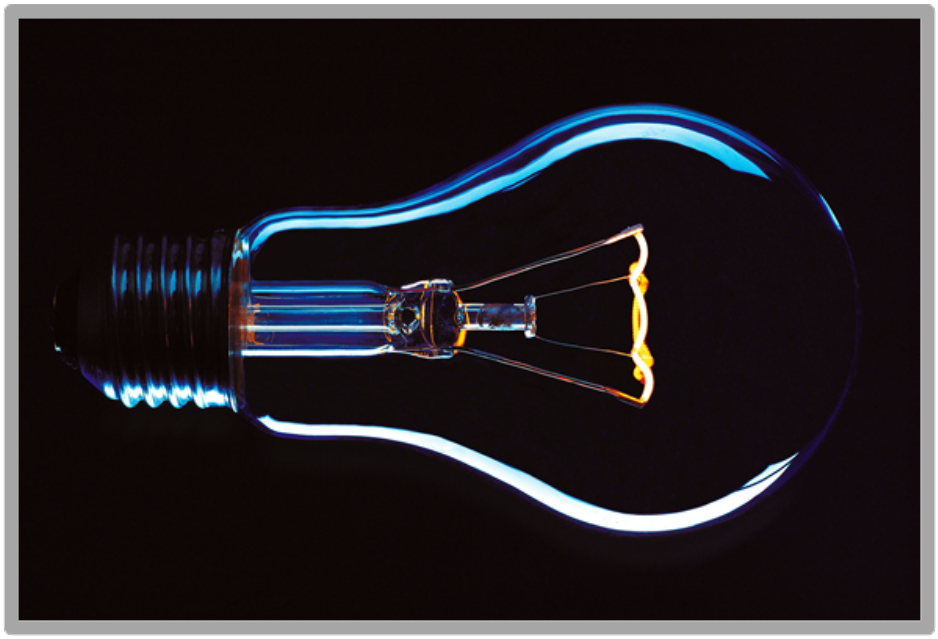
FireWise CONSULTING LEARNING ACADEMY

Fire Inspector I & II

CHAPTER ELEVEN
ELECTRICAL AND HVAC HAZARDS

Part 1



Slide 1	Welcome to Chapter 11, Electrical and HVAC Hazards. This Chapter has been divided into two parts. In Part One we will discuss: • An overview of electrical energy and electrical systems • Some information about basic electricity • The components of an electrical system • Potential electrical hazards and common problems • Electrical systems protection devices including fuses, circuit breakers
Slide 2	A basic understanding electrical theory requires knowledge of four concepts: potential energy or voltage, electron flow or current, opposition to current flow or resistance and rate of work being done or energy released, Power.
Slide 3	Let's begin with voltage.
Slide 4	In order to explain what potential energy or voltage is, it is important to consider: the nature of charged particles and the structure of matter.
Slide 5	Charged partials behave according to the law of attraction or electrical attraction which states opposite charges attract…
Slide 6	And like charges repel.
Slide 7	All matter can be broken down to the atomic scale. The atom is made up of a nucleus that contains positively charged protons and neutrons which have no charge with negatively charged electrons that orbit the nucleus.
Slide 8	The outer most orbit is called the valence orbit. The electrons in this orbit are referred to as valence electrons. There are up to eight valance electrons on any given atom. If an atom that gives up an electron it becomes more positively charged.
Slide 9	It is possible for materials to have surplus electrons that is electrons that are free to move around. Since electrons are negatively charged, the material is considered to have a net negative charge as seen on the left. On the right is material that is deficient in electrons and will accept them. This makes this material more positive with respect to the net negative material. Due to the force of attraction between negative and positive there is a force or pressure called electromotive force (EMF) that is present. This is described as potential difference and is measured in Volts. Shown here is a voltmeter indicating the potential difference between the two materials as 6 Volts. (Represented mathematically as V or E.)
Slide 10	There are many ways of producing a potential difference or voltage. Common methods include the battery which achieves a potential difference using chemicals.
Slide 11	Electromagnetic induction through which a potential difference is produced by passing a conductor through a magnetic field.

