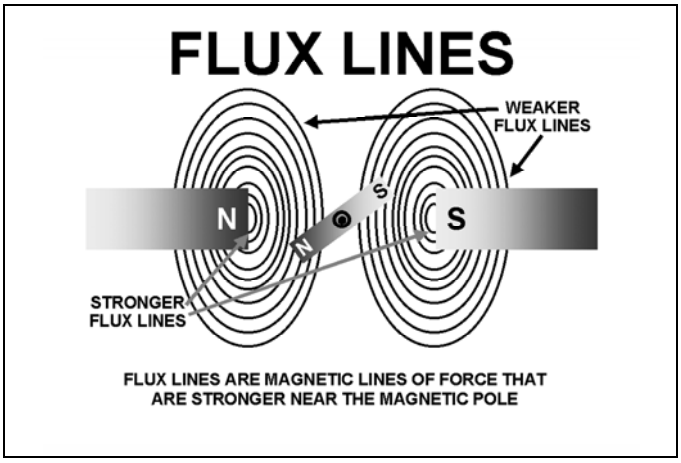
In a schematic circuit, the letter symbol for volts is E (referring to EMF), I for amperes and R for ohms.

Current is found to be directly proportional to the applied voltage and inversely proportional to the circuit's resistance. **Ohm's Law** expresses this relationship.

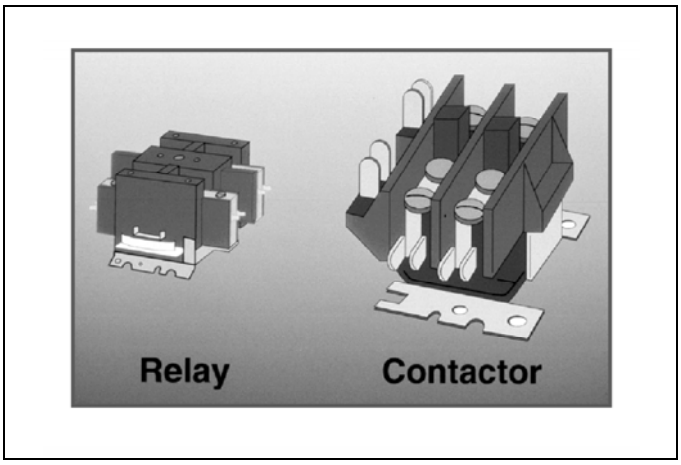


7. Magnetism is also produced by electricity. An electric current flowing through a wire produces a

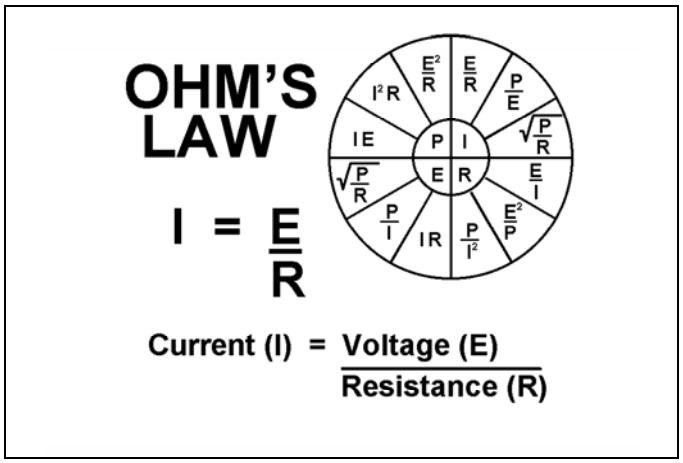
magnetic field around a wire. The wire becomes an **electromagnet**, and its ends are the two poles.



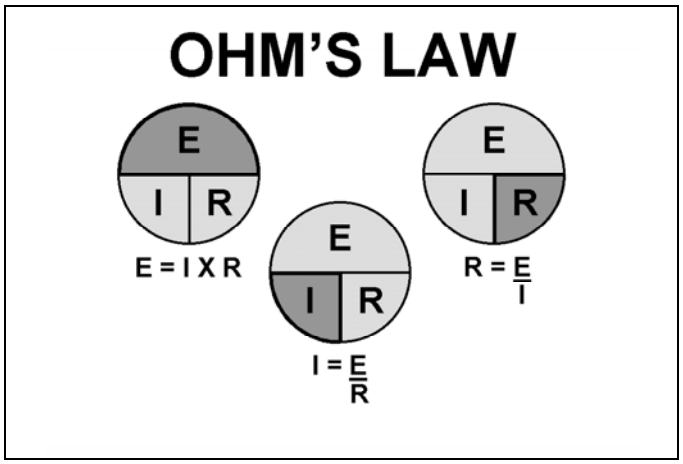
8. **Flux lines** indicate the varying levels of force created by a magnet that become stronger nearer to a magnetic pole and help create movement in an alternating current.



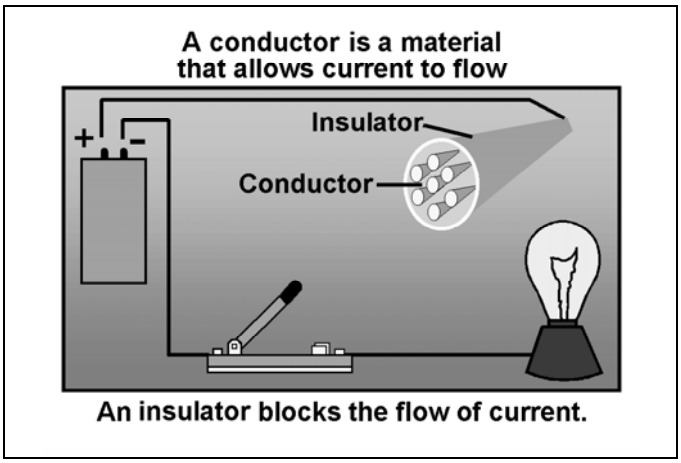
9. Many electrical components rely on the magnetic attraction/repulsion principle, including some contactors and relays.



10. Using the Ohm's Law Wheel, we can mathematically solve electrical problems. In Ohm's Law, I represents the current (in amps), E represents voltage (in volts) and R represents resistance (in ohms). When you know two of the values, you can determine the third value.

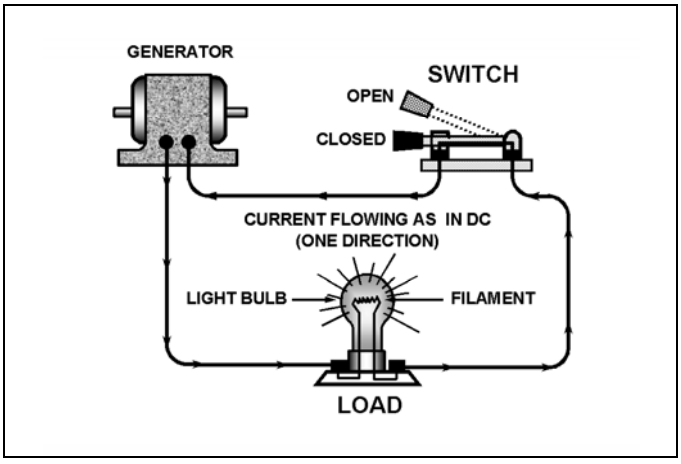


11. These charts show an easier way to relate the formula and to find a value, when given the other two values.



12. A **conductor** is a material that has a low resistance to current flow. It carries or "conducts" current through the circuit. Metals are usually good conductors. Copper is the most common conductor used in electrical wiring.

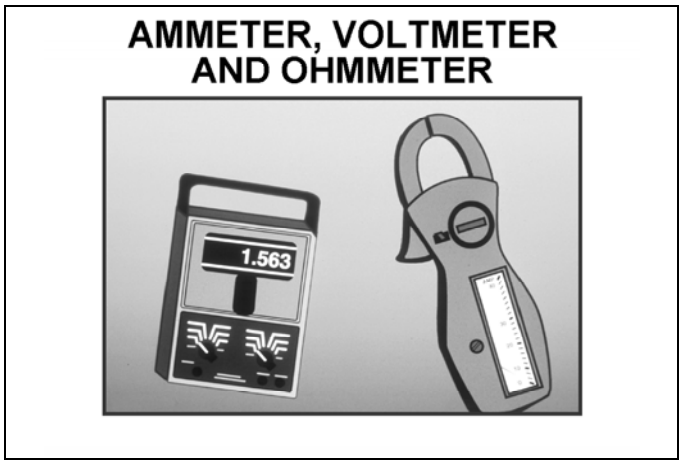
An **insulator** is the opposite of a conductor, offering very high resistance to current flow. The best insulators completely block the flow of current. Air and glass are good insulators. The rubber shielding around a bare wire conductor is an insulator, protecting people coming in contact with the wire and preventing short circuits due to contact between wire and metal objects.



13. A **switch** is a device used to control the flow of electricity. It can connect or disconnect the flow of current or divert the current from one circuit to another. When disconnected, the switch creates an air gap or separation that interrupts the current flow. It will not consume any current and is usually wired to the (hot) side of the circuit.

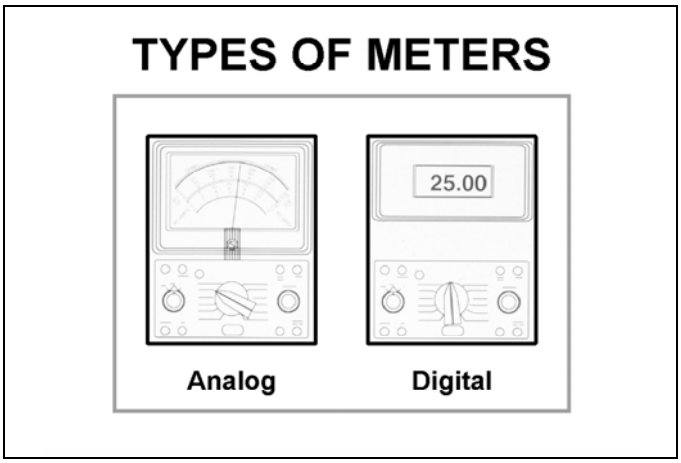
A **load** is any device that uses the energy in a circuit (the electric current) to do some kind of work. This device will consume current and may convert that electrical energy into another form of energy such heat, movement or light.

