Describe Industrial Fire Detection and Alarm Systems
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**Training Objectives**

Upon completion of this training kit, you will be able to:

- Describe the purpose and importance of industrial fire detection and alarm systems
- Describe operator and maintenance personnel responsibilities for the fire detection and alarm system
- Describe fire zones
- Describe fire detection and alarm system components and ancillary devices
- Describe four types of fire detector
- For the four types of fire detector, describe:
  - application
  - limitations
- Describe two types of central control units
- Describe Stage 1 and Stage 2 fire alarms
- Describe precautions to take when one or more fire zones is bypassed
- Describe fire detection alarm system inspection and testing
- Describe limitations of fire detection and alarm systems

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**1 Introduction**

Industrial fire detection and alarm systems are designed to:

- detect fires
- initiate alarms (locally and, for some facilities, off-site)
- activate fire isolation devices and/or fire suppression systems (and, for some systems, activate or shut down equipment)

This training kit describes components, operation, and testing of industrial fire detection and alarm systems:

- fire alarm system regulations and design
- system components, including detailed descriptions of fire detectors and central control units
- one- and two-stage alarms
- system monitoring, inspection, and testing
- limitations of fire detection and alarm systems
Although the kit briefly mentions fire suppression systems, a description of these systems is beyond the scope of this module.

The kit is for operators and maintenance personnel in industrial facilities who may be required to:
- inspect components of fire detection and alarm systems
- occasionally assist certified fire alarm system technicians or electricians with fire detection and alarm system testing
- respond to fire alarms

This kit is one of a series of three HDC training kits that describe fixed detection systems commonly used in industry. The other two kits are:
- Describe Fixed Combustible Gas Detection Systems
- Describe Fixed Toxic Gas Detection Systems

This kit provides instruction on fire detection and alarm system components and their application. The kit does not endorse or promote any specific model, manufacturer, or supplier.

## 2 System Requirements

### 2.1 Regulations

For public, commercial, and industrial buildings that are normally occupied, every aspect of fire alarm system design, installation, maintenance, and testing is closely regulated by federal and state/provincial electrical and fire protection standards and municipal building codes.

Regulations that operators should be aware of include the following:
- Fire alarm systems are **not** required in all buildings. Fire alarm systems are generally required for buildings that are normally occupied; however, an industrial facility may

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1 Every jurisdiction publishes its own codes and standards about every aspect of fire prevention. Many of these codes and standards form the basis of building codes in the United States, Canada, and Europe.
describe industrial fire detection and alarm systems

include buildings equipped with fire alarm systems (e.g., an office building, a service shop) and buildings not equipped with fire alarm systems (e.g., unheated warehouses, equipment installations, garages, and storage trailers or sheds).

- In fire alarm system-protected buildings, the system must be installed throughout the entire building. All levels and all areas of the building must be protected.
- In fire alarm system-protected buildings, one centrally controlled system must be provided for the entire building.
- In facilities with several buildings, each fire alarm system-protected building has a separate fire alarm system. The facility may have a central monitoring station from which all of the separate systems can be monitored.

Municipal fire inspectors, building inspectors, and fire insurance company representatives routinely inspect industrial facilities to ensure that the fire alarm system:

- meets applicable codes and standards
- is compatible with the facility's current use (e.g., current occupancy, type of operations and activities, products and materials stored)
- is tested and maintained according to regulations

Standards

Fire detection and alarm systems and their components and third party fire alarm monitoring stations must meet government regulations (e.g., NFPA 72, EN 54) and cited standards. Depending on the country, components must be certified by organizations such as:

- Underwriters Laboratories of Canada (ULC)
- CSA (Canadian Standards Association)
- Underwriters Laboratories (UL)
- Factory Mutual (FM)
- European Committee for Technical Management (CENELEC)

Personnel who install, adjust, repair, alter, or test fire detection and alarm systems and components must be certified (i.e., must successfully complete approved courses and/or training).
Unauthorized tampering with fire detection and alarm systems places the lives of facility occupants in danger. Only certified persons are permitted to install, service, and repair components of fire detection and alarm systems.

