EXTINGUISHING SYSTEM DETECTION AND CONTROL

INTRODUCTION

Extinguishing systems require prompt detection systems so they operate quickly and effectively. However, the detection system must not be so sensitive that it results in a false discharge of the extinguishing system. This section describes how to select and install detectors used to discharge extinguishing systems so that these systems will operate reliably without false alarms.

POSITION

Detection

Select detectors that sense fire at its earliest stages by detecting heat, smoke, flame, vapor or pressure. Use detectors listed by a nationally recognized testing laboratory to actuate extinguishing systems. Use detection systems appropriate for the hazard that are designed, installed and tested in accordance with NFPA 72. Connect the detectors to control units listed by a nationally recognized testing laboratory for use as releasing devices. Locate the control panel directly outside the area being protected so it will be accessible when needed.

Install electrical wiring according to Article 760 of NFPA 70 unless otherwise specified in this guide. Most control units use wiring of the nonpower-limited type. For power-limited control units, use either FPL (power-limited fire alarm) cable, FPLP (power-limited fire alarm plenum) cable, or FPLR (power-limited fire alarm riser) cable. All wiring and/or cable should be capable of withstanding greater than 212°F (100°C).

Extinguishing systems for computer rooms or similar sensitive occupancies must delay the operation of any exhaust system until the extinguishing system has operated and held an extinguishing concentration long enough to extinguish the fire and summon an emergency response. Detection systems for cleanrooms present unique problems which are addressed in PRC.17.1.1.C.

Consider the air flow patterns and place detectors in the expected path of smoke travel. Do not place detectors in front of air supply ducts or in dead air spaces where they will not respond to smoke.

In special extinguishing systems using ionization, photoelectric or air sampling type smoke detectors, or ultraviolet or infrared flame detectors, reduce the possibility of false trips by designing the detection system so that the alarm is verified before starting the time delay leading to system actuation. The most common way to accomplish this is cross-zoning, where two independent zones are established and at least one detector from each zone must sound an alarm before actuation occurs. Two smoke detectors must operate within the area spacing prescribed in NFPA 72 for detection-only applications. Another way of verifying an alarm is to have the same detector alarm at several levels. Other

proprietary methods include “superzone,” “priority matrix,” “verified detection" and "intelligent” systems. These methods use a single detection zone but rely on two detectors to actuate the system.

In areas containing raised floors, arrange detectors for both horizontal and vertical cross-zoning. An example of vertical cross-zoning is a system that would allow one detector in the underfloor space and one detector in the room to operate the extinguishing system.

Arrange the detector circuit so that a single detector produces a distinctive alarm. In addition to producing an alarm, the detector circuit can start time delays, automatically shut down ventilation or air conditioning equipment and close automatic dampers unless the loss of agent is compensated for in the extinguishing system design. The activation of a second detector will sound a different alarm and discharge the agent after appropriate time delays have operated. Time delays to prepare the room for discharge should be as short as practical to allow for evacuation of the room. The minimum delay time per NFPA 12 is 20 s.

Central HVAC systems may require smoke detectors located in the return air plenum if air patterns hamper efficient detector response at the ceiling. Upon actuation, the duct detector can shut down the HVAC system, allowing area detectors to function normally. Commonly the recirculating air dampers close and the damper to the atmosphere open for exhaust. Another series of smoke detectors are located in the make-up air supply. They are designed to shut down the make-up air fans and prevent products of combustion from entering the building.

Design rate-of-rise or fixed-temperature detection systems so that operation of a single detector results in actuation of the extinguishing system.

Transmit the extinguishing system alarm to a UL-certificated Central Station, Auxiliary, Remote Station or Proprietary signaling system, where available. Also transmit supervisory and trouble signals to the appropriate location.

Provide reserve battery power or an emergency power generation system in accordance with NFPA 72. When calculating the capacity of the battery power supply, consider the power requirements of detectors, control panels, multiple audible and visual alarms, and the actuation circuit, as well as any electrical interlocks, under both the standby and alarm conditions.

Control

When control units listed for releasing device service are provided, supervise essential external circuits. AXA XL Risk Consulting stipulates that all actuation devices be individually supervised unless they are wired to operate in series.