An electrical circuit is comprised of an energy source, an electrical path leading to a load and the electrical path returning from the load to the energy source, completing the circuit.

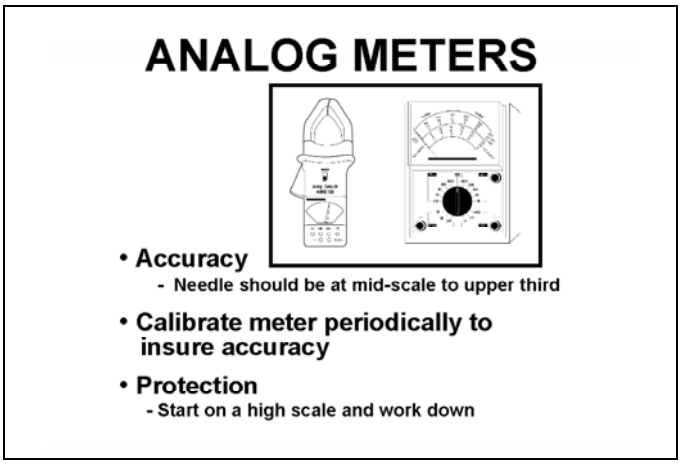


14. Ammeters, voltmeters and ohmmeters are precision devices used to measure functions of electrical equipment and check heating and cooling equipment operation, even when problems are mechanical in nature.

Caution should always be taken when using an ammeter because the meter is used when power is on; therefore, electric shock is possible.



15. There are two types of meters, the analog and the digital. The **analog meter** has a needle that points to the measured value on a scale. The **digital meter** is solid-state and gives a direct numerical readout of the measured value.

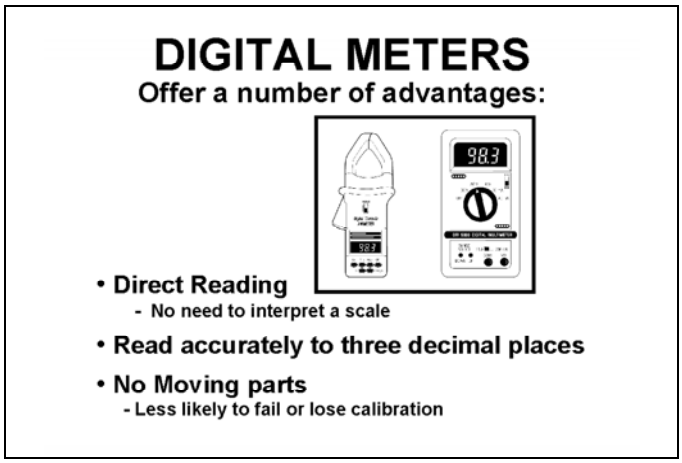


16. There are three important things to remember about analog meters.

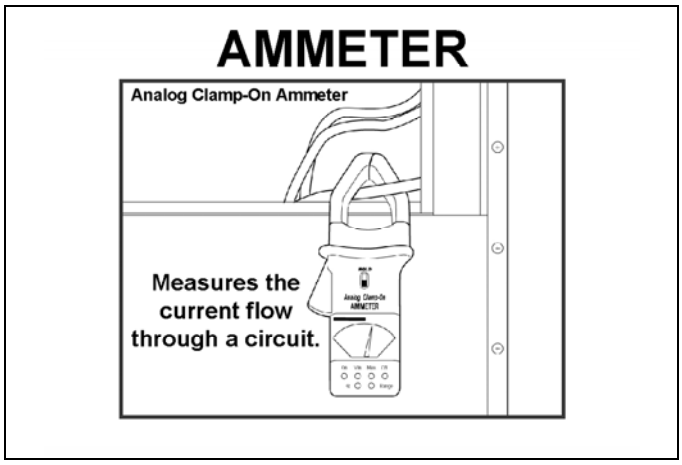
First, the most accurate reading is obtained when the needle is at, or just above the midpoint of the selected scale.

Second, analog meters **must be calibrated** to ensure accuracy.

Third, because the small coil of wire that forms the meter movement is very delicate, it should not be subjected to excessive current. When using meters with multiple scales, always start on the highest scale and work down to lower scales.

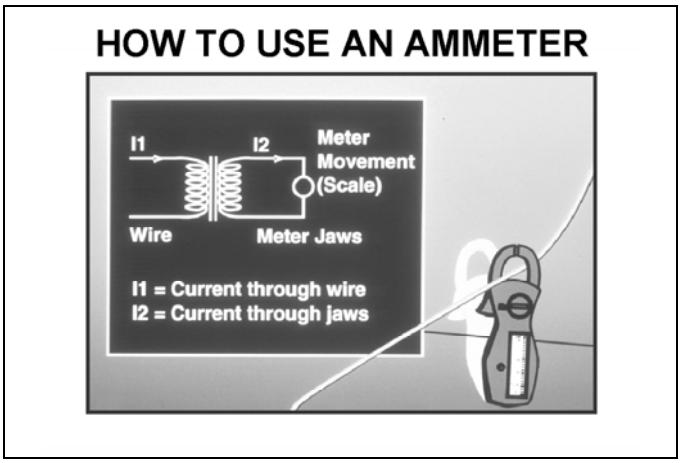


17. Digital meters offer a number of advantages over analog meters. First, digital meters are direct reading, so there is no need to interpret a scale. Second, digital meters read accurately to three decimal places. Lastly, digital meters have no moving parts, so they are less likely to fail or lose their calibration. However, they should still be checked periodically to ensure their accuracy.



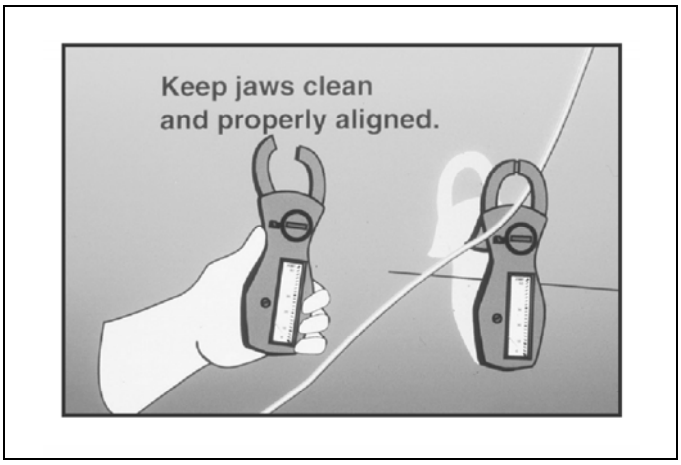
18. An **ammeter** (also called an ampere meter or amp meter) is used to measure the amperage usage of a circuit or component. Simply stated, an ammeter measures how much electricity is being used in amps.

There are basically two kinds of ammeters. One has two probes and is placed in series with the circuit while the other type utilizes a clamp, and is clamped around a **single wire**. This clamp-on ammeter measures the current flow through a circuit and either shows flow or no flow.

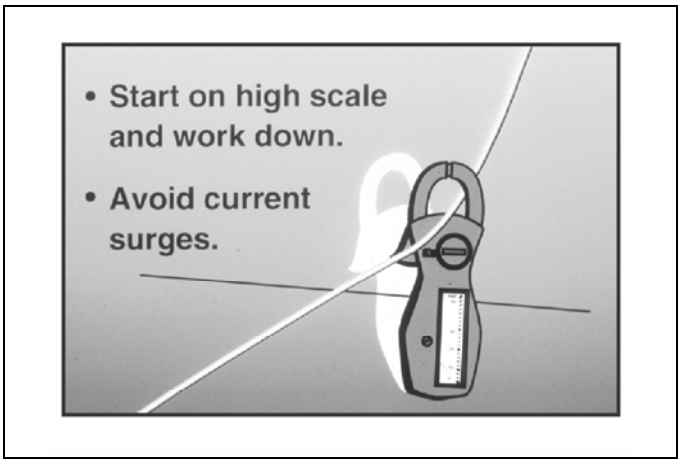


19. The clamp-on ammeter works like a transformer. The wire acts as the primary of the transformer and the "jaws" of the ammeter as the secondary. Current through the wire creates lines of force that induce a current in the jaws. The induced current passing through the meter provides an indication of how much current is passing through the wire and measures the magnitude of the flux lines. The greater the current through the wire, the greater the induced current and the greater the meter deflection.

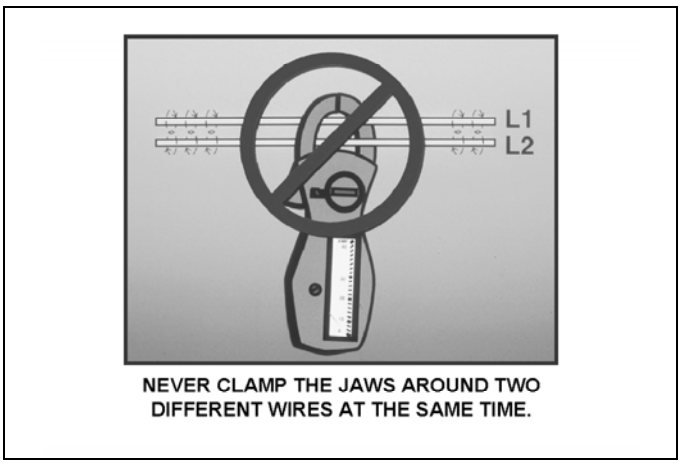
If a motor rated to pull 2.5 Full Load Amps (FLA) is pulling 4 amps, for example, the ammeter is indicating a problem or possible failure in the system. There could be something wrong with the circuit, like low voltage, the motor or a motor part may be failing or there may be a problem with airflow.



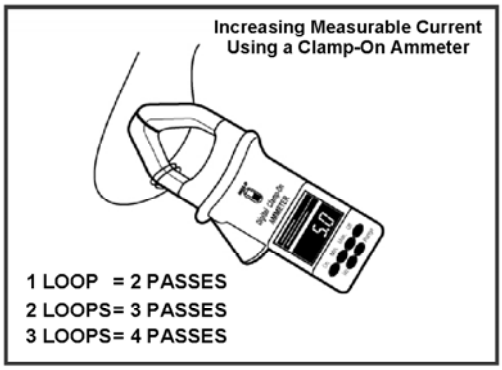
20. Always keep the jaws of an ammeter clean and properly aligned to ensure accurate readings. Check the meter routinely to be sure that the calibration is accurate.