Slide 12	And static builds up, this can occur in many ways, but friction is usually involved. When two materials are rubbed together electrons can be stripped from one object and transferred to the other creating a potential difference. Static builds up can occur just by wind blowing over a flagpole or liquid being transferred between containers.
Slide 13	Machines that convert mechanical energy to electrical energy magnetically are called generators or alternators.
Slide 14	Under the right circumstances an electron can be passed from the valance orbit of one atom to the valance orbit of another.
Slide 15	Materials made up of atoms that easily allow for electrons transfer from on atom to the next are referred to as conductors or wires. Common conductors for use in the electrical trade include copper and aluminum.
Slide 16	If a conductor is connected across a potential difference electron will flow along the conductor from negative to positive. This flow of electrons is referred to as current flow.
Slide 17	Current flow is expressed in amperes or amps and is proportional to the number of electrons flowing through the conductor. The value of ampacity this conductor carries is indicated on the ammeter as one amp.
Slide 18	This means that if the number of electrons flowing along the conductor were to double, the ampacity would also double.
Slide 19	Resistance is the opposition to current flow. All practical conductors possess some resistance. Electrical resistance is related to how easily materials atoms allow for the transfer of electrons. Different conductors have different values of resistance. Copper tends to conduct more easily than aluminum.
Slide 20	A jacket or insulation is usually added to the outside of a conductor to prevent stray or unwanted current flow. Jackets or insulation are made of materials whose atoms that do not allow for the transfer of electrons.
Slide 21	A resistor is a material formed of some atoms that easily allow for the transfer of electrons and some atoms that do not. The result is a material that limits electrical current flow.
Slide 22	Electrical power equals the ability to do work. As current flows through a resistor collision between free and fixed electrons release energy often in the form of heat, light, or mechanical motion. This release of energy is called power and is expressed in watts.
Slide 23	Let's review, Potential Difference is the force or push behind electron flow, measured in volts. Current or electron flow is the movement of electrons along a conductor, measured in amps. Resistance is the opposition to current flow, measured in ohms. Power is the energy released often as heat, light, or mechanical motion.

Slide 24	A common analogy that compares the basic components of an electrical system to a closed hydraulic system. In this comparison a pump would be the equivalent of a generator, the voltage would be represented by the hydraulic system pressure, electrons would be akin to the water or liquid in the system and current flow would equate to the movement of the water. Friction in the hydraulic system would represent electrical resistance and the size of a pipe or hose would be similar to conductor size.
Slide 25	Electricity is provided to a building via service conductors connected to the utility supply. Electricity passes through the electrical meter to the panel or breaker box and terminate to the main overcurrent device. The main overcurrent device is a fuse or circuit breaker. Electricity is distributed by the breaker box to the internal wiring of the building via additional overcurrent devices. The system ground and bonding conductors bring all non-current carrying metal parts and ground to the same potential to reduce shock hazard and provide a path for current flow in the event of these parts become energized facilitating the operation of over current devices. And finally, the grounding electrode connects the system grounding conductor to earth.
Slide 26	A basic electrical circuit consists of a voltage source, conductors, or wires to enable current flow, a load to do work such as a light bulb, and a means of control such as a switch.
Slide 27	When the switch is open no current flow is present in the circuit as indicated by the ammeter as 0 amps, so the bulb is off.
Slide 28	If the switch is closed current will flow through the circuit. The value of which is limited only by the resistance of the bulb and is indicated on the ammeter as 4 amps.
Slide 29	Current will follow the path of least resistance, if a path of low resistance was introduced around the resistance of this light bulb, current would spike. Current flow would only be limited by the small amount of resistance offered by the conductors and the source itself, let's say it limited to 1000A. If over current devices weren't present or failed to operate the conductors could get so hot that they melt. This condition is known as a short circuit.
Slide 30	Another cause of a conductor carrying too much current is an overload situation. This occurs when too many loads or a load that draws too much ampacity is connected to a circuit. When higher than rated current flows through a circuit, heating of the branch circuit feeder conductors or the branch circuit conductors occurs.
Slide 31	Assuming each load draws 4 amps observe the change in ampacity on each conductor as load is added to the circuit.

