BURGLAR & FIRE ALARM ASSOCIATION OF MICHIGAN

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APPRENTICESHIP PROGRAM

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Period 1
Related Training Instruction (RTI)
Module 5 – Fire Alarm Signaling Systems

Reading material associated with this module:
Chapters 10, 11, and 12
Fire Alarm Signaling Systems, Fourth Edition 2010

Chapter 10 – Fundamentals of Fire Detection System Design

Introduction:

- The two major categories of fire protection are *passive* fire protection and *active* fire protection.
  - Passive fire protection can include isolation of hazardous areas in the facility, separation of fuel sources from ignition sources, use of fire barriers such as fire walls, and the use of fire-retardant materials to minimize fire growth and spread.
  - Active fire protection involves controlling fire with specialized systems and equipment, such as fire detection systems to detect early stages of fire, fire suppression systems such as sprinkler systems to actively control fire, and smoke control systems to prevent the spread of smoke and to provide for the exhaust of smoke from an area.
  - Design objectives can include notification of occupants, notification of emergency responders, activating fire suppression systems, and supervising suppression systems for conditions that may impair their operation.

Chapter 10 – Fundamentals of Fire Detection System Design

Design Criteria:

- Design criteria is the method by which the design objectives are achieved in a particular building or structure. It includes an engineering survey of each area to evaluate the types of combustibles present, the likely fire scenarios that could result, and evaluation of the building structure and construction.

Chapter 10 – Fundamentals of Fire Detection System Design

Design Criteria – Prescriptive Requirements:

- The height of the ceiling in a protected area significantly affects fire detector performance. As the ceiling height increases, a progressively larger fire is required to transport heat and smoke to the ceiling level. Consequently, NFPA 72 provides for derating listed heat detector spacing for ceiling heights over 10'.
- Stratification is also a concern with higher ceilings. The closer to the ceiling, the higher the ambient air temperature. At the same time, the further the smoke plume gets from the source of the fire, the cooler the smoke becomes. When the cooling smoke reaches an equal temperature with the increasingly warmer ambient air, the smoke will stratify and not rise any higher.

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Design Criteria – Prescriptive Requirements (continued):

- Ceiling construction is another significant factor in fire detector placement. Once the smoke plume reaches the ceiling, the presence of beams or joists can impede the flow of smoke across the ceiling, which affects the speed with which the smoke plume can reach a detector to activate it.
- Level ceilings include those with a slope of 1.5 in/ft or less. Sloped ceilings (of either the peaked or shed type) are defined as those with a slope greater than 1.5 in/ft.
- A ceiling surface is classified as a beam ceiling if solid portions project down from the ceiling surface more than 4” and are spaced more than 3’ apart (measured center to center).
- If beams, solid joists, or ducts project down less than 4” from the ceiling surface, the ceiling is classified as a smooth ceiling.
- Open truss construction is not considered to impede the flow of fire products unless the upper member in continuous contact with the ceiling projects below the ceiling more than 4”.

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Design Criteria – Prescriptive Requirements (continued):

- A ceiling surface is classified as a solid joist ceiling if solid portions project down from the ceiling surface more than 4” and are spaced 3’ or less apart (measured center to center).
- Girders support beams or joists and run at right angles to the beams or joists. When a girder is within 4” of the ceiling, it becomes a factor in determining the number of detectors and is to be considered a beam. When the top of the girder is more than 4” from the ceiling, it is not a factor in detector location.

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Automatic Fire Detectors:

- Proper application of heat detectors requires evaluating the effect of both ceiling height and ceiling construction. When the ceiling height exceeds 10', the coverage area (box) is de-rated based on the actual ceiling height. For example, a heat detector with 50' x 50' coverage placed on a 17' ceiling would be derated to 71%, or 35.5' x 35.5' coverage.
- After reducing coverage to compensate for ceiling height, the heat detector coverage may need to be further modified based on the ceiling construction. For a beam ceiling, the coverage area is reduced by 1/3 in the direction perpendicular to the beams. Think of beams as speed bumps for the heat and reduce the coverage area by 1/3 in the direction where the heat travels under the beams.
- For a solid joist ceiling, the coverage area is reduced by 1/2 in the direction perpendicular to the joists. If the coverage area is 35.5' x 35.5', reduce the coverage area by 1/2 in the direction where the heat goes under the joists, giving a coverage area of 17.75' x 35.5'. Using this coverage "box", you can then determine how many detectors are required for the room.

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Automatic Fire Detectors (continued):

- Smoke detectors are affected by many variables, including ceiling configuration, ceiling height, burning characteristics of materials, fuel arrangement, room geometry (including openings), and HVAC systems.
- The requirements for derating coverage based on ceiling height and ceiling construction apply specifically to heat detectors, whereas the requirements for smoke detectors are less specific.
- Because of these many variables, and in the absence of an engineering analysis, spacing of spot-type smoke detectors on smooth ceilings should not exceed 30’
- When beams extend more than 18” down from the ceiling, they are considered walls for detector placement purposes.

