Fire Inspector I

CHAPTER ELEVEN

ELECTRICAL & HVAC HAZARDS

Part 2

Slide 1	Welcome to Part 2 of Electrical and HVAC Hazards. In Part two we will discuss: • Grounding • Generators • Alternative Energy Supplies • Transformers • Identifying electrical hazards during an inspection • Electrical boxes and panels • Cables, conduits, and raceways, • Checking the condition for electrical equipment and the maintenance of installations • Hazardous locations and other environmental conditions such as corrosive chemicals • HVAC systems
Slide 2	The service grounding conductor connects to the system grounding electrode buried in the earth at one end and to the neutral via a bus bar at the other. This serves to stabilize system voltages and limit shock hazards, while providing a path for stray current. Grounding conductors are often bare conductors but can also be jacketed, if so, the jacket should be green.
Slide 3	The grounding electrode is the electrical systems connection to earth. It is often a long metal rod called a ground rod or a metal plate called a ground plate that is driven or buried in the earth. It used to be common to see metallic water service pipe used as a ground electrode, however it is now more common for plastic water piping to be used to service a building so this is no longer practical. If a metal water pipe is used the buried portion of the pipe must be at least 10ft or 3m long and supplemented by additional ground electrode. Other types of electrodes include concreate encased electrodes in the footing of the building and ground grids or rings. Fire sprinkler system piping is prohibited by NFPA13 and 24 for use as a buildings electrical grounding electrode, however this prohibition does not relieve the NFPA70 or electrical code requirements. As well the sprinkler system must be bonded to ground to prevent it from becoming energized which could result in a shock or fire hazard. In fact, all non-current carrying metal parts of a building must be bonded to ground such as gas and water lines, metal support structures and even metallic jackets of electrical cables.

	System grounding also reduces the intensity of voltage spikes due to events like lightning strikes, line surges, and accidental contact with higher voltage lines.
Slide 4	When the neutral is connected to earth or ground at the service. The neutral is brought to the same potential as earth eliminating the shock hazard between neutral and ground.
Slide 5	This also reduces the magnitude of shock a person would receive if they were to touch either of the two-line conductors. With the neutral grounded the person would only receive a 120V shock. If there was no ground connection and someone was touching line 1, a 240V shock would be realized if a connection between line 2 and earth was accidently made.
Slide 6	All noncurrent carrying metal parts of the electrical system is then bonded or electrically connected to the service grounding conductor. This reduces shock hazard by bringing ground and the device box to the same potential and provides a return path for current in the event that a live conductor comes in contact with the metal parts of a device that are not intended to become energized. Without a return path a potential shock hazard would exist and no corrective action like the tripping of a fuse or circuit breaker will take place. However, with a bonding conductor in place a low resistance path is created and in the event of a ground fault current will rapidly rise and cause the fuse or circuit breaker to activate.
Slide 7	Cord connected electrical apparatus such as refrigerators, washing machines and dryers come equipped with an additional prong on the plug that when connected bonds the frame of the apparatus the to the electrical systems bonding conductor. If a live wire within the connected devices were to come in contact with the frame high current would flow through the bonding path. Strictly speaking bonding and grounding are specific aspects of an electrical system however the terms are commonly interchanged, for example the bond on a cord end or plug is often referred to as a ground. Bonding is simply the act of mechanically connecting two or more conductive materials together to establish a conductive path between them. It is possible to “bond” components together without ever grounding them.
Slide 8	A generator or alternator is a device that converts mechanical energy into electrical energy. They require a mechanical input, such as wind, water, or a combustion engine to produce rotational force. Many of today’s occupancies have emergency backup generators to supply back up power in the event of a power outage. Historically generators were mainly employed by commercial or industrial users but now are becoming more