21. When taking a reading, always start on the highest possible scale and work towards the lower scales to prevent damage to the meter. **DO NOT** cycle the motor off and then back on with the meter clamped onto the motor lead unless you first set the meter to the high scale. This will prevent damage from current surges.

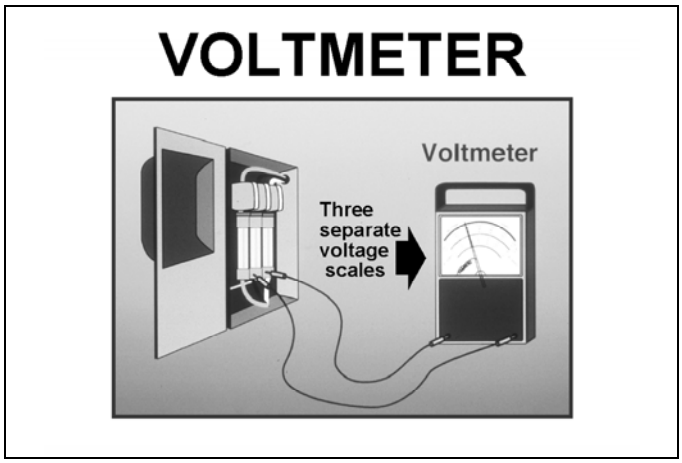


22. **NEVER CLAMP THE JAWS AROUND TWO DIFFERENT WIRES AT THE SAME TIME.** If the currents are flowing in the opposite direction, the meter will read the difference between the two. In the same direction, it will read the sum of the two.



23. When the current is so low that it is difficult to read even on the lowest scale, you can coil the wire through the jaws of the meter. Passing it twice through the jaws, as in this picture, doubles the strength of the magnetic field and therefore doubles the meter reading. Be sure to divide this meter reading by the number of coils around the jaws (in this case two), to determine the actual reading.

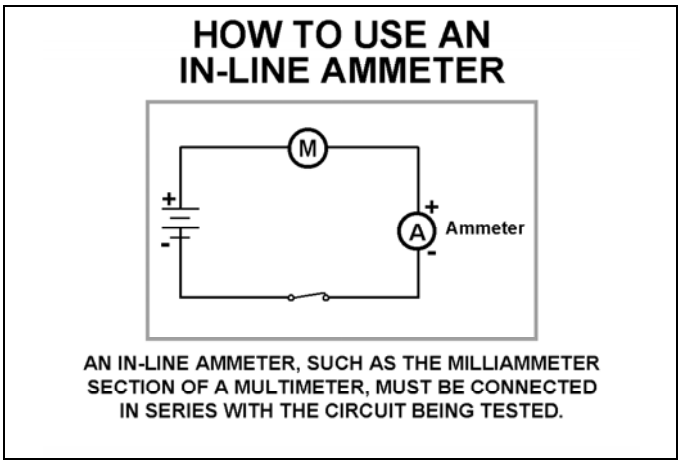
We typically recommend ten turns, just to simplify the math, but any number of turns will work as long as you divide by that number.



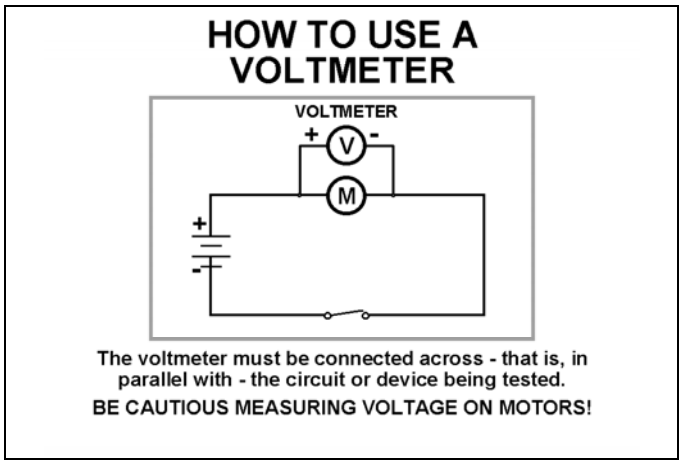
25. Voltage is the presence of electromotive force. A **voltmeter** measures voltage or the potential difference in an AC circuit.

Most voltmeters will have a range switch and a function switch, which may have many different settings.

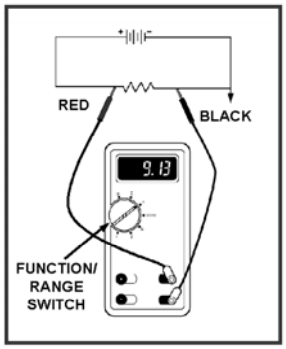
It uses the same basic meter movement as an ammeter. Two meter leads are used to connect the voltmeter to the circuit being tested. Current from the voltage source flows through the meter movement.



24. Most current measurements are made with a clamp-on ammeter. However, if you have an **in-line ammeter**, it must be connected in series with the circuit being tested. The milliammeter section of a multimeter is an example of an in-line ammeter.



26. Voltmeters are always connected across - that is, in parallel with - the circuit or device being tested. The power must be on.

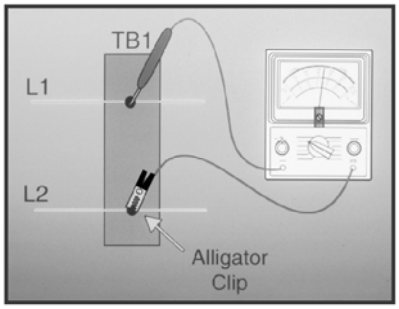


The voltmeter must be connected in parallel with the circuit or device being tested.

BE CAUTIOUS MEASURING VOLTAGE ON MOTORS!

27. Always select the highest voltage range setting and, if the reading is off the scale, move the selector down to the next highest range. This will protect the meter and the user.

Be cautious measuring voltage on motors because the normal characteristics of the motor may cause the voltage on its windings to be far above the line voltage.



SAFETY HINT - Use an insulated alligator clip to attach one probe to a test point, then touch the other probe to the other test point. This is much safer because you have only one hand in the unit at a time.

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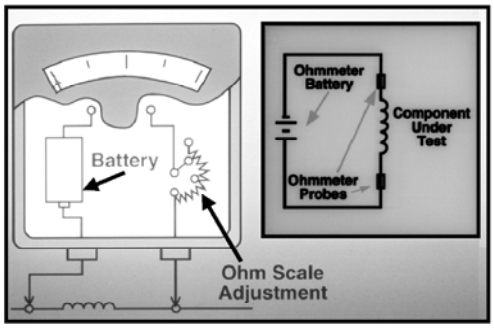
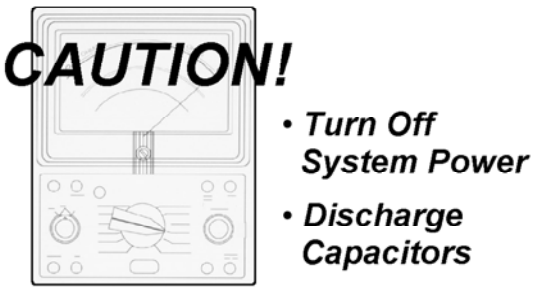
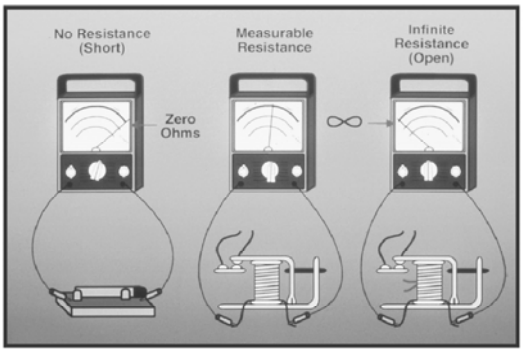


29. An **ohmmeter** is also called a "resistance" meter and measures the resistance of a circuit or a component in ohms. It is connected in parallel with the circuit or component to be measured, using a known voltage (usually a low voltage battery inside the meter's housing).

The ohmmeter uses the direct application of Ohm's Law: the resistance of the component determines the amount of current flow through the meter movement. The higher the component resistance, the lower the current, or meter deflection. Therefore, the needle action and scale readings are opposite those of the ammeter and voltmeter because the meter needle does not swing much for high resistance and swings a lot for little resistance. With an ohmmeter, "0" is at the right of the scale.



30. Before using an ohmmeter, **ALWAYS turn the power off and be sure that capacitors in the circuit have been discharged**.



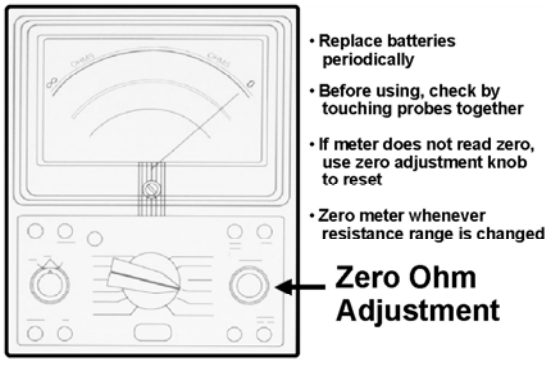
CONTINUITY TESTING

31. Using an ohmmeter to check for open circuits is called **continuity testing**. This allows troubleshooting with the power off.

The closed switch on the left offers no resistance and therefore the needle moves all the way to the right, indicating zero ohms and showing continuity in the circuit.

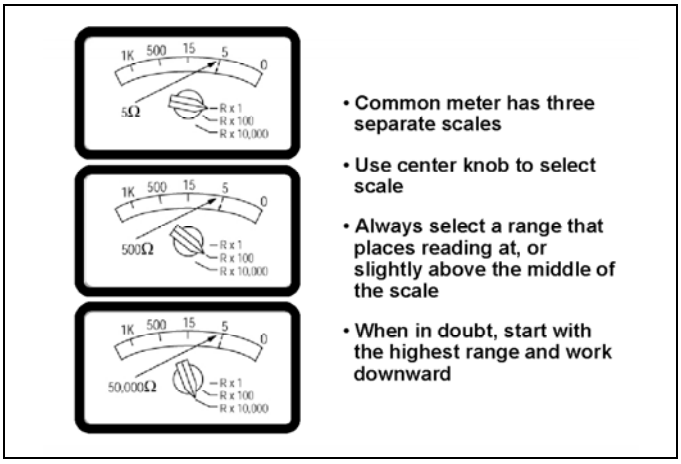
The coil in the center has a measurable resistance, which is read on the meter.