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Automatic Fire Detectors (continued):

- Because a smoke plume will generally not spread out until it reaches the ceiling, it is very important that smoke and heat detectors be located on the ceiling (where the smoke/heat will be). It is a common mistake in industrial occupancies with steel joist construction to mount smoke or heat detectors at the bottom of the joist, which can be 18” to 24” below the ceiling level.
- Another construction consideration is sloped or peaked ceilings. When this type of ceiling is present, a smoke or heat detector or row of detectors must be placed within 3’ of the peak (since the smoke and heat will travel to the highest point). If additional detectors are needed, they are spaced based on the horizontal projection (floor) of the area, not the distance between two points on the slope.

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Automatic Fire Detectors (continued):

- Spot type heat detectors should not be placed within 4” of a wall or ceiling. If wall mounted, they must be installed between 4” and 12” down from the ceiling.
- Spot type smoke detectors shall be located on the ceiling or, if on a sidewall, between the ceiling and 12” down from the ceiling to the top of the detector. There is no minimum distance from the wall to the detector when ceiling mounting.
- Keep in mind that the further a detector is mounted from the ceiling, the slower it will react to smoke accumulating at the ceiling.
- Spot type detector spacing between devices may be increased in areas where one dimension of the room is less than the listed spacing for the device. For example, in a corridor 10’ wide, a detector with a 30’ spacing could be spaced up to 41’ between detectors. This is based on the requirement that every space in the protected area be within .7 times the listed spacing of the detector.

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Automatic Fire Detectors:

- A detector that is listed for 30’ x 30’ coverage covers more than 15’ in each direction. From the detector at the center of the coverage box to a corner of the coverage box, the actual distance is about 21’. Therefore, the detector coverage is a 21’ circular radius from the detector, which is why spacing can be increased in narrow rooms.
- Methods of addressing smoke stratification in high ceiling areas include the use of air sampling systems and projected beam detectors with angled coverage.
- Projected beam detectors and heat detection cable are examples of line type detectors, where the detection can occur at any point in the line of coverage. Spot type detectors will only activate when the smoke or heat reaches the location of the detector. Line type detectors should be installed within 20” of the ceiling and in compliance with their installation instructions.

Chapter 11 – Engineering Documents

Introduction:

- Preparation of engineering documents is a major aspect in the design and installation of a fire alarm signaling system.
- Key engineering documents include design documents, project specifications, shop drawings, and equipment submittals.
- Design documents are intended to convey the intent of the system designer, and generally show intended locations of devices, construction details relevant to installing the fire alarm system, and product or performance requirements.
- Project specifications typically specify the codes and standards the system is required to comply with and may include owners project requirements that go above and beyond minimum building or fire code requirements. They will generally identify the equipment performance required and items such as spare capacity, maximum circuit loading, and future expansion capability.

Chapter 11 – Engineering Documents

Design Drawings:

- The fundamental purpose of design drawings and project specifications is to convey the owners and designers' intent to contractors proposing to supply and install a fire alarm system. Design documents that clearly identify expectations and requirements should allow contractors to provide quotations for equivalent systems.
- To establish minimum design quality, the documents should include, as a minimum, the following information:
  - Selection of type of system and components.
  - Fire alarm panel location.
  - Concept riser diagram.
  - Identification of interface(s) required with fire safety functions.
  - Other fire alarm systems and additional building systems.
  - All initiating devices and notification appliance locations.

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Shop Drawings:

- Shop drawings are drawings prepared by the system installer or equipment provider that incorporate the information contained in the design documents and provide specific installation requirements such as the wire type and size to be used, point to point wiring diagrams, and mounting instructions so that the installer can readily comply with the installation requirements.
- Shop drawings typically include plan views, which show a scaled view of the protected area with the device locations shown, wiring information provided, and device addressing or configuration information, such as the candela rating to select for a specific location. Plan views generally include a device legend, scale, north orientation, and room name designations.
- Another important component of shop drawings is a riser diagram. A riser diagram typically shows the connecting wiring required between control units and field devices, and in multi-story buildings identifies the number and types of conductors from the control equipment to each floor.

Chapter 11 – Engineering Documents

Shop Drawings (continued):

- Larger projects with significant amounts of control equipment may also include an equipment interconnection drawing showing the locations of control equipment and interconnecting wiring.
- Shop drawings should also include a detail page or pages, showing wiring connections or configuration details for each piece of equipment provided for the project. This permits an installer to utilize the shop drawings for all the information necessary to properly install and configure the system.
- Equipment submittals are typically provided by the equipment supplier and include engineering data on each component provided for the fire alarm system. Data sheets are reviewed by the project engineer to verify proper listing of proposed equipment, and the ability of the proposed equipment to comply with the project specifications

Chapter 11 – Engineering Documents

Shop Drawings (continued):

- In addition to equipment data sheets, submittal documents must include calculations to verify proper battery size, known as battery calculations. Battery calculations show the exact current consumption for all the provided equipment and calculate the amount of current required to support the system for both standby and alarm time.
- Most specifications and manufacturers installation manuals also require a safety factor of 20% be added to the calculated minimum battery size to account for the expected deterioration of battery capacity over time. The calculations should show a battery size sufficient to meet or exceed the calculated minimum size plus the safety factor.
- In addition to battery calculations, voltage drop calculations should be provided for each notification appliance circuit (NAC) to show that the designed wire size and circuit length will be sufficient to support operation of each notification appliance, so that the minimum voltage required for operation will be provided for each appliance.

