FireWise
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Fire Inspector I

CHAPTER EIGHT

FIRE ALARM AND DETECTION SYSTEMS

Slide 1	Welcome to Chapter 8 Fire Alarm and Detection Systems A fire alarm system is one of the three most important fire and life safety measures in a building along with fire separation and adequate exiting. In this Chapter we will identify when a fire alarm system is required, the types of systems available, the components that make up the fire alarm system and discuss maintenance and testing requirements. Fire alarm systems are evolving like any other technology, and they are becoming very sophisticated. This course is restricted to the basic functions of fire alarm systems, but fire inspectors must realize that today's systems can be very complex so they must rely on system experts to ensure proper operation. At the end of this chapter, we will also discuss Smoke Alarms which are not part of a fire alarm system but are the most common fire detection device used today. The main purpose of a fire alarm system and smoke alarms are to provide early warning of a fire, so the occupants of a building can evacuate safely. The fire alarm system may also be designed to notify the fire department so they can respond in the early stages of the fire.
Slide 2	There are many factors that determine when a fire alarm system is required. These include the type of building and what it is used for, what the total occupant load is, if it has an automatic sprinkler system throughout, what occupancies are in the building, and what the local building code requires. The first step in the installation of a fire alarm systems requires the designer or installer to submit a permit application and a complete set of plans for approval by the AHJ. This is the opportunity for the plan checker to ensure that the system includes the proper types of devices, their location and adequacy. The plan should reflect the location of the fire alarm control panel or FACP, the annunciator panel, initiating and signaling devices and a copy of the manufacturer's specifications should be submitted with the drawings.
Slide 3	The requirements for fire alarm systems may vary from jurisdiction to jurisdiction but in most cases fire alarm systems are required in every building that is equipped with a sprinkler system that has more than 9 sprinkler heads or buildings that have an occupant load greater than 300. An alarm system is also required in buildings with an occupant load of more than 150 above or below the first story. Schools, daycare, and colleges require a system when their occupant load exceeds 40.

	Restaurants and Licensed Beverage Establishments (Pubs) require an alarm system when their occupant loads exceed 150 people. A fire alarm system is also required when sleeping accommodations are provided for more than 10 people. In low hazard and medium hazard industrial occupancy fire alarm systems are require when there is an occupant load over 75 and in high hazard industrial occupancies the required occupant load drops to 25.
Slide 4	A fire alarm system is **not** required in residential buildings like motels where each suite has direct access to an exterior exit facility leading to ground level.
Slide 5	A fire alarm system is not required in an apartment building if no more than 4 suites share a common means of egress, and the building is not more than 3 stories high.
Slide 6	Most fire alarm systems include 4 main sections or elements: • The fire alarm control panel or FACP • The initiating device circuits • A signal device circuit or notification appliance circuit • A remote annunciator panels Additionally, the FACP may include electrical contractors to operate ancillary devices.
Slide 7	The fire alarm control panel is usually located in the electrical room of the building and can best be described as the 'brains' of a fire detection and alarm system. The fire control panel receives signals from initiating devices such as pull stations, heat detectors and smoke detectors. It can also send signals to warn occupants about the fire through audible and visible signaling devices like fire alarm bells and strobe lights. In some cases, the fire alarm system is required to notify the fire department, and control the spread of heat, smoke or fire by activating other fire systems like hold open devices on fire separation doors. The fire alarm control panel also houses the primary and emergency power supply for the system. The building code requires emergency power capable of providing supervisory power for 24 hours and immediately following that period, emergency power under full load for a time specified in the code.
Slide 8	Control panels vary greatly depending on the age of the system and the manufacturer. Older systems may just indicate that an alarm has been initiated where newer alarms will indicate in which zone the alarm activated. Even newer systems may specify the exact location of the initiating device.

	Fire alarms control panels are also used to silence the alarm and reset the system. The FACP should be locked to prevent tampering by the public.
Slide 9	There are two main styles of wiring an initiating circuit. There is Class B and Class A. Class B requires an end of line resistor to enable monitoring of the integrity of the circuit. When operating, the FACP applies a voltage to the initiating circuit and monitors the resulting current in the circuit. Under normal operation a moderate current will flow through the end of line resistor. An end of line resistor will normally be in an electrical box covered with a plate that looks like this.
Slide 10	If a device was to activate, electrical contacts within the device close shorting out the end of line resistor and circuit current would rise, the FACP would sense the ampacity change as an alarm condition. In response it would activate the notification appliances such as bells and strobes.
Slide 11	If a connection or wire were to become open the monitoring current flow through the circuit would be lost and the FACP would respond by signaling a trouble condition. The wiring and connections should be inspected and repaired immediately. Another condition the FACP will signal is a ground fault in the initiating circuit.
Slide 12	The FACP is connected to multiple initiating circuits. Each initiating circuit covers an area or zone of a building. This helps identify the location within a building where an alarm or trouble has been signaled. Typically, each floor or wing of a building will have its own zone. Mechanical and electrical rooms as well as stairways and specialized areas such as elevator shafts and garbage chutes will also be assigned a zone. The layout of a fire alarm system is determined by engineers and fire alarm contractors and the requirements of approval bodies vary by jurisdiction.
Slide 13	The zones in this diagram are identified by numbers. Zones 1 through 4 indicate the floor levels where the device activated. Zone 5 is the Elevator shaft. Zones 6 and 7 cover the cafeteria, 8 and 9 are mechanical and electrical rooms, and 10 and 11 cover the sprinkler system in the underground parkade. Zone 12 is the garbage chute which is probably a sprinkler head and 13 and 14 are smoke detectors in the stair towers.
Slide 14	A smoke alarm is a stand-alone unit that provides detection and auditory signaling capabilities all in one. They are commonly used in dwelling units such as a house or other places where a fire alarm system is not required. If you are following us in the Jones and Bartlett Fire Inspector manual the