	popular residential markets, particularly rural and remote areas or areas that are prone to outages.
Slide 9	Most backup generators utilize combustion engines. Fuel types vary by installation and include gasoline, deasil, liquefied petroleum products, or natural gas from the utility supply. You as the inspector a required to inspect storage tanks for spill protection, ventilation requirements, and fixed fire protection if the volume of liquids exceeds the limits of the local fire code.
Slide 10	Connection between the utility supply and emergency generators must be made via a transfer switch. This ensures that the electrical systems circuits cannot be connected to the utility supply and the generator supply at the same time. Transfer switches are often automatic and involve detection systems to sense the loss and return of the utility supply and switch the load between the supplies accordingly. This prevents back feed to the utility supply. If the generator was directly connected to the utility supply the generator could electrify the grid and put repair crews and linemen at risk of shock unexpectedly.
Slide 11	Alternative supplies such as wind generators and solar panels are growing in popularity and are mainly used in residential and commercial applications. Solar and wind supplies can be “stand alone” with no connection to the utility supply, or” grid tied” systems which are electrically connected to the grid.
Slide 12	Standalone installations usually possess storage capabilities in the form of batteries. Many batteries produce hydrogen gas when charging or discharging, therefore proper ventilation must be provided as laid out in the national electrical and building codes. Another hazard of batteries is no means by which the disconnect the source of supply from the battery terminals and special care must be taken to protect wiring and associated equipment up to the first point of disconnect and overcurrent protection.
Slide 13	Grid tie installations may or may not possess storage capabilities and are required to utilize a transfer switch to avoid back feed.
Slide 14	Solar installations are similar to batteries and have a constant output when exposed to light and extra caution must be taken up to the first point of disconnect and overcurrent protection. Do not assume a solar panel to be electrically dead even if damaged unless it has been effectively shielded from light by a opaque covering.
Slide 15	A transformer is an electromagnetic device that utilizes magnetic fields to transfer energy from one electrical circuit to another without a direct connection. Transformers can step voltages up or down; voltages are

	stepped up at the power plant for transmission in order to minimize losses and then are stepped back down to levels safe for use at the consumers facility. Some commercial and many industrial consumers have transformers in their electrical systems as they will have loads that operate at different voltages.
Slide 16	Transformers tend to be of the dry or fluid or liquid filled type. This referrers to their cooling method. Dry type transformers are commonly found in lower current installations such as a commercial establishment, while liquid filled transformers lend themselves to high current applications. The cooling method, dry or liquid filled, should be present on the name plate of the transformer.
Slide 17	Typically, dry type transformers do not require a separate room or vault but must be separated from combustible materials and require adequate ventilation as required by the electrical code. Examples of dry type transformers range from small doorbell transformers to large service entrance transformers.
Slide 18	Liquid filled transformers utilize a variety of different fluids as there cooling medium, from older mineral oils and polychlorobiphenyl (PCB) fluid to more modern less flammable or non-flammable fluids. PBC's are being phases out of electrical equipment due to environmental and health concerns as PCB's are classified as a carcinogen, however they may still be found in older installations. PBC filled transformers as required to be prominently marked.
Slide 19	When installed outdoors, transformers should be arranged so that leakage of fluid will drain away from structures and prevented from entering environmentally sensitive areas. Transformers should be isolated by distance and or a grounded fence as required by electrical codes. Transformers installed near buildings shall be positioned away from doors or windows as to not expose them to fire in the event of a transformer failure. Transformers installed close to one another or close to buildings may require a purpose-built barricade to provide protection.
Slide 20	Liquid filled transformers when installed indoors are required to be curbed or installed in a depression that is capable of containing the fluid content of the transformer and any fire protection water discharge. As well these transformers are usually required to be contained in an electrical vault with a 3-hour fire rating and associated opening protection. As such it is important for you as an inspector to note the type and quantity of fluid the transformer utilizes. Modern fluids my reduce or eliminate the need for a vault. When installed outdoors, liquid filled transformers should be arranged so that leakage of fluid will drain away from structures and environmentally sensitive areas.