If a coil has a broken wire (right), it offers no current path so there is no meter deflection and the meter reads infinite resistance (Ω), indicating lack of continuity.



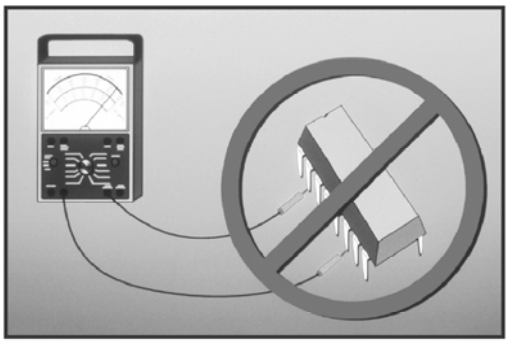
32. Ohmmeters must be able to read resistances from a few ohms to tens of millions of ohms. Low-voltage batteries provide the right potential for low resistance ranges but because more potential is needed for higher ranges, the ohmmeter uses more than one battery. Battery age affects an ohmmeter's accuracy and therefore must be replaced periodically.

Before using the ohmmeter, check it by touching the probes together. If the meter does not read zero, use the zero adjustment knob to reset the meter. Zero the meter whenever the range is changed.



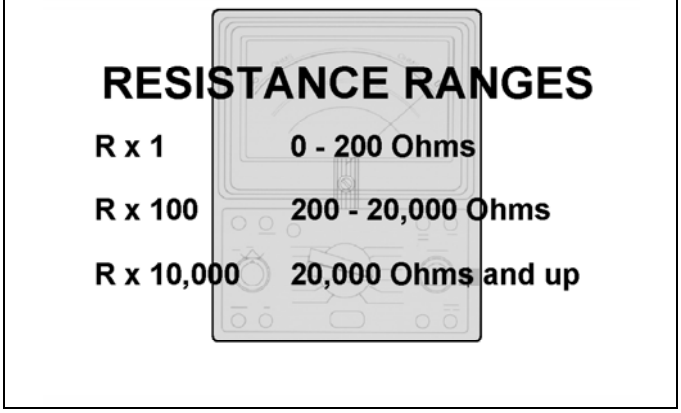
33. Most analog ohmmeters use the same scale to read all the resistance ranges. A common meter has three separate scales. Use the center knob to select the scale. Always select a range that places the reading at, or slightly above the middle of the scale. When in doubt, start with the highest range and work downward. Simply multiply the meter reading by the number next to the selector switch setting, to determine resistance value.

In the examples shown: The top reading (5) is multiplied by the selector switch setting R × 1, to yield a resistance of 5 ohms. At the R × 100 setting, the same reading, would yield 500 ohms, and so forth.

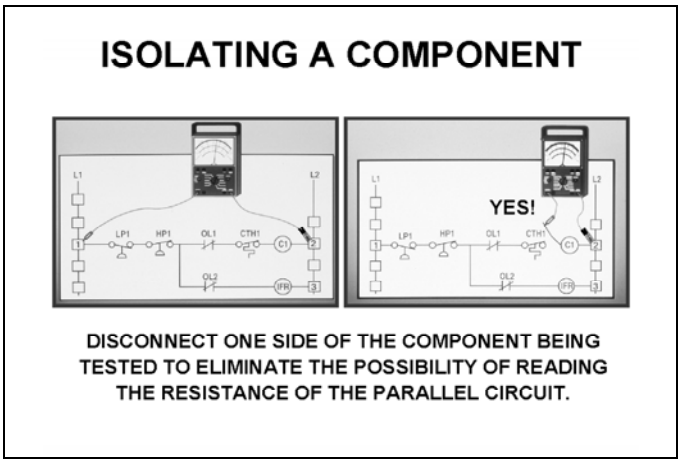


NEVER USE AN OHMMETER ON A SOLID STATE ELECTRONIC DEVICE UNLESS SPECIFIED!

34. **CAUTION!** Never use an ohmmeter on a solid state electronic device unless specified by the manufacturer. The internal battery voltage of the ohmmeter can damage the solid state circuit.

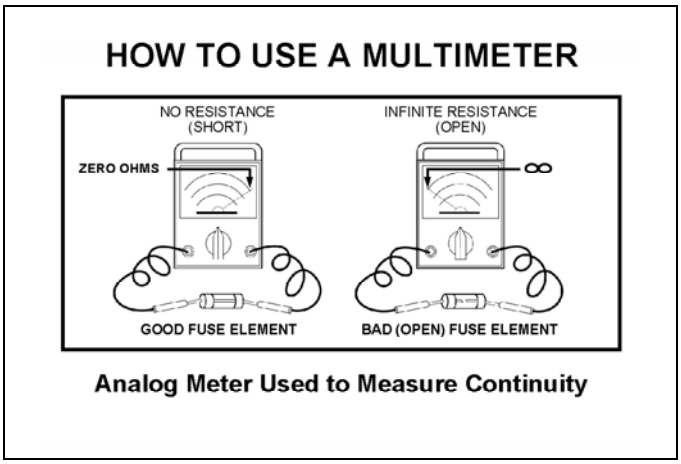


35. Some ohmmeters have R × 100,000 scales for reading very high resistances such as the resistance of a motor winding to ground.



36. The possibility of obtaining an incorrect resistance reading is always present when two or more circuits are connected in parallel.

In the example on the left, we are measuring the resistance of the contactor C1 coil. Even if the coil were open, we would see the resistance of the fan relay coil. If C1 were shorted, the ohmmeter would not tell whether it was C1 or IFR that was shorted. In the example on the right, one side of the component being tested is disconnected and isolated, allowing us to read the resistance of the parallel circuit.



37. A continuity check is a go/no-go resistance check used to test for open and closed circuits.

KEY POINTS ABOUT ELECTRICAL METERS

METER	MEASURE	UNIT STATUS	NOTES
Ammeter	Measures current flow (amps) through an electrical load	Always used with the unit ON and loads operating	Clamp-on type is most common
Voltmeter	Determines voltage available to an electrical circuit	Used with unit ON	
Ohmmeter	Determines continuity or resistance of an electrical circuit	NEVER used with system power on	
Multimeter	Combines functions of all three types	Depends on meter used	Many can only read direct current in the milliamp range and inaccurate or intermittent readings can occur near high-voltage sparks

38. This chart gives the key points of the different types of meters.

Remember, when using a meter; use a schematic to help isolate the various components in the system.

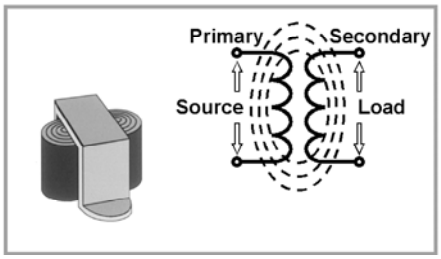
WATT TO BTU CONVERSION

1 WATT = 3.414 BTU/HR

39. To furnish 50,000 Btu's per hour directly from electric strip heaters you would need 14.6 kW. To convert this use the formulas:

1 Watt = 3.414 Btuh
1 kW = 3414 Btuh
50,000 Btu ÷ 3414 = 14.646 kW

TRANSFORMER RATIO



A TRANSFORMER IS USED TO RAISE OR LOWER VOLTAGE LEVELS AND USUALLY CONSISTS OF TWO OR MORE COILS OF WIRE WOUND AROUND A COMMON MAGNETIC SOURCE

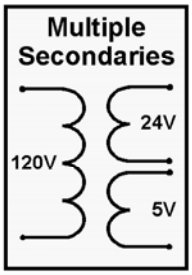
40. A **transformer** is used to raise or lower voltage levels and usually consists of two or more coils of wire wound around a common magnetic source or core that is usually made of thin steel plates that are laminated together.

Transformers have a primary and secondary set of windings. They produce an electrical current in the secondary circuit through electromagnetic induction.

A magnetic field is created when current flows through the coil of wire. If the second coil is placed close to the first (the primary winding), a voltage will be "induced" into the secondary winding by the primary.

TRANSFORMER RATIO

If Secondary Has:	Voltage Is:
Fewer Windings	Stepped-down
More Windings	Stepped-up



41. The voltage transfer is in direct proportion to the ratio of the number of turns on the primary side to the number of turns on the secondary side. If the secondary has fewer windings than the primary, the voltage is reduced, or **stepped down**. If the secondary

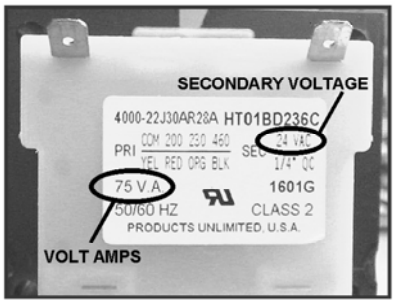
has more windings than the primary, the voltage is **stepped up**. If different levels of AC voltage are needed for different circuits, a transformer with more than one secondary winding may be used.

VOLT AMPS (VA) IN A TRANSFORMER

VOLT AMPS (VOLTAGE X AMPS IN A CIRCUIT) IS THE POWER RATING FOR A TRANSFORMER

42. Transformers are rated by "kilovolt amperes" (kVA) or "Volt amperes" (VA). **Volt amps** is figured by multiplying the voltage times the amps in a circuit and is the **power rating** for a transformer.

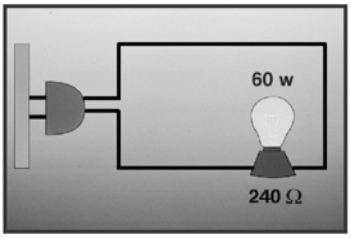
The total load of the circuit to be fed by the transformer must not exceed the transformer output. When replacing a transformer, be sure to use one with the same VA rating, to prevent possible failure.