	next section deal with residential smoke alarms. As these units are not part of a fire alarm system, we will address them at the end of this chapter rather than here.
Slide 15	Initiating devices are connected to an initiating circuit and include devices that can automatically sense flame, heat, smoke, or the flow of water in a sprinkler system. Manually activated devices such as pull stations are also considered to be initiating devices and are connected to an initiating circuit. Activation of any devices on an initiating circuit will send a signal to the FACP that an alert or alarm condition is present. Initiating devices include pull stations, heat detectors, smoke detectors, flame detectors, and water flow switches and tamper switches of sprinkler systems and we will take a closer look at each of these in the next few slides.
Slide 16	Pull stations are manually operated devices that close a set of electrical contacts when operated. Once pulled, a pull station cannot be reset by simply closing it. Pull stations must be manually reset by means of a key or tool. Older pull stations incorporated a glass pain or rod that that must be broken to activate the device. This prevents accidental activation due to contact or vibration, as well as acting as a physiological deterrent against false alarms. Some newer pull stations require a double action like lift and pull to avoid accidental activation.
Slide 17	Resetting a fire alarm pull station after it has been operated normally requires building personnel or emergency responders to open the station using a key which is often either a hex key or a more traditional key. Opening the station normally causes the handle to go back to its original position allowing the alarm to be reset from the fire alarm control panel after the station has been closed. Some of the older pull stations have a toggle type switch that must be moved before the pull handle can be reset. Responsibility to reset the fire alarm system lies with the building owner or occupant. Most fire departments will not reset the fire alarm or initiating device due to liability concerns. Firefighters by nature want to help people but they must understand the policies and procedures of their fire department when it comes to resetting fire protection systems and devices.
Slide 18	The building code says pull stations must be located near every required exit and every principal entranced to a building. Only one manual station need be provided near a group of doors serving as a principal entrance or as a single exit facility.

	Egress facilities that are provided for convenience that do not include all the features of required exits are not required to have a manual pull station. Often a pull stations will be located on each floor near the doorway to the stairs and at each exit on the ground floor. In the case of horizontal exits a manual pull station should be provided on both sides of the exit on the wall before the door in the direction of exit travel as shown in this drawing.
Slide 19	There are a number of automatic initiating devices that activate and send signals to the fire alarm control panel. These include: • Smoke detectors Heat detectors • Flame detectors • Gas detectors We will look at each of these in the next few slides. Smoke detectors are an initiation device that are similar to but should not be mistaken as smoke alarms. A smoke detector does not contain an auditory signaling device, it only detects products of combustion and must be connected to a FACP. Smoke alarms and smoke detectors work on either of two principals and can be referred to as photoelectric or ionization smoke detectors. Photoelectrical smoke detectors utilize a focused beam of light landing on a photosensitive receiver. When visible products of combustion enter the smoke detector, the beam of light is reflected and scattered diminishing the amount of light striking photosensitive receiver and the device is activated.
Slide 20	Ionization smoke detectors work by ionising the air between 2 electrodes which are positively and negatively charged which creates a small current inside the sampling chamber. Ionization smoke detectors utilize a small amount of radioactive material to release charged particles between two conductive plates. Due to the charged particles, a small number of current flows between the plates. When visible or invisible products of combustion enter the chamber, the charged particles become neutralized, the current flow diminishes, and the device is activated. As you can tell from these photos it is difficult to tell at a glance which operating principle is used in the detector. You will have to check the manufacturers label to tell for sure.

	Smoke detectors can only provide coverage for a specific area and need to be strategically placed throughout a building or room to insure adequate coverage.
Slide 21	Video.
Slide 22	Smoke detectors react much faster to fire than heat detectors, so they are required to be installed in certain locations by local building and fire codes. When residential buildings like hotels, apartments and condominiums are equipped with fire alarm systems, smoke detectors must be installed in public corridors, exit stair shafts, and in the elevator room.
Slide 23	In institutional occupancies like homes for the aged and care facilities smoke detectors are required in each sleeping room and each corridor serving as part of a means of egress. They are also required in each room in a contained use area like a jail and corridors serving those rooms.
Slide 24	In assembly occupancies like churches, community halls, restaurants and licensed beverage establishments smoke detectors are not required as part of the fire alarm system. Usually, these types of buildings are protected by heat detectors. Heat detectors are much cheaper to install.
Slide 25	Smoke detectors seldom fail but can if they accumulate dust on their sensors. The outer case and plastic covers of smoke detectors may be cleaned by using a brush for the dry dust and dirt. Compressed air can also be used to blow dust away from the detector. The detector case can also be cleaned with a cloth dampened with a solution of dish washing liquid, but the interior of the unit must be kept dry. They can also vacuum the exterior of the smoke detector with a vacuum cleaner brush attachment to remove dust. If the smoke detector continues to cause problems, they should have it replaced by a qualified technician.
Slide 26	The most common type of automatic initiating device in a fire alarm system is the heat detector. Heat detectors are used in scenarios where other initiating devices, like smoke detectors, tend to fail. For example, any environment having a high concentration of airborne particles like dust or steam would not benefit from having smoke detectors. In such cases, heat detectors become the preferred choice as they focus on temperature, not smoke to detect fires. Heat detectors have a low cost of installation compared to other detection systems and offer high stability. They can operate under varied environmental conditions and are less prone to false alarms and can be effectively paired with automatic sprinkler systems**.** There are two main types of heat detectors: fixed temperature and rate of rise detectors.