Slide 21	It should be noted that transformers produce significant heat when under heavy load and could become hot to the touch. Maintaining unobstructed ventilation is paramount. Materials shall not be stored on top of transformers or in the ventilation pathways. Minimum clearances can be found on the transformers name plate.
Slide 22	When you as the inspector are identifying electrical hazards there are many things to consider such as: • The quality of workmanship displayed in the installation • Damage to cables and conductors • Inappropriate use of extension cords • Integrity of the bonding pathways • Condition of electrical equipment • Maintenance of the electrical installation • Environmental conditions and hazardous location installations • Ambient temperature
Slide 23	The quality of workmanship displayed in the installation can be an indicator that closer inspection may be needed. Professional electricians pride themselves on their quality of workmanship, clean and neat installations are a good sign, however poor-quality installations often indicate unlicensed or unsafe work. Loose terminations at devices and overcurrent protection terminations will generate heat and can lead to ignition given the right circumstances. Equipment covers such as panel covers, junction box covers and device plates should be intact and securely in place, as covers along with the box or panel serve to contain arcs and sparks or explosion in the event of an electrical fault. Missing damages covers should be immediately replaced.
Slide 24	Electrical boxes and panels have pre punched holes for entry of cables and conduits, the pre-punched holes or knockouts are capable of being opened by removing material from the knockouts. Unused open knockout must be sealed using an approved device known as a knockout filler.
Slide 25	Electrical panels use a similar system to provide for cover of unused breaker spaces. If a breaker is removed the opening in the panel cover must be filled using a panel filler.
Slide 26	Damage to conductors reduces their cross-sectional area and there for their current carrying capability. If a conductor is damaged a hot spot can be developed and could become a source of ignition. Conductor insulation damage increases the likely hood of shock and could lead to short circuits, ground faults and electrical arcing.
Slide 27	Extension cords are designed to be used for temporary wiring of portable equipment not as a permeant supply path for loads. Extension cords can become overheated when concealed or surrounded by building or other materials. Extension cords are commonly designed with undersized

	conductors as they are not meant to feed multiple devices as opposed to proper electrical circuit conductors, overloading is a common problem when extension cords are utilized. Another common abuse of extension cords is running them through doors or windows which can result in damage to the cords conductors or insulation. Extension cords in disrepair or used in a inappropriate fashion should be disconnected and or removed from service.
Slide 28	The wiring methods in an electrical system often include cables, conduits, and raceways. Cables are assembling of individually insulated conductors packaged in an outer jacket. They come in many forms and sizes dependant on use and environmental conditions. They run between junction boxes and equipment to distribute power and feed individual loads. Conduits and raceways provide mechanical protection for the conductors and cables installed in them and come in many forms.
Slide 29	Cables, conduits, and raceways should be supported through out each run with approved straps and hangers. Cable insulation and armour shall be intact throughout all runs and conduit or raceway systems shall be continuous whit all connections done up tight as to protect the wiring from physical hazards such as abrasion or environmental conditions. Damage or poor installation of conduits raceways, and cables should be noted and remedied by a qualified electrician.
Slide 30	In building's electrical system bonding comes in many forms such as wires contained in cables, metallic conduits, and metal armor cables. When inspecting an electrical system, it should be noted that all metallic components need to have a secure mechanical and electrical connections. All couplings and connectors should be done up tight and any bonding wire connections shall be secure.
Slide 31	The condition for electrical equipment should also be monitored during an inspection. Electrical switch's contain contacts operated by a lever if the contacts become damaged due to ware or contaminated and will not close properly excessive heat and arcing can occur. Switches should be cool to the touch when in use, operation should be smooth and the body fully intact. Receptacles have contact points that allow for connection the external portable devices. Similar to switches wear and contamination can create hazards. Look for signs of excessive heating such as physical temperature or discolouration and ensure the device body or surrounding covers are not broken or loose. Any electrical equipment found in disrepair should be noted and disconnected or repaired by a qualified electrician.