TOTAL AMP DRAW OF A CIRCUIT = $\frac{\text{VOLT AMPS}}{\text{SECONDARY VOLTAGE}}$

43. To calculate the total amp draw on a circuit, use the formula: **VA divided by secondary voltage**.

SERIES CIRCUIT



THE LOADS ARE CONNECTED IN SERIES ON THE SAME CIRCUIT TO THE VOLTAGE SOURCE

44. A series circuit will have only one single path for the current to flow. The loads are connected in series on the same circuit to the voltage source, and the voltage must pass through each electrical device in succession in that circuit.

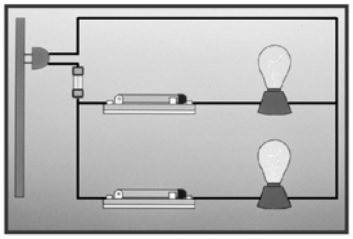
This type of circuit is very common in heating and air conditioning. Usually, there is one load, controlled by a series of switches, and all switches must be closed in order for the load to function.

SERIES CIRCUIT

- **Each load added to a series circuit reduces the amount of current flowing in the circuit, and therefore reduces the amount of work performed by the circuit.**
- **When one component in a series circuit fails, the entire circuit fails. While this characteristic may not be helpful in a lighting circuit, it is important for control and protective circuits.**

45. Each load added to a series circuit, reduces the amount of current flowing in the circuit and, therefore, reduces the amount of work performed by the circuit. When one component in a series circuit fails, the entire circuit fails. While this may cause a problem in a lighting circuit, it is important for control and protective devices.

PARALLEL CIRCUIT



EACH OF THE LOADS
IS CONNECTED DIRECTLY
TO THE VOLTAGE SOURCE

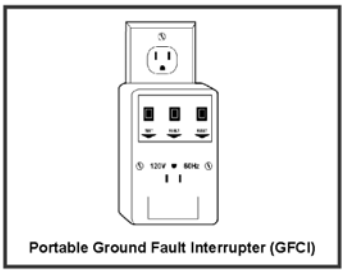
46. A parallel circuit is one that has more than one path for the electricity to flow into each load. Most equipment's loads are connected directly to the voltage source, with the control circuits normally using a lower voltage and controlling one or more loads.

PARALLEL CIRCUIT

- Unlike the series circuit, we can continue to add loads without reducing the effectiveness of the existing loads, though limited by the rating of the fuse and current carrying capacity of the conductors. Adding loads to a parallel circuit increases current unlike a series circuit which would reduce the current with added load.
- When one component in a parallel circuit fails, the others continue to operate. Loads are wired in parallel with each other while control and protective devices are wired in series with the loads.

47. Unlike the series circuit, in a parallel circuit we can continue to add loads without reducing the effectiveness of the existing loads, though limited by fuse rating and current carrying capacity of the conductors. When one component in a parallel circuit fails, the others continue to operate. Loads are wired in parallel with each other while control and protective devices are wired in series with the loads.

GROUND FAULT INTERRUPTER (GFI)



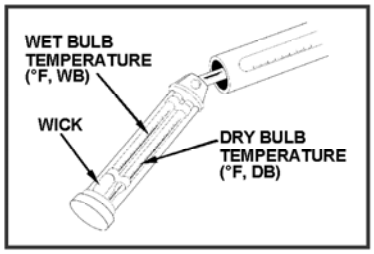
Portable Ground Fault Interrupter (GFCI)

An over current device that detects minute leaks
of current and quickly de-energizes the circuit
(also called a Ground Fault Circuit Interrupter GFCI)

48. A **Ground Fault Interrupter** (GFI), also called a Ground Fault Circuit Interrupter (GFCI) or a Ground Fault Circuit Breaker (GFC), is an over-current device used to protect the person and the load device in the circuit. These types of devices detect minute leaks of current (when the circuit is grounded) and quickly shut down the circuit.

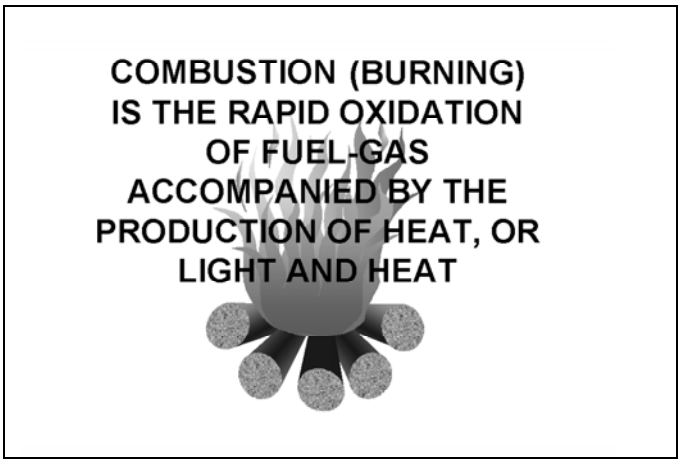
Before touching any electrical circuit, be certain that all electricity to the unit is disconnected, locked out, and tagged.

SLING PSYCHROMETER



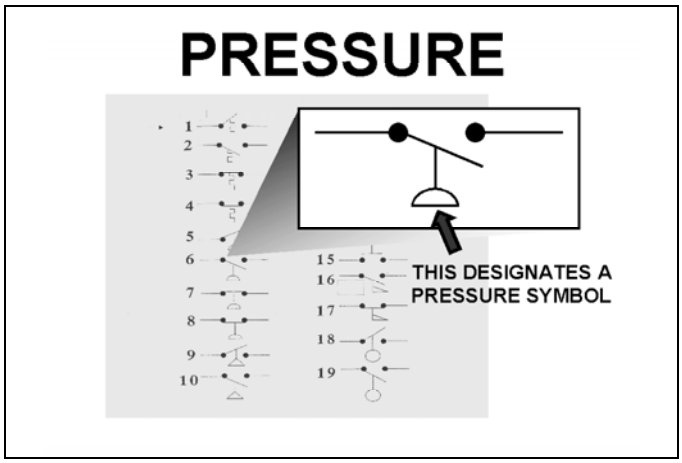
A device with wet and dry bulb thermometers
that is whirled rapidly in the air to measure
sensible wet and dry bulb temperatures

49. A **sling psychrometer** is a device with wet and dry bulb thermometers that is whirled rapidly in the air to measure sensible wet and dry bulb temperatures.

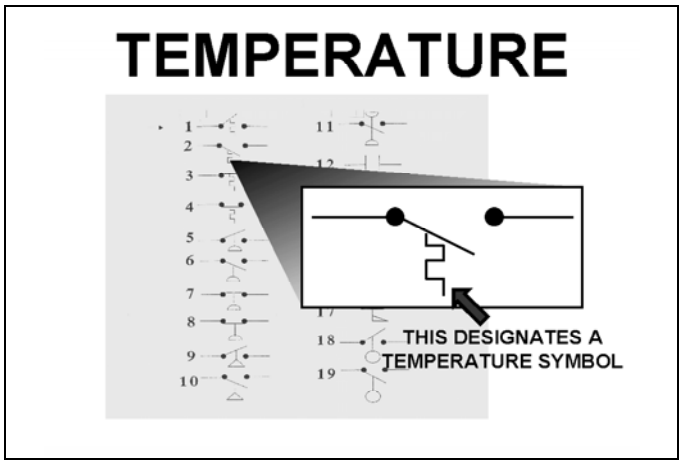


50. **Combustion** is the rapid oxidation of fuel-gas accompanied by the production of heat or light and heat.

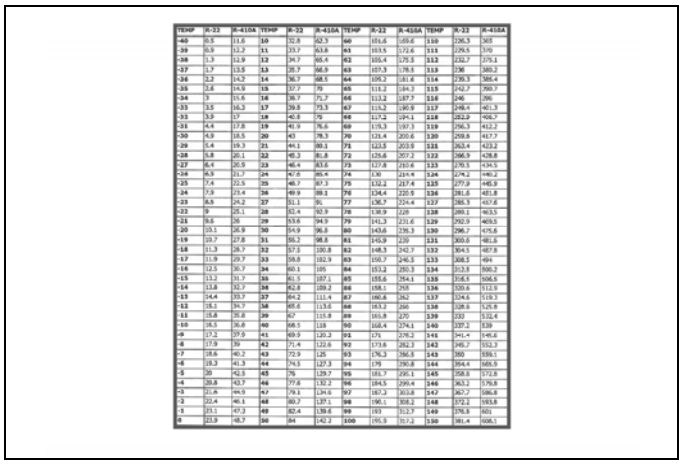
51. The three things needed for combustion are **fuel**, **oxygen** and some form of **ignition**.



52. This shape designates a pressure symbol.



53. This shape designates a temperature symbol.



54. A **pressure-temperature chart** shows the correlation between refrigerants, pressures and temperatures at saturation. If the refrigerant is in the

saturated state, the temperature of the refrigerant will correspond with a specific temperature. Psi and psig represent the same measurement when using a pressure/temperature chart.

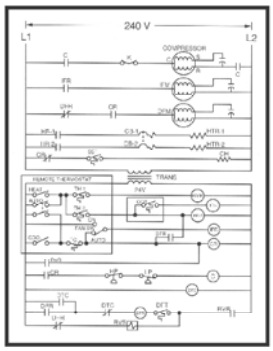
STARTING TORQUE

- PERMANENT SPLIT CAPACITOR MOTOR (PSC) has a run capacitor only which increases its running efficiency
- CAPACITOR START INDUCTION RELAY MOTOR (CSIR) has a start capacitor only which increases its starting torque but does not increase its running efficiency
- CAPACITOR START - CAPACITOR RUN MOTOR (CSCR) has both a start capacitor and a run capacitor, giving it high torque and excellent running efficiency

55. **Torque** is the twisting or turning force that must be developed by a motor to turn its load. Different motors have different starting torque. A greater amount of torque is required to start a motor than to keep it running. The motor with the smallest torque while still being able to perform the job is selected for cost efficiency.