AXA XL Risk Consulting supports a fully integrated design - one that uses all system components from the same manufacturer. These systems usually result in fewer problems; when problems do occur, vendor responsibility can easily be established. AXA XL Risk Consulting recognizes that, in a competitive market, designers will specify the most economical package with a considerable degree of equipment mixing. With proper care in the design, satisfactory system reliability can be achieved. However, problems have been experienced when installers have used components that were not compatible with the combined resistive, inductive and capacitive load characteristics of the control panel circuits.

When the system design is unique, the installer may be limited by standard panel configurations and may find it necessary to use another manufacturer’s equipment. The designer should verify the compatibility of the components used in the control panel and should verify that circuits meet the voltage, current and capacitance requirements of the component. Include this documentation as part of the submittal for review by AXA XL Risk Consulting.

On pneumatically actuated systems, supervise all piping or tubing necessary to operate the system. Although it would be preferable, the interconnecting pipe or tubing used between containers need not be supervised if the pneumatic means of actuation relies solely on backpressure through the discharge manifold to trip subsequent containers **or** if the following conditions are met:

- Containers are adjacent to each other so that they are practically touching.

- The interconnection is a direct run between two adjacent containers and is of minimal length.
- Suitable mechanical protection, such as caging of the containers, is provided. In lieu of this, provide mechanical protection, such as concentric piping or barriers. For tubing, use Schedule 80 piping with malleable fittings, and use listed flexible connectors.

Detection and control systems can be easily impaired. Provide manual means outside the protected area to actuate the extinguishing system when the detection system is temporarily out of service.

When two or more extinguishing systems protect the same hazard, actuate each system by a separate detection circuit and control panel. An example of this may be a clean agent primary system and a pre-action sprinkler back-up system both protecting a computer room. Separate detection circuits and control panels would prevent both systems from being impaired simultaneously in the event of a detection circuit open or other panel failure.

For smoke detector testing and maintenance, see NFPA 72 and PRC.11.1.1.0.

DISCUSSION

Selection of the most applicable automatic detection system depends on a thorough analysis of the hazard's pre-ignition and burning characteristics, as well as the limitations of the selected extinguishing system.

Common detectors are those that sense thermal changes, smoke evolution, flame spectrum, pressure development or changes in vapor concentration. Refer to PRC.13.0.1.A for a summary of detection system selection factors.

Detectors may be one of the following types:

Fixed temperature - Uses materials that expand or melt when heated. These devices include:

- **Fusible element** - Composed of a eutectic metal (low melting alloys). At a predetermined temperature range the eutectic metal element in this device melts and either releases the extinguishing agent or electrically operates a circuit that actuates the extinguishing agent's release mechanism. It can be installed on an area basis or on a per hazard basis. It is nonrestorable.
- **Frangible element** - Composed of a glass encapsulated liquid. At a predetermined temperature range, the liquid expands and breaks the glass capsule, releasing the extinguishing agent or other medium, which in turn actuates the extinguishing agent's release mechanism. It can be installed on an area basis or on a per hazard basis. It is nonrestorable.
- **Bimetallic element** - Uses two metals with different expansion coefficients that cause an element to move upon rise in temperature. The movement mechanically operates an electric circuit that actuates the extinguishing agent's release mechanism. It can be installed on an area basis or on a per hazard basis. It is restorable within the temperature limitations of the metals used.
- **Linear element** - Uses one metal with known physical characteristics. It is designed to be installed on an area basis or along an extended narrow width and may be of the following types:
  - **Thermistor cable** - Uses a coaxial cable with a center conductor covered with a temperature sensitive semiconducting material covered by a metallic tubing. A temperature increase causes a reduced resistance in the semiconducting material and increases the pre-established current flow. It is a restorable device capable of withstanding very high temperatures.
  - **Thermostatic cable** - Uses a thermoplastic insulated cable pair which at a predetermined temperature range melts and causes a short in the circuit. This action mechanically closes the actuation circuit of the extinguishing system. It is nonrestorable, but easily replaced by splicing.

- **Eutectic cable** - Uses a coaxial cable with a center conductor covered with a temperature sensitive eutectic salt mixture, that in turn is covered by a metallic cover. A temperature increase causes a current flow to the outer jacket, which electrically actuates the actuation circuit of the extinguishing system. It is a restorable device capable of withstanding very high temperatures.