Slide 32	GFCI's and AFCI's should be capable of being tested and reset. Failure to trip when tested or failure to reset indicates a problem with the equipment or circuity protected by the device. If you encounter one of these situations a qualified electrician is required to investigate the cause and make necessary repairs.
Slide 33	Electrical installations require periodic maintenance. This often includes testing of safety devices such as GFCI's, ensuring integrity of connections, checking the security of devices and cover plates, and regularly clearing built up dust and debris from electrical equipment surfaces and ventilation pathways. Dirty equipment reduces the ability to dissipate heat and contaminate contacts and moving parts, leading to heat buildup or malfunction of devices causing arcs and sparks. Many petroleum products and oils can be corrosive to electrical conductor insulation and should be stored away from conductor insulation.
Slide 34	Lighting equipment also requires maintenance. Lighting fixtures should be approved for their installation location, for example fixtures installed outdoors or in wet locations should be of the weatherproof or wet location type, while fixtures mounted on a celling should be celling mount rated. Fixtures with broken shades, excessive buildup of debris on the lens or that has become loose due to vibration or in need of repair. Overtime lighting sockets for attachment of bulbs can become worn creating loose connections that could be a source of heat or arcs. Discolouration of fixtures and lenses is often associated with improper bulb selection. Using bulbs that are rated greater than the fixtures intended designed results in excessive heat buildup can cause damage to the connected conductors' insulation and subject adjacent surfaces to high temperatures. Higher fixture temperature can as result from buildup of dust and debris on the fixture or lens.
Slide 35	Many industrial and some commercial installations contain areas with explosive dust or gas atmospheres. These areas are designated as hazardous locations. Under normal operation electrical equipment such as switches, contactors and motors produce arcs and sparks. In hazardous locations there are stringent equipment and wiring requirements. Safety measures include explosion proof equipment and sealing of electrical conduits and cables to prevent migration of gasses.
Slide 36	The approval of equipment and wiring methods vary by type and degree of hazard. Electrical codes use a class and division system to identify hazards and type of suitable equipment and wiring methods. Newer code requirements have move to a zone system of classification. The class and division or zone a piece of equipment is rated for must be provided on the name plate of installed equipment. Any portable equipment must also be

	rated for the hazardous location. Definitions of classes and divisions can be found in article 500 of the NFPA 70. Static electrical build up and discharge can also be of concern in hazardous locations. Mitigation of static build up is achieved by means of humidification, bonding, grounding, ionization and conductive floors and surfaces or a combination of these methods.
Slide 37	In addition to hazardous locations other environmental conditions such as corrosive chemicals and humidity are of concern. All equipment and wiring must be resistive to and rated for installation in corrosive or humid environments. In this case the electrical room is located in the basement of the building. The fire inspector noted that plastic containers were placed under the electrical panel. On closer examination the containers were full of what appeared to be contaminated water and the electrical panel was heavily corroded near its base. The exposed breaker or switch gear device on the exterior of the panel appeared to be contaminated by moisture also. The inspector recorded the information and discussed it with the building manager who said they had experienced water leaking over the past few months. The inspector reported the condition to the electrical safety agency, who said they would do a follow- up inspection.
Slide 38	Ambient temperature refers to the normal or maximum temperature of the room or area. The current carrying capacity of a conductor is related to the heat produced by the conductor during normal operation, however these ratings are usually based on an maximum ambient temperature of 300C, when installed in an ambient above 300C the current carrying capacity must be reduced or de-rated. Similarly, equipment such as motors and transformers have a maximum temperature that can be installed in and must be de-rated if installed in an ambient temperature that exceeds this rating. Ratings for equipment can be found on the equipment's name plate.
Slide 39	Heating, ventilation and air conditioning or HVAC systems are present in almost all installations in some form. These systems provide for occupant comfort, fresh air supply, and filtering of recycled air. The components of a HVAC system vary dependant on requirements and design and usually include: An air handler comprised of a motor and fan to facilitate movement of air throughout the system or a hydronic system such as circulating pumps and a piped radiator system. An energy converter such as a gas or oil-fired boiler, a gas fired burner, or electrically supplied boilers or elements for producing heat. Chillers, cooling towers and refrigerant compressors may be incorporated for