A Permanent Split Capacitor Motor (PSC) has a run capacitor, which increases its running efficiency but has low torque capacity. The Capacitor Start Induction Relay Motor (CSIR) has a start capacitor to give it good starting torque but without increasing its running efficiency. The Capacitor Start-Capacitor Run Motor (CSCR) has both a run and a start capacitor, giving it high torque with excellent running efficiency.

SCHEMATIC DIAGRAMS

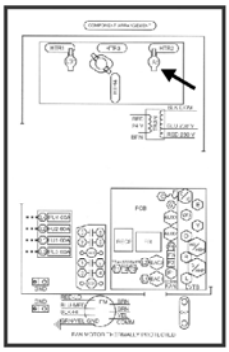


Ladder Diagram

A simplified schematic in which each load line is shown as a separate circuit.

56. A **schematic diagram** lays out a control system circuit by circuit and is composed of symbols representing components and lines representing interconnecting wiring. A **ladder diagram** is a simplified schematic showing each load line as a separate circuit.

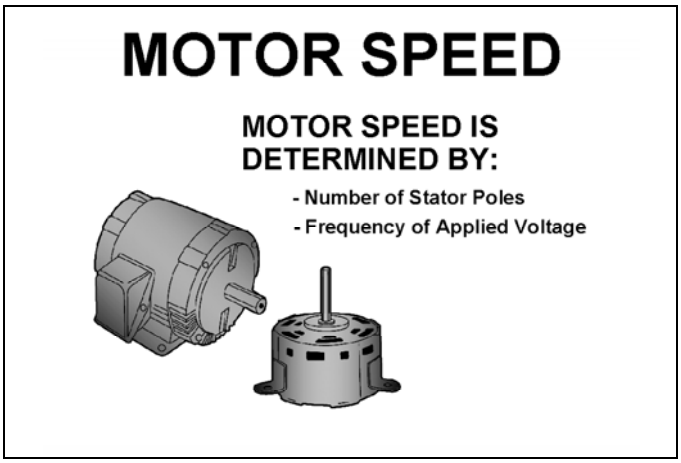
SCHEMATIC DIAGRAMS



Component Arrangement Diagram

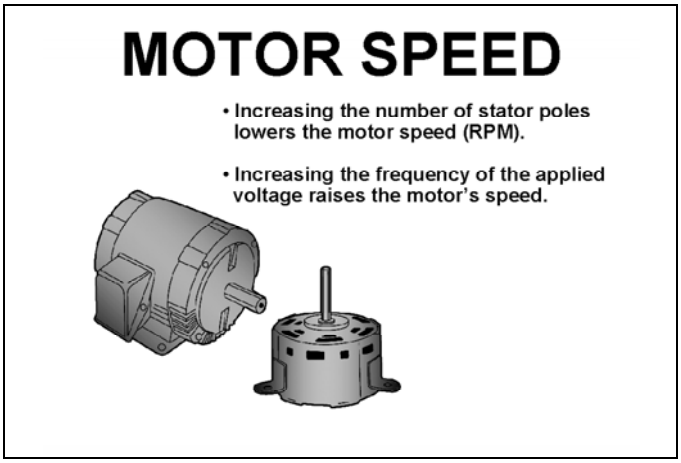
Shows where electrical components are physically located in the unit.

57. A **component arrangement diagram** is a schematic that shows where components are physically located in the unit and the interconnected wiring. This type of schematic is also called a pictorial or point-to-point diagram.

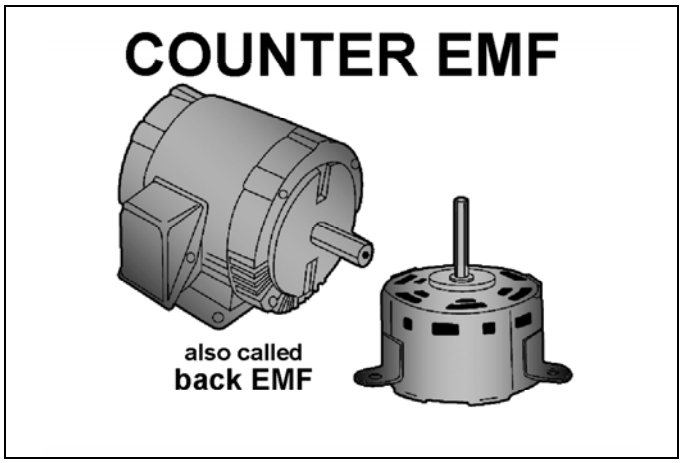


58. All motors use magnetism to create rotation. Most motors are made up of the following parts: stator, rotor, bearings, end bells and housing. If you can diagnose one type of motor, you can fix any type.

All motors use magnetism to create rotation, and motor speed is determined by the number of stator poles in the unit and by the frequency of the applied voltage.



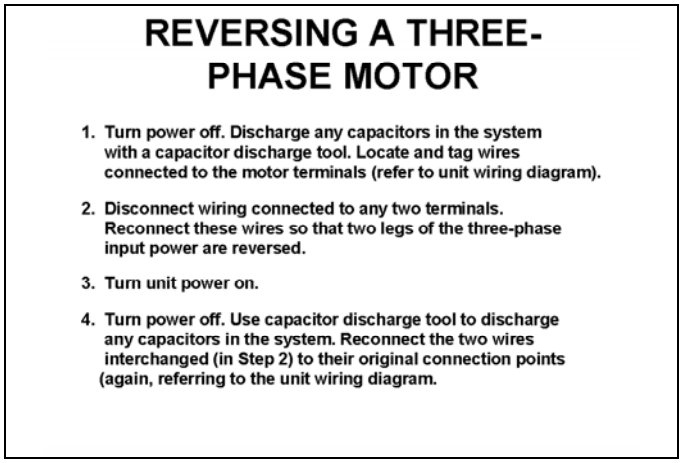
59. Increasing the number of stator poles in a motor lowers the motor speed (RPM); while increasing the frequency of the applied voltage raises the motor's speed.



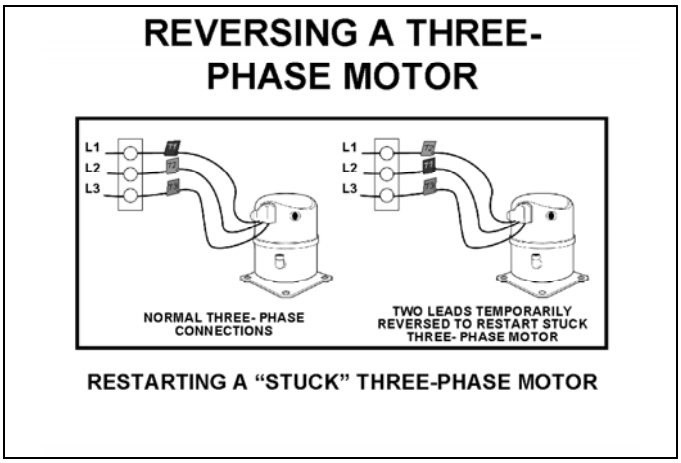
60. A running motor will develop an EMF in the motor's bars and windings. This is called **counter (back) EMF**. It opposes the applied voltage that is driving the motor. The amount of counter EMF depends on the speed, horsepower, and the applied voltage of the motor.

As the load increases and the speed decreases, the counter EMF drops. As a result, the applied voltage sends more current through the windings to maintain speed and the amps increase.

If a heavy load slows the motor considerably, the supply current will increase gently due to the reduction of counter EMF, and the motor may overheat or burn out. If the motor is locked up so it cannot turn when the current is applied, the motor will pull high current, due, in part, to the lack of counter EMF.



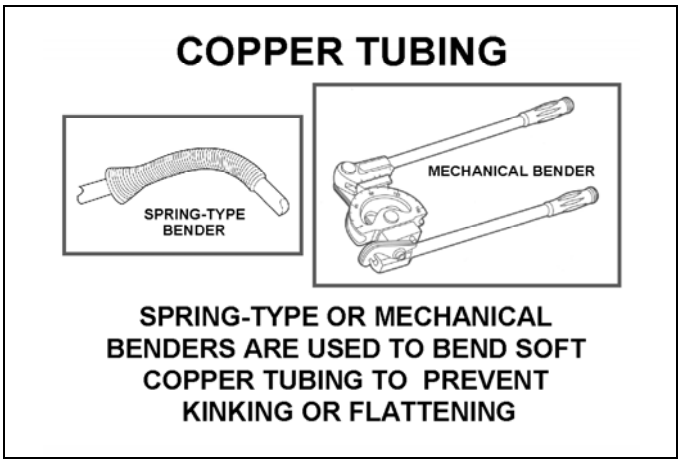
61. To restart a "stuck" three-phase motor, like that in a compressor, it is often necessary to reverse the motor.



62. First, turn the power OFF. Be sure to discharge any capacitors in the system with a capacitor discharge tool. Locate and tag the wires connected to the motor terminals using the wiring diagram as a guide.

Disconnect the wiring connected to any two of the motor terminals and reconnect those two wires so that two legs of the three-phase input power are reversed.

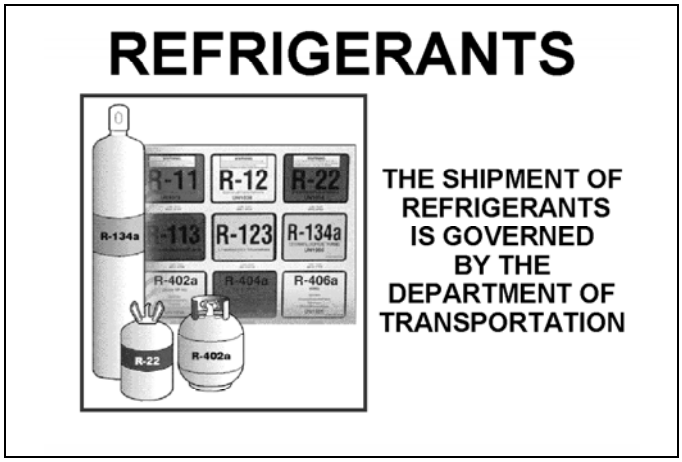
Turn the unit power ON. Then turn the unit power OFF. Use the capacitor discharge tool to again discharge any capacitors in the system. Then reconnect the two interchanged wires to their original connection points, again checking the wiring diagram.