	Fixed temperature heat detectors are designed to activate upon reaching a specific temperature. While multiple temperature selections are available for different environments a typical setting for a low hazard space such as an office would be 1350F/570C.
Slide 27	Rate of rise heat detectors sense a change in temperature over time. A temperature increases at the sensor of 15F (9C) or more per minute activates the rate-of-rise feature. This closes the contacts in the sensor to transmit the alarm condition to the fire alarm control panel. Rate of rise heat detectors often utilize a diaphragm or air chamber that expands as the air contained within the chamber expands in response to temperature rise. The chamber is vented via an orifice that regulates the amount of air that can exit the chamber. The chamber will expand and operate as set of electrical contacts if the specified rate of temperature rise is exceeded. Rate of rise heat detectors often incorporate a fixed temperature element as well. Rate of rise detectors can operate at a lower ambient temperature than would be possible if the threshold were fixed.
Slide 28	Heat detectors are sometimes referred to as spot detectors as they only provide effective coverage for a certain amount of area. Strategically spaced multiple detectors may be required to cover a larger area. It is important to note that most fixed temperature heat detectors are non-restorable meaning they are for a single use and must be replaced after activation. A non- restorable heat detector has a disk on the bottom of the detector that will detach from the unit when it has been activated. They typically incorporate a low melting point solder attached to a spring that holds electrical contacts open. When the activation temperature is reached the solder melts releasing the spring and closing the contact. It is important to note that non-restorable detectors cannot be tested individually and are commonly batch tested.
Slide 29	Some modern fixed temperature heat detectors are restorable meaning they can be automatically reset once the temperature cools. Restorable fixed temperature heat detectors incorporate bi-metallic strips or electronic sensors. A bi-metallic strip is two dissimilar metals that expand at different rates when heated and join together in such a way that the strip bends activating a set of electrical contacts. When cooled the strip returns to its original shape. Electronic sensors have the attribute of changing their resistance in response to temperature, when a specific resistance is reached the device is activated. Some modern fire alarms allow for adjustment of the temperature setting of these types of devices.

Slide 30	Commercial installations primarily utilize heat detectors and photoelectric detectors, as ionization detectors are prone to false alarm. Other detectors are also employed such as beam detectors, line heat detectors, flame detectors, gas detectors and air sampling detectors. Beam detectors incorporate a light emitter and a light receiver. The emitter focuses a beam of light on to the receiver that converts the light into an electrical signal. When smoke passes through the beam the light falling on the receiver diminishes and the output electrical signal changes activating the detector. The detectors are calibrated to signal trouble but not alarm when the light is completely blocked to avoid nuance alarms when a solid object obstructs the beam. Beam detectors are used to cover large areas or spans as an alternative to multiple smoke detectors.
Slide 31	Line detectors activate in response to heat and are used to cover large areas like conveyor belts, cable trays, and warehouse rack storage like those found in industrial and petrochemical plants. There are two types, wire and tube line detectors, which provide continuous sensitivity along the length of the conductor. A non-restorable wire type line detector utilizes two conductors separated by electrical insulation which melts as it is heated. As the insulation melts a short circuit between the conductors develops, activating the detector. A restorable wire type line detector monitors the resistance of a single conductor. The resistance of the conductor changes in response to ambient temperature and activates the device in a specific temperature range. A tube type line detector operates in a similar way but instead monitors the air pressure in a sealed metal tube and activates at a specific pressure range which varies with the ambient temperature. Tube type detectors are considered to be restorable.
Slide 32	A flame detector is a sensor designed to detect and respond rapidly to the presence of a flame or fire. How they respond depends on the installation, but can include sounding an alarm, deactivating a fuel source such as a propane or a natural gas supply, and activating a fire suppression system. Flame detectors are used in a wide range of hazardous process and manufacturing industries that require continuous flame monitoring to prevent catastrophic fires. There are four primary optical flame-sensing technologies in use today. They are ultraviolet, ultraviolet/infrared, multi-spectrum infrared, and

	visual flame imaging. They are all based on line-of-sight detection of radiation emitted by flames. An ultraviolet flame detector can often respond faster and more accurately than a smoke or heat detector due to the mechanisms it uses to detect the flame. The downside is that they are expensive, and they may activate quickly in non-fire situations like welding, sunlight or other bright light sources.
Slide 33	There are many industries that rely on toxic, flammable, and asphyxiant gas detection technology including wastewater treatment, chemical plants and pulp and paper producers to name a few. Workers nearby these processes are in danger of exposure and require reliable gas detection to keep them safe. Gas detectors can be connected to a fire alarm system or can be connected to other systems to warn occupants of the presence of gas. Gas detectors are specialized equipment that require regular calibration to operate effectively, and calibration should be part of a regular service schedule.
Slide 34	Air sampling detectors continuously test the environmental air for the presence of products of combustion or other gasses. A good example of an air sampling detector is a Duct Detector which is installed in the ductwork of a air handling system to detect transmission of smoke. The unit continuously samples the air moving through the ducts and activates when products of combustion are detected. They can operate on the photoelectric or ionization detection method. Some installations treated the duct detectors as part of the air handling system and therefore were powered by that system. However, when air handlers were shut down the FACP would indicate trouble. Modern installations utilize the FACP to power the duct detectors to avoid this situation. When a duct detector activates the FACP will signal alert or alarm and take action to reduce the transmission of smoke such as activating dampers to redirect air or shut down the air handler.
Slide 35	In some cases, building and fire codes call for Fire Detectors to be installed as part of the fire alarm system. Fire detectors can be heat, smoke or flame detectors but the code does not specify which is needed. Normally heat detectors will be chosen because they are usually much less expensive that smoke or fire detectors, but it is the owner's choice which to install.
Slide 36	If a fire alarm system is required in a building that is not sprinklered, fire detectors must be installed in:

	• Storage rooms not within dwelling units • Service rooms not within dwelling units Janitors' rooms • Rooms in which hazardous substances are to be used or stored • Elevator and dumbwaiter shafts • Laundry rooms in buildings of residential occupancy, but not those within dwelling units Fire detectors are not required in floor areas that are sprinklered because the sprinkler head acts as a heat detector.
Slide 37	Most building codes require buildings that have fire sprinkler systems to also have fire alarm systems. Fire suppression systems such as sprinkler systems are then monitored by the FACP. When a sprinkler system is activated, the moving water in the sprinkler system activates a flow switch. A flow switch is constructed of a paddle connected to electrical contacts held open by a spring, when water flows against the paddle the electrical contacts close causing an alarm. In a dry system switches are replaced by pressure sensors. These methods have the additional advantage of providing monitoring of leaks or component failure. Tamper switches indicate the position of a valves in a sprinkler system. If a valve is not sufficiently open, a trouble signal will be activated. This protects against accidental or intentional repositioning of valves that could sever or limit water supply.
Slide 38	The general requirements for all types of initiating devices include: • Initiating devices should only be installed in accessible locations where the can easily be maintained. • They must be protected if they are exposed to mechanical damage. They can be protected with a mechanical guard, but the guard must be approved for use with the device. Detectors must be supported by another means besides their own wires meaning they have to be properly attached to the wall or ceiling with a mounting bracket and cannot be left dangling.
Slide 39	Notification appliances are the audible and visual devices that notify building occupants that a fire has been detected. Types of notification appliances include bells, horns, sirens, loudspeakers, chimes, and strobes. Notification devices are installed on the notification appliance circuit or NAC to produce the desired auditory and visual indication required by the building code.

	Auditory devices are selected based on normal ambient sound level and type of sounds present. Modern devices emit a repeating pattern of 3 short bursts followed by a brief pause. This is referred to as temporal 3 pattern and has been adopted internationally as a standard to limit confusion as to what a fire alarm condition sounds like.
Slide 40	Notes to Part 3 of Canadian building codes state "The temporal pattern of an alarm signal relates to the time during which the signal is produced and the intervals between the individual signal pulses. The international standard ISO 8201, "Acoustics – Audible emergency evacuation signal," includes a pattern that is becoming widely used in different countries and it is appropriate for this pattern to be adopted in Canada. The temporal pattern can be produced on most signalling devices. Most existing alarm systems can be modified, and this pattern could be phased in when the systems require modification. The characteristic of the pattern is a 3-pulse phase followed by an off phase. The 3pulses each consist of an on phase lasting for 0.5 ± 0.05s followed by an off phase lasting for 0.5 ± 0.05s sounded for 3 successive on periods and then followed by an off phase lasting for 1.5±0.15s. This figure indicates the pattern that is intended. Reference: BCBC 3.2.4.18 and Notes to Part 3 A3.2.4.18
Slide 41	Audible signal devices should be installed so that alarm signals are clearly heard throughout the floor area and should be in the 65 to 110 decibel range. If the fire alarm system is two-stage, the sound patterns of alert signals must be significantly different from the temporal patterns of the alarm signals. Two- stage alarms will be discussed later in this Chapter. Some systems incorporate loudspeakers as a means of signalling alarm and recorded messages can be broadcast to provide information or instructions in multiple languages. Some systems can also be utilized as a P.A. so personnel and emergency responders can give real time instructions. Chimes are quitter and are for use in normally quite environments where a sudden loud noise could cause distress such as hospital wards.
Slide 42	Visual signal devices must be installed in addition to audible devices in buildings intended for use by persons with a hearing impairment. Visual signals are also required in assembly occupancies where loud music is played, in any floor area in which the ambient noise level is more than 87 dBA, and in any floor area in which the occupants use hearing protection devices. Visual devices must be installed so that they are visible throughout the

	floor area. They must be approved for use with the fire alarm system and have a clear or white translucent lens with the word “FIRE” clearly visible on the lens or attached nameplate. Strobe lights range between 15 to 1000 candela and should flash white or red incandescent lights at one second intervals. With the aging population, some existing fire alarm systems may have to be retrofitted to include visual signals, or replaced.jui
Slide 43	The Fire Alarm Control Panel, which is the brains of the fire alarm system, is typically hidden in an out-of-the-way electrical room or other places that the fire department may have difficulty finding. When the fire department arrives, they need to know where and why the fire alarm system activated as soon as possible. Instead of hunting for the control panel, they can look for an annunciator panel and quickly establish what is going on. An annunciator panel is another form of visual and sometimes audible notification device.
Slide 44	A fire alarm Annunciator Panel is a small keypad with an LCD screen or collection of lights normally located near the main building entrance where the Fire Department can easily find it. They are typically small boxes that have an LCD screen, and a few buttons or a group of lights with floor numbers or zones beside each light. The lights indicate if the system is operating normally, is in alarm, or a trouble condition exists and if an initiating device has activated and where that device is located. The fire department and building management use the annunciator to quickly pinpoint the location where the device activated. Annunciators often incorporate an auditory signaling device that indicates if the fire alarm is in alarm or trouble. In this case the annunciator indicates that the power is on, an alarm has been initiated, the alarm has been silenced and the digital panel identifies the problem to be on Level 1 in the center wing.
Slide 45	In addition to alerting occupants to the fire, fire alarm systems may provide other important functions through ancillary devices. Ancillary devices are devices controlled by the FACP but not integral to the operation of the fire alarm system. Examples include but are not limited to elevator capture, magnetic fire door releases, start up or shut down of intake or exhaust fans, or release of automated door locks. Generally speaking, the FACP has sets of normally closed and normally open contacts that will operate during an alarm. These contacts are used to control the ancillary devices.
Slide 46	Elevator capture refers to overriding the elevator controls so that the elevator returns to the main floor and cannot be called to another floor for use.