Slide 32	With each additional load the ampacity carried by the conductors increases, this causes the conductors to heat up.
Slide 33	As the load on the branch circuit continues to increase so does the heat generated by the conductors.
Slide 34	As the current flowing approaches, the rating of the circuit conductors significant heat is produced.
Slide 35	When too much load is added the conductors will overheat. If this condition is allowed to persist the conductors can produce enough heat to damage the conductor's insulation or subject any material surrounding the conductor to excessive heat.
Slide 36	Another typical overload scenario is the when too many loads are plugged in at one outlet, this can prove to be significantly dangerous. This is a common problem during the holidays when outlets and extension cords can be overexerted to supply decorations and lighting displays. Over loading of a conductor can also result from conductor damage. Conductors can be damaged before, during or after installation.
Slide 37	One of the factors in a conductor's ability to carry current is its cross-sectional area. When damage reduces the cross-sectional area the conductor, its ability to carry current is compromised at the point of damage, resulting in a localized hot spot.
Slide 38	Another common source of heat in an electrical system is an arc. Series electrical arcs are produced when there is a small gap in a wire or at a termination. An arc is produced by electrons jumping the gap. Parallel arcs occur between an electrified and a grounded surface or between two conductors. Arc's produce high temperatures and can disperse molten metal from the conductor igniting flammable material nearby. Some electrical equipment produces arcing under normal operation such as switches, contacts, and motors that possess brushes, arcing can increase to dangerous levels as a result of equipment wear. Arc producing equipment must be contained when installed in ignitable atmospheres.
Slide 39	Overcurrent devices such as fuses, and circuit breakers are installed to limit the amount of current drawn by a circuit or system. Fuses and circuit breakers come in many ampacity ratings and automatically open the circuit and disconnect it from the source of supply when current ampacity exceeds the rating.
Slide 40	Fuses have an internal element or fuse link that melts open to disconnect the circuit when excessive current is flowing. The speed at which they trip is proportional to the current flow through the fuse element, therefor the higher the current the faster the response time.

	Fuses come in a variety of designs, the most common are the plug fuse and cartridge fuse. Both types come in a time delay or quick acting variety. A time delay fuse is used for devices such as motors that draw higher than normal current for a short period of time upon start up. Most fuses are one time use; however, some cartridge fuses are renewable. That is to say the fuse element can be replaced. Selection and servicing of renewable fuse links should always be done by a qualified individual such as an electrician.
Slide 41	Circuit breakers use various technologies to trip a latch which opens the circuit. For this reason, they are resettable, however each time a breaker operates automatically due to a high current event the attributes of the circuit breaker may change, field testing of circuit breakers is not possible and if the integrity of the circuit breaker is suspect it should be replaced by a qualified electrician. Basic circuit breakers provide overload, and over current protection. An overload is a moderate increase in current sustained over a period of time and a overcurrent is a rapid and large increases in current, as an example a short circuit would be an overcurrent event.
Slide 42	AFCI's or arc fault circuit interrupters use electronic circuitry to detect the signature of an arc fault. Upon detection the circuit breakers latch would then be tripped opening the circuit. AFCI's also provide overload and overcurrent protection. AFCI receptacles are also available but will only detect arc faults and disconnect circuitry downstream from the receptacle.
Slide 43	GFCI's or ground fault circuit interrupters use electronic circuitry to detect unwanted current flow outside of the normal path, usually to ground. Upon detection the circuit breaker would then be tripped, opening the circuit. GFCI's also provide overload and overcurrent protection. GFCI receptacles are also available but will only detect ground faults and disconnect circuitry downstream from the receptacle. Primarily GFCI's are used to protect life and are generally installed in wet or damp locations, such as in bathrooms and kitchens near sinks and outdoors on receptacles or heat trace/tape installations that prevent freezing of pipes and drains. GFCI's also come as equipment ground fault protective devices (EGFPD's) the main difference is the amount of current deviation is required to trip the device. EGFPD's are generally used for commercial or industrial applications of heat trace/tape or de-icing and snow melting.
Slide 44	In this Part we discussed: • Basics of electricity

	• The law of electrical attraction states that opposites attract and like charges repel • A charge of static electricity usually involves friction • Machines that convert mechanical energy to electrical energy magnetically are called generators or alternators • Voltage is the force behind the flow of electrons • Current is the flow of electrons and is expressed in amps • Resistance is the opposite to current flow and is a source of heat • Power is the release of energy measured in Watts
Slide 45	We discussed: • How electricity is provided to a building through service conductors through the meter base and on to the main panel • Components & operation of an electrical circuit • Short circuits and overloads can result in excessive heating • Some electrical equipment produces arcing under normal operation • Damaged conductors can result in a localized hot spot • And we finished this part with a discussion on over current devices like fuses, circuit breakers, and ground fault circuit interrupters
Slide 46	Please move on to part 2.