	cooling. A distribution system such as pipe work and radiators or embedded in floor pipe work for hydronic systems, and ductwork, return air plenums, lovers, dampers, registers, grates, and filters for forced air systems. Lovers and dampers are used to direct air flow through the system as required. A means of introducing fresh air and exhausting used air. Exhaust systems my include dust collection devices or chemical scrubbers to remove hazardous contaminants from exhausted air. As well as a control system including temperature sensors and actuators is required to automate the operation of the HVAC system.
Slide 40	Transmission of fumes, gasses and smoke is a concern when forced air systems are employed. Compartmentation or passive smoke management such as smoke barriers between floors or walls can be compromised by a HVAC system, for this reason HVAC systems and fire alarm systems are often integrated as to allow for shut down of air handlers and provide for closure of lovers and dampers in the event of a fire. Fire alarm components such as smoke detectors installed inside duct work commonly called duct detectors, and relays or contactors operated by the fire alarm are employed to detect smoke, activate dampers, and shut down air handlers in the event of a fire.
Slide 41	The fire alarm system may also utilize relays and contactors to start up exhaust fans for evacuating smoke or depressurizing areas that contain smoke to prevent transmission to other areas. Stairwells, elevator shafts and evacuation routes may be pressurized to prevent ingress of smoke, however consideration should be given to the effect of pressure differentials will have on the ability to open doors or other means of egress. HVAC design and integration of the fire alarm system can be very complex, considerations for breathable air for evacuations with minimal effect on fire patterns and best practices for fire protection are the job of an engineer and the technical trades that work with them, consultation with professionals is an essential part of inspecting these systems. Smoke management systems may also include sprinkler suppression to mitigate the amount of smoke and fumes created.
Slide 42	The commissioning of HVAC system will involve testing of all components integral to the system. Initial verification of a fire alarm system is required to be completed before occupancy is approved and additional testing is required yearly or in the event of addition or renovation of the system. Part of this testing will include proper operation of all integrated components of the HVAC and fire alarm system.
Slide 43	During building inspections, you should take note of obstructed clearances around boilers and energy conversion devices and ventilation pathways. Non- essential storage of materials in boiler rooms and chiller plants is a

	hazard and should be removed. Adequate supply of combustion air is required to minimize buildup of combustible products and prevent overheating of combustion chambers. Inefficient burning of combustible products due to low air flow can result in buildup of soot and other combustible products inside the unit or chimney flue. Observation of restricted combustion air pathways or tampering of the safety controls or equipment should result in discontinued use of the equipment until proper maintenance or repair of the unit is completed by a professional. Clearances from combustible products must be maintained from all heat producing components of HVAC system. Any deterioration of combustible surfaces due to heat such as discolouration or charring should be noted and rectified. Exhaust pathways such as chimney's and flues should be inspected for cracks and openings as well as build-up of combustible products warrant further investigation by a qualified mechanical or structural inspector.
Slide 44	Modern high efficiency hot water tanks, boilers and furnaces utilize PVC exhaust systems as the temperature of the gasses leavening the device are significantly lower than that of a traditional unit. Manufactures installation instructions and documentation will specify the reduced separation, clearances, an exact requirement of these units.
Slide 45	In this part we discussed: • Grounding electrical devices to prevent electrical shock or damage • Grounding electrodes • Fire sprinkler piping is not to be used for grounding • All current carrying metal parts of a building should be bonded. • The terms bonding and grounding are often used interchangeably • Emergency back-up generators to supply back up power • Connections between the utility supply and emergency generators • Transfer switches
Slide 46	• Alternative energy supplies like wind and solar • Transformers • Liquid filled transformers and PCB's • Leak protection for transformers • Identifying electrical hazards • Storage of combustible materials in electrical rooms • Damaged conductors • Use of extension cords • Conduits, cables, and raceways

	• Switches, plugs, panels, and protective covers • GFCI and AFCI – circuit interrupters • Lighting fixtures • Light bulbs • Hazardous locations and environmental conditions that can cause electrical fires and explosions • Static electricity
Slide 47	We concluded this Part with a discussion on: • HVAC systems • Duct smoke and fire detectors • Smoke control measures both dedicated and non-dedicated • Stair tower ventilation • Commissioning of HVAC system with other fire protection systems • Some things to look for during your inspection