**Responsibilities**

In an industrial facility, the facility’s owner is responsible for providing a fire alarm system that is appropriate for the operations and activities conducted, and meets the applicable codes and standards.

The facility’s operator (e.g., owner, landlord) is responsible for ensuring that:

- the fire alarm system is properly maintained and periodically tested by certified fire alarm system specialists
- fire alarm procedures are developed and documented in a Facility Fire Plan
- facility personnel are informed of the response procedures described in the Facility Fire Plan
- fire drills are held periodically

All facility occupants are responsible for:

- learning the recommended fire alarm response procedures (e.g., by reviewing the Facility Fire Plan)
- following the recommended procedure when a fire alarm occurs
- helping those who need assistance to evacuate the building or facility when a fire alarm occurs

Operators and maintenance personnel should be able to identify:

- the buildings at their facility that have fire alarm systems
- the installations at their facility that have fire detection systems
- the buildings and installations at their facility that do not have fire detection and alarm systems
- the procedures to follow when a fire alarm occurs in their work area, including:
  - responsibilities/actions (e.g., shut down power supply)
  - evacuation routes and procedures
  - muster points
  - fire department notification procedures
2.2 System Design

Fire detection and alarm system design takes into account the potential:

- locations of fire
- classes of fire
- stages of fire
- products of fire at each stage

Locations of Fire

Fires are most likely to occur in areas where any of the following are present:

- flammable or combustible liquids or gases
- piles of combustible materials or wastes
- flammable mists, aerosols, dusts, and fibers
- smoking materials and open flames
- cooking equipment
- faulty or improperly-installed electrical or heating equipment
- poor housekeeping

This training kit differentiates between two types of systems to detect fires and provide warning of the fire emergency:

- **Fire alarm systems**, which are installed in occupied buildings. Fire alarm systems are designed to detect fires and to warn occupants to evacuate to a safe location. Often fire alarm systems also notify a monitoring station or the Fire Department. This type of system is installed in occupied buildings such as schools, hospitals, apartment buildings, shopping malls, dormitories, and office buildings.

- **Fire detection systems**, which are installed in unoccupied buildings, and to monitor processes and equipment. Fire detection systems are designed to detect fires and to warn any person in the vicinity to evacuate to a safe location. Often fire detection systems are set up to notify a Control Room or monitoring station. This type of system is typically installed:
  - in enclosed facilities and buildings that are not normally occupied, (e.g., pump stations, utilities buildings, unattended warehouses)
  - on equipment (e.g., electrical transformers, conveyors, utility tunnels)
  - at outdoor facilities (e.g., fuelling stations, tank farms).
Industrial facilities may have one or both types of systems, depending on the types of buildings and installations present and on the codes and standards that apply.

**Classes of Fire**

Fires are classified according to what fuels the fire. The table on the next page lists the four classes of fire used in North America, the type(s) of fuel each class involves, and typical characteristics of each fire class.

Fire/fuel classification systems vary, depending on the country. For example, the following system is used in the United Kingdom and Europe: Class A—freely burning solid materials (e.g., wood, paper); Class B—flammable liquids; Class C—flammable gases; Class D—flammable metals; Class E—energized electrical hazards; Class F—cooking oils and fats.