Chapter 11 – Engineering Documents

Shop Drawings (continued):

- Most equipment manufacturers provide software programs to perform the necessary calculations for voltage drop and battery calculations. Essentially these calculations will reveal deficiencies in the application design, such as too many appliances on a NAC, or insufficient wire size to support all the devices shown on a single circuit.
- Verification of the design through voltage drop and battery calculations allows errors in the design to be corrected at the beginning of the project, as opposed to having to change the wire size on a circuit, or adding circuits after the job is already installed and failed to work properly.

Chapter 11 – Engineering Documents

Record (As-Built) Drawings:

- Upon completion of the fire alarm system installation, as-built documentation should be provided, including the following:
  - As-built drawings consisting of current updated shop drawings reflecting the actual installation of all system equipment, components, and wiring.
  - A sequence of operations to reflect actual programming of the system at the time of completion.
  - Revised calculations, if necessary, based on the final configuration of the system.
- Documentation, including as-built drawings shall be turned over to the owner with a copy placed inside the documentation cabinet.

Chapter 12 – Approvals and Acceptance

Introduction:

The fire alarm systems designer and installer are responsible for obtaining proper approvals at several phases of system design and subsequent installation, acceptance testing, and periodic test and maintenance.

- *Approved* means acceptable to the *Authority Having Jurisdiction*. Typically, AHJ's require equipment to be listed and labeled as a condition of approval.
- *Labeled* equipment has a label or symbol attached indicating that a listing agency has evaluated and listed the equipment as complying with a product standard.
- *Listed* refers to equipment or services included in a list published by a listing organization indicating that the equipment or service has been evaluated and meets the requirements of the standard to which it is listed. Generally, fire alarm equipment is listed as complying with the product standard, and has a label attached as well.

Chapter 12 – Approvals and Acceptance

Codes and Standards:

- Fire alarm systems typically must comply with three types of codes and standards:
  - Building and fire codes, such as the *Michigan Building Code* and *International Fire Code* which specify which occupancies require fire alarm systems, and the minimum extent of protection required.
  - Installation standards, such as the *National Electrical Code* and the *National Fire Alarm Code*, which specify the methods and materials to be used in the installation of a fire alarm system and include requirements for maintenance and periodic testing of the installed equipment.
  - Product standards, such as UL 864 *Standard for Fire Alarm Control Units* and UL 268 *Standard on Smoke Detectors*, which specify the required functions and capabilities of fire alarm equipment. Product standards generally specify the testing criteria, so performance can be independently tested. This allows other testing agencies (ETL) to list and label products as complying with a UL standard.

Chapter 12 – Approvals and Acceptance

Testing Laboratory Procedures:

- The smoke detector testing process for UL 268 is a two-stage process. In the first stage, the detector is placed in a smoke box. The smoke box measures the percent of obscuration per foot of the smoke, and the smoke detector is tested in 5 different mounting configurations. To pass this test, the detector must activate before the maximum percent of obscuration, but not before the minimum percent of obscuration.
- The maximum obscuration percentage is 4% for a gray smoke test, and 10% for a black smoke test. If the detector does not activate before these limits are reached, it fails the test as it is not sensitive enough.
- The minimum obscuration percentage is .2% for a gray smoke test, and .5% for a black smoke test. If the detector activates before these limits are reached, it fails the test as it is too sensitive and would likely be prone to false alarms.

Chapter 12 – Approvals and Acceptance

Testing Laboratory Procedures (continued):

- After passing smoke box testing in five mounting configurations, the data is reviewed to determine if there is a least favorable orientation for smoke entry into the detector. If one of the mounting configurations is determined to have a slower response, that mounting is selected for the next stage of testing, which is the room fire test.
- The fire test room consists of a 10’ high room, with detectors in three different locations, each spaced 17.7’ from the fire source. With the detectors mounted in their least favorable orientation, the fire testing begins. The detectors need to activate within a maximum time for each of five fire tests to pass this second stage.

Chapter 12 – Approvals and Acceptance

Testing Laboratory Procedures:

- The maximum activation time per test is as follows:
  - 4 minutes for the shredded newsprint fire.
  - 4 minutes for the layered fir wood strip fire.
  - 3 minutes for the heptane fire.
  - 2 minutes for the polystyrene fire.
  - 70 minutes for the Ponderosa pine hot plate test. This is a smoldering fire test, while all the other tests are for flaming fires.
- UL 268A, *Standard for Duct Smoke Detectors*, utilizes similar testing with ductwork and measured quantities of smoke, and varies the velocity of the air from 300 feet per minute to 4000 feet per minute.

END OF PERIOD 1 – MODULE 5