	Intake fans are often shut down to avoid feeding oxygen to the fire and exhaust fans often start up to evacuate products of combustion. Evacuation routes such as stairwells may have an intake fan that starts to pressurize the route preventing products of combustion from entering the pressurized compartment. Magnetic fire door releases or door mags are electromagnets that hold fire doors open under normal circumstances but in event of an alarm they are de- energized releasing the doors. Automated door locks that normally require a key or card to open may need to be released if they are along a evacuation route. Tele-dial systems are also considered to be an ancillary device. This is an automatic dialer that phones out to a monitor when the system is in alarm.
Slide 47	Fire alarm systems can be very basic or extremely complex based on the age of the system and the complexity of the property being protected. There are two types of fire alarm systems – Single Stage and Two Stage. The most common is the Single Stage Fire Alarm System, designed so that upon activation of any initiating device like a manual pull station, smoke or heat detector a general evacuation alarm signal sounds on all audible signal appliances throughout the building. All Group F high hazard industrial occupancies are required to have a single stage alarm system. Most Group B institutional occupancies are required to have a two-stage alarm system, but other occupancies can have either a single or two stage system at the discretion of the owner or designer. More information about the requirements for fire alarm systems in Canada can be found in Section 3.2.4 of the Building Code.
Slide 48	A two-stage fire alarm system is designed so that the activation of any alarm initiating device like a manual pull station, smoke or heat detector will cause an alert signal to sound that alert on duty supervisory staff about the fire emergency. Two-stage alarm systems are normally used if a general alarm would cause undue distress to the occupants, for example in health care facilities. In these facilities the evacuation of the occupants is difficult and could be physically or psychologically harmful. Therefore two-stage alarm systems are used to reduce the possibility of false alarms. Staff are constantly on duty and expected to immediately investigate the source of the alarm and, if a fire exists, to activate the alarm signal. The alarm signal is automatically set off after five minutes if the staff have not already activated it or reset the alarm system.

	There is no prescribed sound for the alert signal to notify staff, but it must be distinctly different from the evacuation (alarm) signal. In new buildings, that evacuation signal will be the temporal signal.
Slide 49	Some two-stage fire alarms have keyed pull stations. When an alert is signaled, staff must use a key at a pull station to active a general alarm or acknowledge the false alarm at the FACP. Trained staff have the keys for the manual stations to initiate the second stage. It is crucial to recognize that it is the trained staff who are responsible for evacuating the building occupants and that human interaction is an integral part of the fire protection system. It is evident that the two-stage system has serious implications: • The Fire Safety Plan requires much greater detail, • Significant training is implied, • Staff levels must be considered. And there are issues such as: • Who has the evacuation keys? • Where are the keys located? • Who makes the evacuation decision? • Under what conditions is evacuation mandatory?
Slide 50	Some fire alarm systems provide no information about the initiating device that activated the alarm while others provide extensive information which may include the exact location of the device and the time of activation. Fire investigators often use this type of information to track the progress of a fire. Noncoded alarm systems do not indicate where in the system the activation occurred. In this case the whole building has to be searched to find activated initiating device. Zone noncoded alarms are very common especially in smaller buildings. These indicate the zone where the initiating device activated. Zone Coded Systems are capable of indicting the zone in which a device has been activated by utilizing the notification devices to emit a unique auditory sequence for each zone. These type of alarm systems were utilized in situations where full evacuation for any alarm may not be practical like a hospital or prison. Master coded systems can be used for other audible functions but most of these have been replaced with modern alarm systems.

Slide 51	So far, we have discussed conventional fire alarms, but most modern fire alarms are addressable. The major difference between the conventional and addressable systems is how the initiating circuit is monitored. In a conventional fire alarm system, a monitoring current is continuously flowing in the initiating circuit and through the end of line resistor if class B, or back to the fire alarm panel if Class A. The Zones are developed by creating independent initiating circuits for each area. However, in an addressable system each initiating device is identified by a settable electronic address. The FACP continuously polls each device on the initiating circuit and each device is continuously updating and singling its condition as normal or activated when polled. If a device fails to respond, the FACP will perceive it has been disconnected and it will signal a trouble condition. Zones are created by grouping addresses, eliminating the need for independent circuits. This has additional advantage of the ability to indicate not only the zone, but exactly which device has been activated. This can provide very important information as described in the following example.
Slide 52	Video.
Slide 53	In some cases, building and fire codes require fire alarm systems to be monitored so that there is no delay in notifying the fire department. Generally speaking, fire alarm activation signals must be automatically relayed to the fire department when: • An assembly occupancy building has an occupant load more than 300 • The building has an automatic sprinkler system • The fire alarm is a two- stage system.
Slide 54	Alarms may be relayed to the fire department in a few ways as follows: • Remote supervising stations send a signal directly to the fire department. This can only be used where the fire department is equipped to receive the call. • Auxiliary Systems can be used if the jurisdiction is equipped with public fire alarm call boxes. • Proprietary systems are operated by the building owner who relays the alarm to the fire department.