<table>
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<th>Fuelled by</th>
<th>Description</th>
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| A     | combustible materials (e.g., wood, paper, plastics, straw) | ▪ fire is slow to develop  
▪ more easily contained than the other classes of fire |
| B     | flammable and combustible liquid (e.g., petroleum, oil, lubricant—POL—solvents, grease) | ▪ vapors burn quickly  
▪ produces intense heat  
▪ fire moves with the liquid, e.g., to low areas  
▪ difficult to contain |
| C     | live electrical equipment (e.g., transformers, electrical motors) | ▪ class is related to electrical hazard, not fuel  
▪ after electrical source is disconnected, reverts to the class of the primary fuel (e.g., Class A or Class B) |
| D     | combustible metals (e.g., magnesium, sodium, titanium) | ▪ least common type  
▪ slow to ignite  
▪ once ignited, burns intensely  
▪ extremely difficult to extinguish |

In an industrial facility, different classes of fire may occur in different areas, depending on the products used, materials stored, and activities taking place in the area. For example, based on the above table, potential fires in a machine shop may include:
▪ a Class A fire in the file storage room
a Class B fire in the solvent/cutting oil dispensing room
a Class C fire in the electrical room
a Class D fire in the room where welding rods are stored
a combined Class B, C, and D fire on the milling and welding floor

Fire detection and alarm systems are specifically designed to detect the types of fire that are likely to occur in different parts of a facility.

**Stages of Fire**

There are four stages of fire (combustion):

- stage 1—incipient
- stage 2—smoldering
- stage 3—visible flames
- stage 4—intense heat

The length of time a fire remains in each stage depends on the class of fire and the properties of the available fuel(s). For example, in Class A fires stages 1 and 2 are of relatively long duration; it may take several minutes, hours or days for the fire to reach stages 2 and 3. For Class B fires, stages 1 and 2 are extremely short; the fire enters stage 3 almost immediately and rapidly progresses to stage 4.

The earlier the fire is detected:
- the earlier the fire alarm system can warn people to evacuate to a safe location
- the higher the likelihood of extinguishing the fire before the fire spreads or causes significant damage

**Products of Fire**

All types of fire produce four potentially harmful products:

- flames
- heat
- smoke
- toxic gases
Different classes of fire produce different products at different stages. For example:

- **smoldering mattress**—toxic gas is produced in the incipient stage; during the smoldering stage, invisible and then visible smoke are produced. As the fire progresses to stages 3 and 4, flames and heat are produced.

- **smoldering oily coveralls or rags**—in stage 1, toxic gas is produced; in stage 2, invisible smoke and then visible smoke are produced. If the fire is not controlled, the fire produces smoke and flames (stage 3) and heat (stage 4).

- **burning gasoline**—stages 1 and 2 are extremely short. Flames and smoke are produced almost immediately (stage 3), and then intense heat and toxic gas (stage 4).

**WARNING**

Combustion (burning) of synthetic construction materials, products such as adhesives, and furnishings can:

- produce extremely toxic gases (e.g., chlorine and cyanide) in stages 1 and 2 that can cause poisoning, asphyxiation, and death
- produce up to twice the amount of heat in stage 4 that is generated by burning natural materials (e.g., wood, paper)

Fire detection and alarm systems are designed to detect products generated at different stages of fires. For example, most systems can detect:

- products of stages 1 and 2 (e.g., toxic gas, invisible smoke, visible smoke)
- products of stages 3 and 4 (e.g., flames, heat), in case the fire alarm system fails to detect products of earlier stages.

When the fire alarm system detects one or more products of fire, the system activates fire alarms and may also activate other systems to prevent the fire from spreading (e.g., door closing devices, fire suppression systems).

**NOTE**

Not all fire suppression systems are activated by the fire alarm system (e.g., often sprinklers are activated directly by exposure to heat, not by the fire alarm system).
2.3 Fire Zones

In buildings, fire alarm systems are divided into different fire zones. The fire zones are separated from one another, both physically and electrically. Separation ensures that:

- malfunction/servicing activities in part of the system does not shut down the entire fire alarm system.
- a fire cannot spread rapidly from one part of the building to another (fire walls and fire doors help to isolate the fire).
- personnel and firefighters can quickly identify the location of a fire. The greater the number of fire zones provided, the more precisely the location of the fire can be identified.