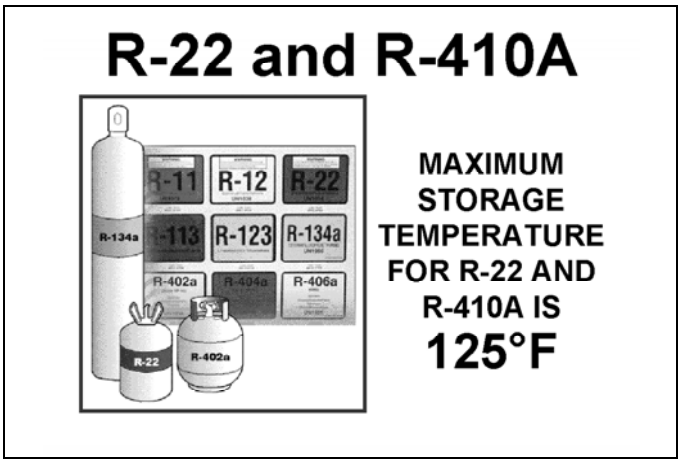
63. A spring-type bender of the proper size should be used over soft copper tubing to prevent kinking or flattening the tube. Kinks restrict the flow of refrigerant.

A mechanical bender is used for larger-diameter tubing and when a more accurate bend is required. These benders normally have a clip to hold the tubing while bending and a calibrated degree scale and can be used to get smooth bends up to 180°.

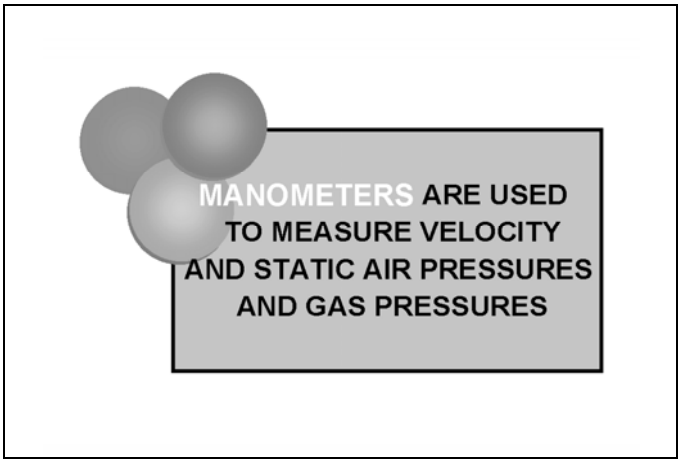
64. Unlike alloys such as copper-phosphorus, silver-bearing alloys DO NOT contain flux; and, therefore, require the use of flux to help keep surfaces clean, to prevent re-oxidation from the heat and to help the melted alloy to flow.



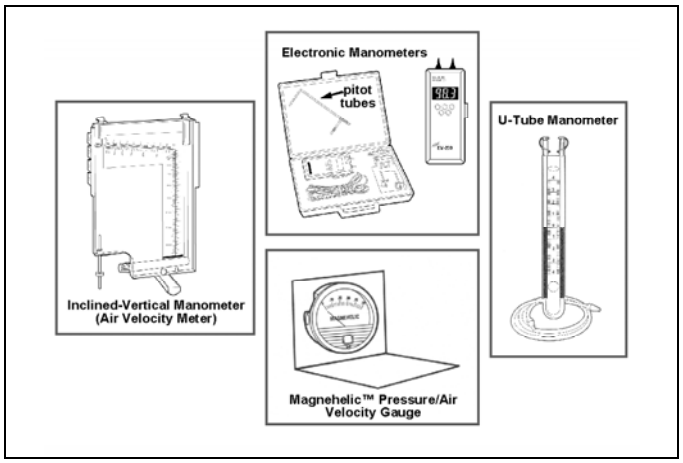
65. Any time you ship or transport refrigerants, you must abide by the laws set forth by the **Department of Transportation** (DOT).



66. The maximum storage temperature for cylinders of either R-22 or R-410A refrigerant is **125ºF**.

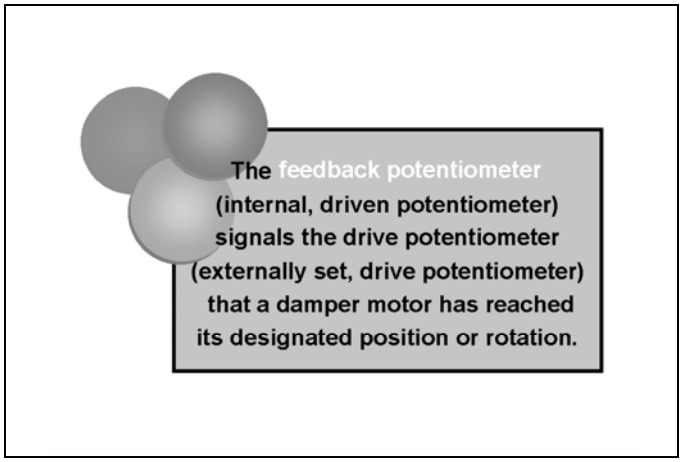


67. **Manometers** are used to measure positive, negative and differential air and gas pressures. They are calibrated in inches of water column (in. w.c.)



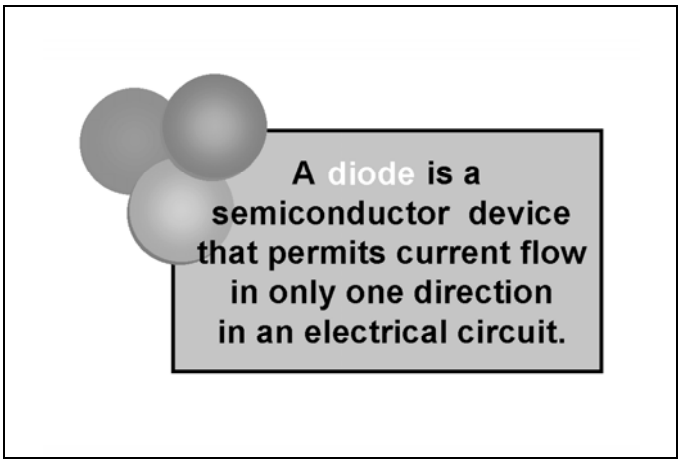
68. There are several types of manometers, including U-tube, inclined vertical, dial-magnahilic and electronic. The U-tube manometer is most commonly used to measure natural and propane gas lines and manifold pressures.

Pitot tubes are used on certain types of manometers when measuring velocity pressure. They are not needed when measuring static pressure with an inclined manometer.

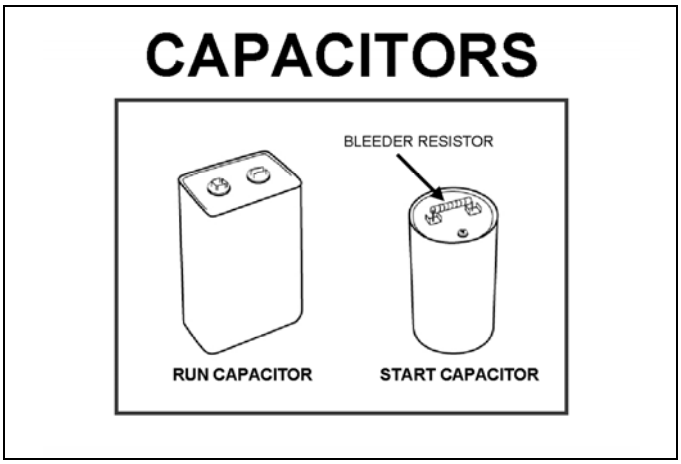


69. A **feedback potentiometer** (variable resistor) is used on a damper motor to allow the current flow to be adjusted, altering the operation of its circuit.

The **drive potentiometer** is the external device that sets the amount that a damper is to open. The feedback potentiometer is an internal, driven device that signals the drive potentiometer that the damper has reached its designated position or rotation.

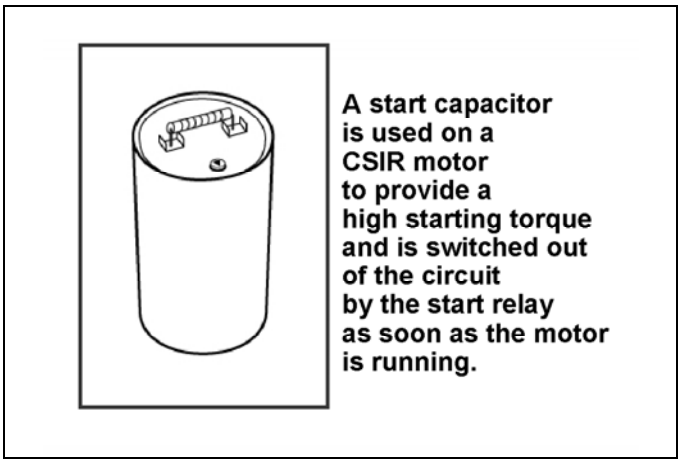


70. A **diode** is a semiconductor device that permits current flow in only one direction in a direct current type of electric circuit. It serves as an electronic check valve. It is used, for example, on a rectifier to convert an AC circuit to a DC circuit.



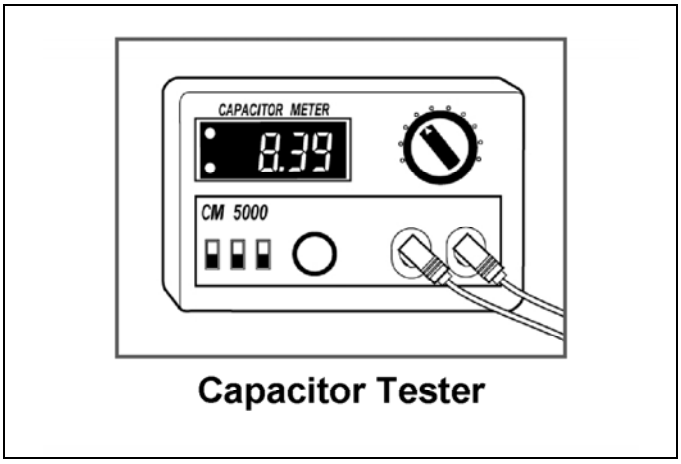
71. A **capacitor** is a device in an electrical circuit that allows electrical energy to be stored up for later use. Capacitance is the amount of charge a capacitor can store and is determined by the physical characteristics of the capacitor. There are two types of capacitors, start capacitors and run capacitors.