	Central Station alarms are the most common and involve a third party who monitors a lot of different alarm systems and notifies the appropriate agency in the event of an alarm.
Slide 55	The building code requires any Central Station system to comply with ULC S561-13 which is the standard for the Installation and Services for Fire Signal Receiving Centres and Systems. This standard is referenced in the Fire Code and Building Code for any building that is required to have its fire alarm or sprinkler system monitored. This standard defines: • What type of equipment may be used • How the Signals Receiving Centre (SRC) is constructed • How the monitoring transmitter is physically installed on site • How the monitoring transmitter communicates with the SRC • How alarms are handled when received in the SRC If the fire alarm system is not monitored, it is referred to as a Protected Premises Fire Alarm system. A legible sign must be posted near each manual pull station stating that this is a “Local Alarm Only – Call 911” or provide the fire department emergency contact number.
Slide 56	All buildings equipped with a fire alarm system need to have a Fire Safety Plan. Part of the Fire Safety Plan should include instructions on measures to be taken if the fire alarm is inoperable for any reason including breakdown, maintenance, or periodic inspection. The building owner/manager may silence the fire alarm on the conditions that: • An investigation of the area of fire alarm activation is concurrently taking place • Notification of the fire department is not affected or delayed • The system can be immediately put back into full alarm mode where it is determined a fire or hazardous condition is present • Notification is given to any third party such as the alarm maintenance company • A fire watch procedure is in place and can be implemented immediately Building owners/managers or fire wardens who silenced the alarm must remain at the fire alarm control panel or annunciator panel until the fire department arrives and they have provided all necessary information to the Fire Department Incident Commander.
Slide 57	The building owners, managers or fire wardens must assist the Incident Commander in identifying the origin, nature and cause of fire alarm activation. The operation of the fire alarm systems can be compromised

	because of accidental damage, building renovation or alteration, new construction and/or routine or emergency maintenance. When system shutdown is planned ahead of time, at least 24 hours' notice should be given to the occupants of the building and the fire department. Depending on the use of the building and duration of the shutdown an approved fire watch may be required based upon a risk analysis.
Slide 58	If the system is to be out of service for more than 4 hours signs should be posted in conspicuous locations and the main entrance to warn occupants that the fire alarm system is temporarily out of service and to call 911 if smoke or fire is noticed. If the building is equipped with a public address system an announcement should be made advising of the impairment and repeated every two hours until the system is operational. In some cases, pre-recorded messages can be programed into the public address system that will automatically play. As soon as the system is restored to full operation and tested the fire department should be notified, all signs removed and an announcement advising occupants that the system is operational should be made
Slide 59	The fire department can require a fire watch anytime a fire protection system is out of service. Usually, they do this when the system will be inoperable for more than 4 hours in a 24-hour period. It is the responsibility of the owner/occupant to provide the fire watch. The procedures for a Fire Watch should be documented and include: • The person assigned to perform the fire watch has no other duties • They must initiate a warning to occupants and notify the fire department when necessary • They must have portable fire extinguishing equipment available and be trained to use it • They must try to extinguish a fire but only when it is very small They must make sure that no hot work and/or other tasks that create sparks or an open flame take place in the area
Slide 60	The owner is responsible to maintain the fire alarm system in operational condition at all times. The system must be inspected and tested in conformance with CAN/ULC-S536, "Inspection and Testing of Fire Alarm Systems" by a person acceptable to the authority having jurisdiction. Authority having jurisdiction means the governmental body responsible for the enforcement of any code. Fire alarm systems are expected to help protect people, property, and assets. But it is hard to tell if they're fully operational just by looking at them. As with other electronics, components can degrade over time and

	compromise the system's operation. Dust, dirt, and other contaminants can cause problems with smoke detectors. Such things as vandalism, remodeling, and improper maintenance procedures can also damage fire protection equipment. The good news is that with proper testing, inspection, and maintenance fire alarm systems can be kept at optimum operating performance. In addition to ensuring protection, keeping your system in good condition reduces emergency repairs and false alarms.
Slide 61	Systems under five years old should require little effort to maintain. Systems between five and ten years old may experience some component breakdown caused by normal wear, but this should be identified by the maintenance and inspection program. Systems between ten and fifteen years old can still provide appropriate life- safety response but need close attention. Even with proper maintenance it's likely that failure of some components will occur. Owners should develop a replacement plan. Systems over 15 years of age may be beyond their life expectancy. These systems may continue to work satisfactorily if properly maintained but need continuous testing and inspection by trained specialists to ensure their reliability in an emergency.
Slide 62	Accurate and detailed records of routine checks, inspection, testing and maintenance of the fire protection equipment and systems in the building are required. These records must be retained for a period of two years and be presented to the fire department representative upon request. Some fire departments also require the records to be submitted to them annually. A "check" means a visual observation to ensure the device or system is in place and is not obviously damaged or obstructed. An "inspection" means a physical examination to determine that the device or system will perform in accordance with its intended function A "test" means actual operation of a device or system to ensure that it will perform in accordance with its intended function.
Slide 63	A visual check should be made every day to make sure the annunciator panel or the fire alarm control panel indicates normal operation. Any fault indicated must be recorded and receive immediate attention. Check the principle and remote trouble lights for trouble indication and make sure the AC power-on light indicates normal operation. Most jurisdictions do not require the daily check to be recorded.
Slide 64	Once a month a more detailed inspection of the fire alarm system is required. The person conducting the monthly inspection must:

	• Confirm the system power lamp is illuminated • Test one initiating device on a rotating basis to ensure it sets off the audible and visual signaling devices • Confirm the annunciator indicates the correct zone where the initiating device was activated • Visually inspect the standby power batteries to make sure the terminals are clean, tight and lubricated • Test the system's "trouble indicator"
Slide 65	• Test one emergency telephone if the system is so equipped • Test paging capability to one zone • Record the inspection in the maintenance logbook • The monthly inspection does not need to be performed during the month when an annual test is conducted
Slide 66	An annual in-depth test of the entire fire alarm system is required and must be performed by a qualified person acceptable to the authority having jurisdiction. The person performing the annual test and inspection should be familiar with the ULC Standard (CAN/ULC-S536). They should also have completed formal training or have sufficient experience acceptable to the authority having jurisdiction. All aspects of the system must be tested including: • An overall system checks to ensure proper installation and examine any changes, alterations, additions or damage. • Access to, and functioning of, every connected device such as heat detectors, smoke detectors, pull stations and signaling devices. This includes devices in all common areas as well as any device inside dwelling units. • All auxiliary and ancillary functions and connections. • Internal fire alarm control panel.
Slide 67	• Functioning of fire system monitoring, to ensure the monitoring company is receiving required trouble and alarm signals. • Alarm zone annunciation and operation of all remote annunciators, which inform the fire department or on-site staff where the device has been activated. • Functioning of EVAC (evacuation) system, including voice communication and paging systems, firefighters' phones and related equipment. • Documentation detailing the operational readiness of the system for review by fire department inspectors.

	Some jurisdictions require the annual test documentation be sent to them.
Slide 68	Carbon Monoxide is a colorless, tasteless and odorless compound produced by incomplete combustion. It is often referred to as the "silent killer" because it is undetectable without using detection technology. Elevated levels of CO are dangerous to humans depending on the amount present and length of exposure. CO alarms are designed to measure CO levels over time and sound an alarm before dangerous levels accumulate giving people adequate warning to safely ventilate the area or evacuate. Some system-connected detectors also alert a monitoring service that can dispatch emergency services if necessary. While CO alarms do not serve as smoke detectors and vice versa, dual smoke/CO alarms are available. Smoke alarms and smoke detectors react to detect smoke generated by flaming or smoldering fires, whereas CO alarms detect and warn people about dangerous CO buildup caused, for example, by a malfunctioning fuel-burning device.
Slide 69	Some common sources of CO include open flames, space heaters, water heaters, blocked chimneys or running a car inside a garage. CO alarms can be placed near the ceiling or near the floor because CO is very close to the same density as air. According to NFPA 720 carbon monoxide alarms should be centrally located outside of each separate sleeping area in the immediate vicinity of the bedrooms," and each alarm "shall be located on the wall, ceiling or other location as specified in the installation instructions that accompany the unit." CO alarms are required by the Building Code for new construction and retroactively in some jurisdictions. Ontario for example passed legislation that requires carbon monoxide alarms in all residential homes so other Provinces can be expected to follow suit. If CO alarms are installed as part of a code requirement or voluntarily it must be inspected, tested and maintained in conformance with the manufacturer's instructions. Be prepared to answer questions about CO alarms by knowing what code requirements and policies are in place in your jurisdiction.
Slide 70	A smoke alarm is another type of initiation device but is not to be mistaken as a smoke detector. A smoke alarm is a stand-alone unit not connected to the fire alarm system that provides detection and auditory signaling capabilities all in one. They are commonly used in single occupancy's such as a house or apartment and have no requirement to be connected to a FACP.

	Building codes have evolved from requiring smoke alarms in hallways adjacent to bedrooms and one on each floor of a residential occupancy, to newer requirements for a smoke alarm installation in each bedroom and one on each floor. Most building codes also require interconnection of smoke alarms so that all alarms in an occupancy will sound if any individual alarm is activated. Modern installations often utilize hard wired smoke alarms that are powered from the buildings electrical system and interconnected via the buildings electrical circuity and contain a backup battery. Stand alone battery operated units are still commonly in use.
Slide 71	Wireless smoke alarms that are interconnected via an independent Wi-Fi network are now available as well. There are many models available from the major manufacturers but also there are some emerging technologies as well. Google recently release the Nest smoke alarm. These units incorporate smart technology which can distinguish between levels of urgency in smoke and CO levels and send a text to a smartphone immediately upon detection. If it detects a little bit of smoke or rising levels of CO, it sends a message but if the situation gets worse, it flashes red, activates the alarm, as well as voice communications. Once the devices are installed and activated, they automatically connect with each other through blue tooth technology.
Slide 72	Smoke alarms use two methods to detect smoke. They are ionization and photoelectric or a combination of both. Ionization smoke alarms tend to respond faster to the smoke produced by flaming fires than photoelectric smoke alarms do. Photoelectric smoke alarms tend to respond faster to the smoke produced by smoldering fires than ionization smoke alarms. Both have their advantages. They look very similar so the best way to determine the type is to read the label. Ionization smoke alarms are the most common and quicker at sensing flaming and fast-moving fires. This type of alarm uses a small amount of radioactive material to ionize air in an internal sensing chamber between two electrically charged plates, which causes current to flow between the plates. When smoke enters the chamber, it disrupts the flow of ions, thus reducing the flow of current and activating the alarm.
Slide 73	Photoelectric smoke detectors are well-known for protecting against smoldering fires. A photoelectric smoke alarm uses light to detect **smoke.** Inside the alarm, there's a light-sensing chamber. In this chamber, an LED light shoots a beam of light in a straight light across the chamber. The alarm detects smoke; when smoke enters the chamber, it deflects the LED light from the straight path into a photosensor in a different compartment in the same chamber. As soon as light beams hit this sensor, the alarm begins to sound. The dual sensor smoke alarm uses both ionization and photoelectric technology. Since it cannot be predicted what type of fire will start in a home, it is important that both smoldering and flaming fires