Building code specifications include:

- the maximum size of each fire zone
- fire resistance ratings for vertical separations (e.g., fire walls) between zones
- specific requirements for manual and automatic alarm initiation devices (pull stations and fire detectors)
- specific requirements for fire detectors in elevator shafts, stairwells, and ventilation ducts. When fire detectors are installed in these areas, each area is considered a separate fire zone.
- requirements for fire-indicating devices that notify building occupants of a fire. Depending on the type of facility, the devices may include:
  - alarms, including audible and/or visible alarm devices and signals
  - annunciators (a separate indicator light is displayed for each fire zone)

Some fire alarm systems have different alarm signals for different fire zones to help personnel identify the location of a fire.
3 System Components

Fire detection and alarm systems can be configured in different ways, depending on the applicable codes. However, all fire detection and alarm systems consist of four basic components:

- alarm-initiating devices, such as pull stations and fire detectors
- a central control unit (fire control panel or modular fire controller)
- fire-indicating devices, such as sirens, beacons, and annunciators
- power supply

When an alarm-initiating device is triggered, a signal is transmitted via the alarm circuit to the central control unit. The central control unit activates the fire-indicating devices on the circuit, sends alarm messages to remote annunciators, and, depending on the system, may shut down and isolate equipment. Figures 1, 2, and 3 show three different fire detection and alarm system configurations that are commonly used.

Figure 1—Fire Alarm System with Fire Control Panel
Figure 1 shows the configuration typically used for occupied buildings. Alarm-initiating devices are monitored and controlled by a fire control panel (fire alarm system control panel, fire control panel, fire cabinet). When a device initiates an alarm, the fire control panel activates local and remote alarms, ancillary devices, and suppression systems.

Figures 2 and 3 show the configurations typically used for industrial processes and for industrial facilities such as fuelling stations, pump stations, and tank farms.

**Figure 2**—Fire Alarm System with Modular Fire Controllers and PLC/DCS

In Figure 2, alarm-initiating devices communicate with, and are monitored by a modular fire controller (rack-mounted controller, fire control module). When the modular fire controller receives an alarm signal, the fire controller relays the alarm signal to the PLC or DCS (refer to the text box on page 14).
When the PLC/DCS receives the alarm signal, the PLC/DCS (i.e., not the modular fire controller):

- activates local and remote alarms
- depending on the operation or process, may:
  - shut down equipment
  - activate isolation devices and/or suppression systems

In Figure 3, unitized (stand-alone, intelligent, smart) fire detectors can communicate directly with the station PLC or DCS and a modular fire controller is not needed. When the PLC/DCS receives an alarm signal, the PLC/DCS:

- activates local and remote alarms
- depending on the operation or process, may:
  - shut down equipment
  - activate isolation devices and/or suppression systems
In occupied buildings, depending on the applicable codes and standards, fire alarm systems can be supplemented by:

- emergency communications systems
- ancillary devices
- fire suppression systems
- smoke control systems (required in high rise buildings and residential institutions such as hospitals)

This section provides an overview of the principle components of fire detection and alarm systems. Note that not all facilities are equipped with all the components. During the walkthrough that accompanies this training kit, you will have an opportunity to identify the components at your facility.

### 3.1 Alarm-Initiating Devices

Alarm-initiating devices are critical components of fire detection and alarm systems. For this reason, building codes and industry regulations typically specify the required number, type, and location of alarm-initiating devices. Alarm-initiating devices must also meet specific standards and, once installed, be regularly inspected, tested, and serviced to ensure they are operating properly. Alarm-initiating devices fall into one of two categories:

- manual alarm-initiating devices
- automatic alarm-initiating devices
Manual Alarm-Initiating Devices

Fire alarm systems may provide manual alarm-initiating devices, such as:

- manual pull stations
- break glass stations
- call (phone) boxes

Figure 4—Manual Alarm-Initiating Devices (Courtesy of The Protectowire Company, Inc.)