CAUTION should always be used when handling capacitors because they may be holding a charge.



72. A **start capacitor**, which has a higher microfarad rating, is used to increase a unit's torque or starting capability. It does not stay in the circuit for a long period of time.

The **run capacitor** will usually have a smaller microfarad rating and will stay in the circuit for the entire time, thus increasing a unit's running efficiency.



73. Capacitors are checked using a capacitor tester or capacitor analyzer.

If an analyzer is not available, a quick check may be done using an ohmmeter but care must be taken to first discharge the capacitor properly, using a resistor. **NEVER** use a screwdriver to discharge a capacitor because an explosion could occur.

CAPACITOR
MEASUREMENT PROCEDURES

USED TO TEST CAPACITORS USED WITH OR WITHOUT MOTORS

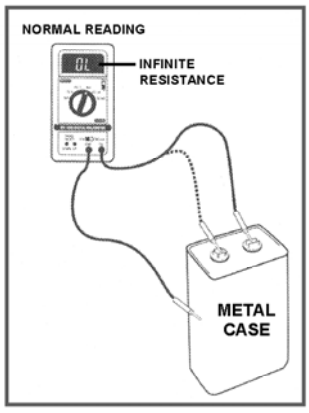
1. Turn off all power to unit. Discharge capacitor and any other high-voltage circuit capacitors in the unit, using a capacitor discharge tool (resistor).
2. Locate and disconnect wires from capacitor to isolate it from rest of circuit. (Refer to wiring diagram.) Inspect capacitor for signs of damage, like bulging or leaking.
3. Set up VOM/DMM to measure resistance on the R x 100 or R x 10,000 ohm scale across the capacitor terminals.

74. To test a capacitor, first turn all power to the unit OFF. Discharge the capacitor and any high voltage circuit capacitors in the unit using a *capacitor discharge tool* (not a screwdriver).

Using the wiring diagram, locate and disconnect the wires from the capacitor to isolate it from the rest of the circuit. Inspect the capacitor for signs of damage such as bulging and leaking.

Set up the VOM/DMM to measure resistance on the R × 1,000 or R × 10,000 ohm scale. Connect the VOM/DMM across the capacitor terminals and measure the resistance. If the capacitor is good, the needle will swing toward zero and slowly move towards infinity. If it is shorted, the needle will not move.

CHECKING FOR A GROUNDED CAPACITOR



75. If testing a capacitor enclosed in a metal case, check for a grounded capacitor. After setting the VOM/DMM to measure resistance on the R × 1,000 and R × 10,000 scales, connect the VOM/DMM between each one of the capacitor terminals and the metal case and measure the resistance. Again, this ohmmeter test will only indicate whether the capacitor has capacitance, not what the capacitance is.

To measure the capacitor's exact capacitance MFD value, test the capacitor using a capacitor tester, following the tester manufacturer's instructions.

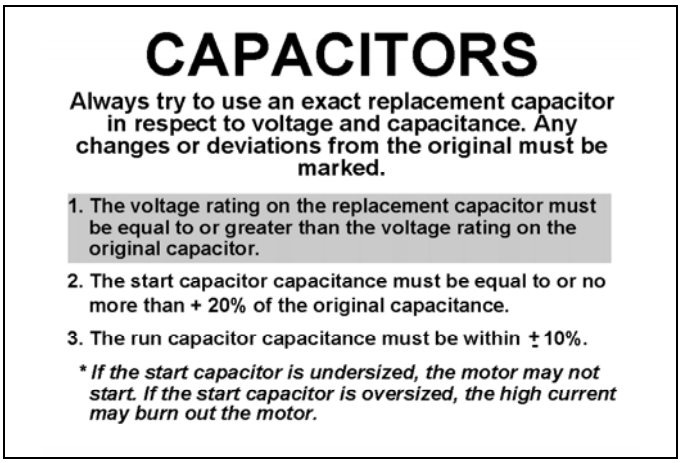
CAPACITORS

To remove a capacitor from a CSIR motor:

- **Check for a visual indication of capacitor failure.**
- **Test capacitors with a DMM that has a microfarad function or a capacitor analyzer.**
- **Always replace a defective capacitor with one specified by the manufacturer.**

76. Depending on the type of capacitor, a bad capacitor can adversely affect the wattage, amperage draw, torque, speed, efficiency and power factor of a motor and therefore need to be replaced.

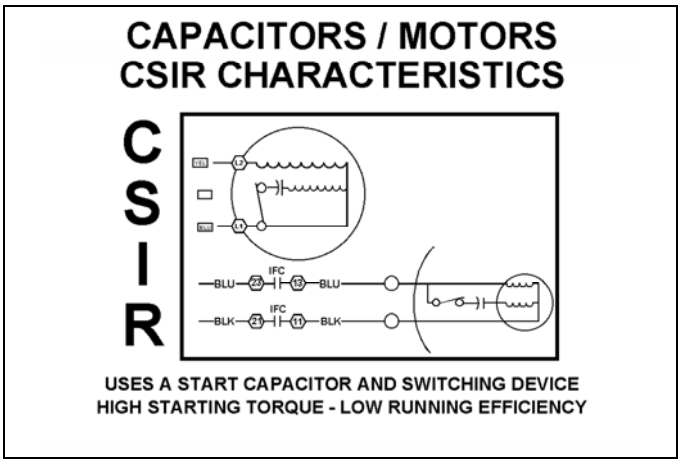
Properly discharge the capacitor and visually inspect and test the electrical condition. If these steps indicate that replacement is required, remove the capacitor from the CSIR motor and replace it one *specified by the manufacturer.*



77. Always try to use a replacement capacitor with the same exact voltage and capacitance as the original.

If they do not match exactly, any variations from the original must be marked. The voltage rating on the replacement must be equal to or greater than the voltage rating of the original. Start capacitor capacitance must be equal to or no more than 20% of the original and a run capacitor capacitance must be within plus or minus 10% of the original.

Undersizing a start capacitor may prevent a motor from running while oversizing could cause the high current to burn out the motor.



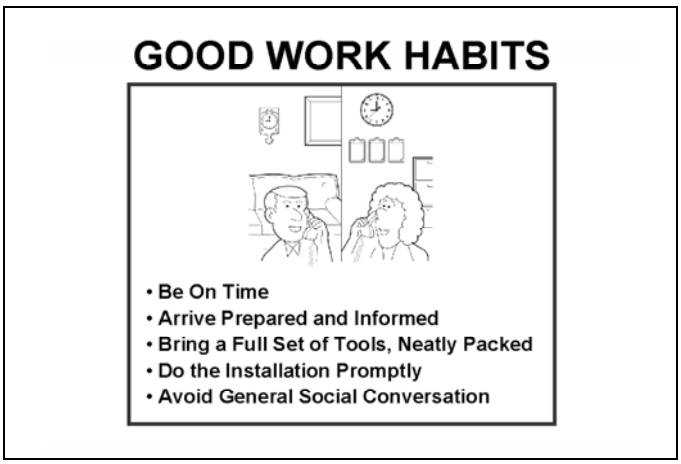
78. This diagram shows how a CSIR motor uses a start capacitor and switching device to give it high starting torque but low running efficiency. CSIR motors may be found in circulating pumps.

79. Customers' first and lasting impressions of the service repairperson are based on many factors. Appearance, work habits and the way he or she talks to and treats the customer go a long way towards having a successful, profitable and continuing good relationship.

80. Customers form a critical first impression from your appearance. Are you rested and alert? Do you practice good personal hygiene and are your uniform and shoes neat and clean? Do you identify yourself promptly with proper ID and do you smile and display confidence and polite respect for the customer?

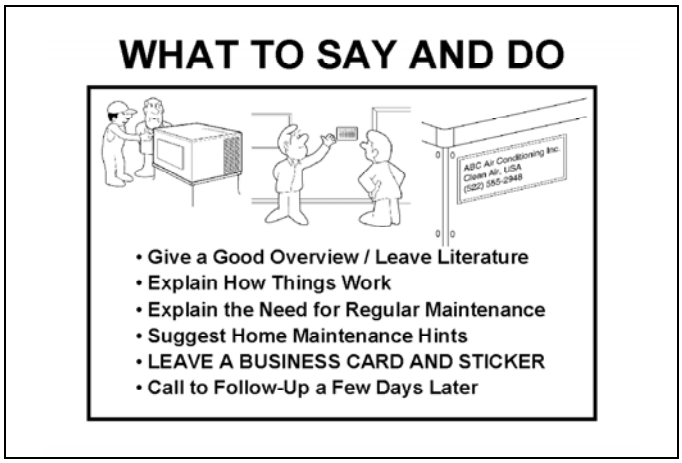
Additionally, your vehicle is a traveling "billboard" for your business. How it looks and how you drive it on the road makes an impression.

81. Treat your customers with respect with regards to their home. Do not smoke on the job. Be careful to avoid tracking dirt into their house. Use drop cloths to protect floors and carpets and carry rags to clean up after yourself. Dispose of any trash. Protect the work area and return the home to its original condition upon completion of the job.



82. As a professional, be sure to arrive on time, since a member of the household may have taken time off from their own work to be there when you arrive. Call in a reasonable amount of time if it looks like you may be running late.

Be sure to arrive on the job well prepared, with a full set of proper tools, neatly packed. Being prepared by reading the product operating and service instructions before arriving on the job will also show your professionalism and help you do a better job. Avoid general social conversation and tackle the job promptly. Finally, neatly repack your tools when you are finished. It helps leave a good, last impression.



83. Think of good communications with your customer as essential to understanding his or her needs. The customer can often lead you in the right direction to the problem. After doing the job, ask the customer if they have any questions and explain what you have done, how things work and how to use the product.

Be observant and suggest simple hints on how they can maintain their system. Offer optional system parts to make routine maintenance easier and emphasize the need for regular professional maintenance to prolong the life of the system.

Return the product literature packet to the customer, being sure they know how a system runs and how to adjust parts of the system, like the thermostat. Leave a business card and check back with the customer in a few days to be sure things are running smoothly and to check if they have any other questions.

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