	are detected as quickly as possible. The best protection is to have both types of smoke alarms installed or install dual sensing technology smoke alarms that incorporate both ionization/photoelectric sensors. References: IAFC "Smoke Alarms – Ionization and Photoelectric Technology" Position Paper, April 2008
Slide 74	The building code requires at least one smoke alarm to be installed on each storey of a dwelling unit or suite of care occupancy. If the floor level of a dwelling unit contains sleeping rooms, a smoke alarm must be installed in each sleeping room, and in a location between the sleeping rooms and the remainder of the storey. If the sleeping rooms are served by a hallway, a smoke alarm should be located in the hallway and each sleeping room. Newer building codes require this because many people sleep with their bedroom doors closed which could cause a delay in notifying other occupant of a fire. Smoke alarms must be installed on or near the ceiling with a permanent connection to an electrical circuit that does not have a disconnect switch other than at the electrical panel. Smoke alarms should have a battery as an alternate power supply that can provide power for at least 7 days in case of regular power failure. If more than one smoke alarm is required in a dwelling unit, the smoke alarms must be wired so that the actuation of one smoke alarm will cause all smoke alarms within the dwelling unit to sound. Smoke alarms should also have a built-in manually operated silencing device so that it will silence the alarm for a period of not more than 10 min, after which the smoke alarm will reset and again sound the alarm if the level of smoke in the vicinity is sufficient to reactivate the smoke alarm.
Slide 75	Smoke alarms are prone to power problems. Battery operated smoke alarms require the batteries be changed frequently, twice per year is recommended. Unfortunately, occupants will sometimes remove batteries to prevent nuance alarms or to utilize the battery for another purpose, rendering the smoke alarm inoperable. Hard wired smoke alarms overcome these disadvantages however they can be disconnected at the circuit breaker. Most smoke alarms will emit a chirp like signal to indicate low battery life or if the battery of a hard-wired smoke alarm has been removed. Battery operated smoke alarms will only indicate low battery life while the battery is still providing some power and eventually indication cannot be sustained.

Slide 76	Smoke Alarms should be tested frequently, and batteries replaced if missing or depleted. Smoke alarms have a life span of ten years or per manufactures recommendation. Some smoke alarms come with a ten-year rated lithium-ion battery so that the back-up battery never needs to be replaced. New smoke alarms should also come with a replacement date marked on the outside of the case as shown in this photo. While doing inspections one day this fire inspector got a laugh when he came across this smoke alarm. The purpose of the decal was to indicate the date of installation not where it was installed.
Slide 77	During fire investigations, questions often arise about the operation of smoke alarms. Did they or did they not function and provide early warning to the occupants? Until recently, analysis of the operation of smoke alarms was limited to electrical diagnostics to determine whether or not a smoke alarm had the electrical power to sound the alarm during the fire. It is now possible, in many cases, to evaluate soot deposits around a smoke alarm horn assembly to determine whether the smoke alarm sounded during the fire. Soot particulate forms identifiable patterns on internal and external surfaces of the smoke alarm cover near the edges of the horn and on the surface of the horn mechanism. This photo is an example of macroscopically observable enhanced soot deposit on the external face of a smoke alarm. This is representative of the result of an alarm sounding during exposure to a fire.
Slide 78	Some newer smoke alarms come with a voice recording features that allows adults to record a message that sound on the device when it activates. This is in response to a study that found sleeping children are fairly impervious to the sound of a smoke alarm. Researchers found that most children ages 5 through 8 took more than five minutes to wake up with a standard smoke alarm, as compared with around four seconds when they heard the sound of their mother's voice. Dr. Gary Smith, who directs the Center for Injury Research and Policy at Nationwide Children's Hospital in Columbus, Ohio said "The thing that was most remarkable to us was to see a child sleep five minutes through a very loud high-pitched tone, but then sit bolt upright in bed when their mothers voice sounded through the alarm," "We didn't expect the difference to be so dramatic." He went on to say the research "is an important step towards optimizing smoke alarms for waking up young children,"

Slide 79	In this Chapter we discussed: • The factors that determine when a fire alarm system is required • The basic components of a fire alarm including the FACP, initiating devices, signaling devices and annunciator panels • Zones in a fire alarm system • Initiating devices including pull stations, heat detectors, smoke detectors, flame detectors, and water flow switches and tamper switches of sprinkler systems • The operation of photoelectric and ionization detectors • Where smoke detector are required • Heat detectors both rate of rise and fixed temperature • Beam, line, flame, gas and air sampling detectors • Sprinklered buildings are connected to the fire alarm system through flow and tamper switches
Slide 80	• Visual and audible alarm notification devices including bells, gongs, strobe lights and the annunciator panel • Ancillary devices that perform functions like closing doors or turning on or off fans • Single stage and two-stage fire alarms systems – Single stage is the most common and the activation of any initiating device causes a general evacuation of the building • Conventional and addressable systems – the addressable system indicates exactly which device activated • Monitoring fire alarms and methods to notify the fire department • Protected premise systems do not automatically notify the fire department • Out of service fire alarms may require a fire watch • Inspection, testing, and maintenance of fire alarm systems • Carbon monoxide alarms We concluded this Chapter with a discussion on smoke alarms which are the most common type of fire detection equipment in use today.