In occupied buildings, manual alarm-initiating devices are installed in several locations on each level of the building, including:

- normal traffic routes (e.g., in hallways, near exit doors, outside stairwell entrances)
- hazardous work areas (e.g., process areas, laboratories, paint booths, areas where flammable and combustible materials are used, stored, or handled)
- areas where ignition sources, flammable or combustible materials, or smoking materials are used (e.g., outside mechanical rooms, in welding and grinding areas, in cafeterias and smoking areas)
- areas where valuable items, equipment, or data are used or stored (e.g., materials storage warehouses, garages, and computer rooms)
In occupied buildings, all manual devices are connected to the fire control panel. Not all fire control panels are programmed to respond the same way when they receive an alarm signal from a manual device:

- Some fire control panels only activate building alarms. After initiating the alarm at the manual station, personnel must phone the fire department.
- Some control panels activate building alarms and, additionally, may automatically notify either:
  - the fire department
  - a third party monitoring station. When a fire alarm is received, the monitoring station personnel phone the fire department.

Find out whether activating a manual station in your facility automatically notifies the fire department or whether a separate phone call is required.

Do not depend on a monitoring company to notify the fire department. Phone lines can fail or personnel may be responding to another call. When a fire alarm occurs, phone the fire department immediately.

In addition to notifying the fire control panel, activation of a manual device may automatically deactivate automatic door locks. This feature is designed to enable evacuees to escape without delay and to provide ready access to firefighters.

**Automatic Alarm-Initiating Devices**

Fire alarm systems include automatic alarm-initiating devices, such as:

- fire detectors
- waterfall detectors

Fire detectors detect the products of fire (smoke, heat, flames, or carbon monoxide). When a product of fire is detected, fire detectors initiate an alarm via a signal to the fire control panel or modular fire controller. As shown in Figure 3, *unitized* detectors used in some industrial installations combine the functions of a fire detector and a modular fire controller. These unitized detectors do not need a fire controller, because they can send signals directly to the installation’s PLC or DCS. Fire detectors are described in detail in Section 4—*Fire Detectors*.
Waterflow detectors detect water flowing from sprinklers or deluge systems and are described in Section 3.7—Fire Suppression Systems.

### 3.2 Central Control Unit

As previously mentioned, two different types of control units are used for fire detection and alarm systems:

- **fire control panels,** which are typically installed to monitor buildings. Fire control panels carry out a wide range of functions.
- **modular fire controllers,** which are typically installed to monitor processes, equipment installations, and outdoor facilities. Modular fire controllers carry out a much narrower range of functions than fire control panels.

Features of both types of control units are described in detail in Section 5—Central Control Units.

#### Fire Control Panel

The fire control panel is the *brain* of the building’s fire alarm system. All circuits for the fire alarm system terminate at the fire control panel, which is installed in a non-hazardous area.

When the fire control panel receives an alarm signal from an alarm-initiating device (manual station, fire detector, or水流流测器), the panel activates:

- local fire alarms
- local annunciators
- ancillary activation devices
- fire suppression system activation devices
- alarms at remote monitoring facilities (e.g., one or more off-site monitoring stations, the fire department)

The fire control panel continually monitors the condition of all alarm-initiating devices and circuits in the fire alarm system. If an abnormal condition is detected, the control panel activates appropriate alarms (e.g., FIRE, TROUBLE).

Older *conventional* fire control panels have separate displays for each fire zone, but not for each alarm-initiating device within a zone. For example, if any device in fire zone 3 initiates a trouble alarm, the display for zone 3 indicates TROUBLE. A newer type, the *addressable* fire control panel, has separate
displays for each alarm-initiating device within each zone (e.g., in zone 3, smoke detector 7 displays TROUBLE; all other detectors display NORMAL).

**Modular Fire Controller**

As previously described, the modular fire controller carries out fewer functions than the fire control panel. The modular controller:

- is installed in a non-hazardous area that is relatively secure
- receives signals from manual alarm-initiating devices (fire detectors and, if applicable, manual stations) and transmits signals to the PLC/DCS.

The modular fire controller continually monitors the condition of all alarm-initiating devices and circuits within its limited fire detection system. If an abnormal condition is detected, the unit transmits the appropriate alarm to the PLC/DCS (e.g., FIRE, TROUBLE).

Both conventional and addressable modular fire controllers are available:

- conventional controllers do not have separate displays for each device (e.g., if any device initiates a fire or trouble alarm, the controller displays FIRE or TROUBLE).
- addressable controllers have separate displays for each device (e.g., smoke detector 4 displays TROUBLE; all other detectors display NORMAL).

### 3.3 Fire-Indicating Devices

Fire detection and alarm systems provide two types of fire-indicating devices:

- fire alarms
- fire annunciators

**Fire Alarms**

Fire alarms include:

- audible alarms (e.g., sirens, bells, horns, whistles, and voice messages)
- visible alarms (strobe lights, beacons, text messages, alarm icons or alarm pages on terminal screens)
Building codes have strict requirements for installing fire alarms. For example, audible fire alarms must be:

- loud enough to be heard above background noise levels in the building
- distinguishable from other signals or alarms that may occur
- installed in sufficient numbers and locations to be heard in all parts of the building (e.g., in corridors, stairwells, storage areas, operation and process areas, offices, lunchrooms, washrooms, and locker rooms)

In high-noise areas, and in areas commonly occupied by hearing-impaired persons, visible alarm displays must also be provided. The displays must be:

- clearly visible to personnel working in any part of the room
- readily distinguishable from all other potential light displays or effects

In addition to fire alarms, fire alarm systems provide other types of alarms, including:

- trouble alarms, to notify personnel that one or more system components is/are not functioning properly
- workflow alarms, to notify personnel that water is flowing in sprinkler system piping

Depending on the system, the alarms can be displayed as audible and/or visible signals on detectors, fire control panels, modular fire controllers, and on fire annunciators.

Fire Alarm Locations

Depending on the system, fire alarms can be activated in more than one location, including:

- on the central control unit (fire control panel or modular fire controller)
- on annunciators at one or more locations in the facility
- on monitoring screens at an off-site location, such as a:
  - control room DCS or SCADA screen
  - third party monitoring station
For their own facility, operators and maintenance personnel should know:
- locations of on-site fire alarms
- whether fire alarms are monitored off-site (remotely)

**Fire Annunciators**

Fire annunciators, which are typically installed in buildings, are also called *repeater panels* or *annunciator panels*. Figures 5a and 5b show two different types of annunciators: a graphic annunciator and a tabular annunciator.

*Figure 5a—Graphic Fire Annunciator*
(Courtesy of Space Age Electronics, Inc.)

*Figure 5b—Tabular Fire Annunciator*
(Courtesy of Space Age Electronics, Inc.)
Annunciators have different indicators (colored lights, LED displays, or text displays) to indicate the current status of each fire zone. Depending on the system, the indicator may be activated either by the alarm-initiating device or by the fire control panel. Typical indicators include:

- **NORMAL**—no fire, no mechanical or electrical problem
- **FIRE**—fire is detected; immediate action is required
- **SUPERVISORY**—a condition exists that is not normal and may indicate a mechanical or electrical problem could occur in the near future
- **TROUBLE**—a mechanical or electrical problem has occurred or one or more components are disabled
- **WATERFLOW**—water is flowing in the sprinkler system; immediate action is required

Fire annunciators are **not** the same as fire control panels, even though they look similar. Fire annunciators do **not** perform control functions but can only display the status of fire zones and alarm-initiating devices.

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End of Sample

A full licensed copy of this kit includes:
- Training Module and Self-Check
- Knowledge Check and Answer Key
- Blank Answer Sheet
- Performance Checklist

The full version of this kit can be purchased at: [http://www.hdc.ab.ca/purchase_description.asp?ID=33](http://www.hdc.ab.ca/purchase_description.asp?ID=33)