- **Rate of rise** - Responds to a quick temperature rise but will not alarm with slow change in ambient conditions. There are two basic designs. One is a metal chamber containing air which increases in pressure when heated. A vent in the connecting tubing system vents slow rates of pressure increase due to ambient conditions of too small a thermal flux. The other depends on the expansion of a metal rod. These devices are restorable.
- **Rate compensated** - Uses two metallic parallel component elements encased in a metal shell. The shell expansion rate is faster than that of the internal struts under a rapid thermal flux. This device can operate as a result of a quick temperature rise or at a predetermined fixed temperature. Usually restorable except for some with fusible fixed temperature portions.

Smoke - Senses combustion products in a variety of ways. These devices include:

- **Ionization** - Detects smoke particles that are not generally visible in the incipient stage of a fire. The detector may contain a single or dual ionization chamber. The detector has a small radioactive source which ionizes the air in the sensing chamber. When smoke enters the chamber, it slows the movement of charged ions which changes the current flow causing the detector to go into an alarm condition. It can be installed on an area basis or on a per hazard basis. It is a restorable device. Since most of the detector is made of plastic, it can easily be destroyed by high temperatures.
- **Photoelectric** - Detects smoke particles that are generally visible in the incipient stage of a fire. It can be installed on an area basis or on a per hazard basis. It is a restorable device unless destroyed by high temperatures. The operating principles are based on light intensity. Two types are:

- **Obscuration** - Uses a light source and photo cell collector. Smoke reduces the amount of light received at the collector. This reduced light intensity decreases the current flow in the circuit which causes the device to go into an alarm condition.

- **Light scattering** - Uses a light source and photo cell collector. Smoke reflects the light which is collected by the photo cell. This increased light intensity increases the current flow in the circuit which causes the device to go into an alarm condition.
- **Air sampling** - Provides ultra sensitive smoke detection at a variety of preset levels. The device is arranged to continually draw a sample of the air from the protected area. It can be installed on an area basis or a per hazard basis. It is a restorable device unless destroyed by high temperatures. The sample is analyzed by one of the following methods:

- **Wilson cloud chamber** - Introduces water vapor in the sample chamber which forms a cloud and coats each particle with water vapor making them larger and more easily detected. The detection device counts the particles and alarms at a variety of levels.

- **Photoelectric** - Has much higher sensitivity; similar to other photoelectric devices.

Flame - The fire signature range is present over a wide range of the light spectrum. This exceeds the visible range on both ends. The detected energy increases the current flow in the circuit which causes the device to go into an alarm condition. This device can be installed on an area basis or on a per hazard basis. It is restorable unless destroyed by the fire or its effects. Some smoke detectors can react to specific flame signatures.

- **Infrared (IR)** - Designed to respond to electromagnetic energy in a range of less than 4000 Angstroms (0.4 microns). IR detectors respond to fire in milliseconds. Nonfire false alarms can be caused from light sources such as sunlight, lightning, welding arcs and x-radiation.

- **Ultraviolet (UV)** - Designed to respond to electromagnetic energy in a range of greater than 7000 Angstroms (0.75 microns). UV detectors respond to fire in milliseconds. Nonfire false alarms can be caused from light sources such as sunlight, lightning, welding arcs and x-radiation.
- **Dual spectrum** - prevent false trips by requiring both an IR and a UV. In some cases, one spectrum must be satisfied to arm the other.
- **Fiber optic cable** - Designed with a flexible closed loop cable. When exposed to fire, the light signal is degraded causing it to go into an alarm mode. Response time is 3 to 8 s.

Pressure - Changes in pressure not directly related ambient heat can also be used to detect combustion.

- **Pressure transducers** - An ultra sensitive diaphragm reacting to minor pressure increases from an explosion can be detected in advance of destructive forces. The sensed pressure initiates a current flow in the circuit which causes the device to go into an alarm condition. It may be of the fixed or variable pressure design. It can be installed on an area basis or a per hazard basis and is nonrestorable.
- **Pressurized tubing** - Small diameter pressurized plastic tubing (nylon) melts in the presence of fire. The resulting loss of pressure causes a pressure cartridge to activate sending a pressure wave to the suppression system container control device. Response time is 3 to 8 s and the detector unit is not restorable. Typical uses are inside robots and heavy mobile equipment.

Vapor - Combustion gas analyzers. Detects a particular class of gas. The detecting element is a catalytic metal element that increases the oxidation rate of combustible gases; the subsequent temperature rise initiates a current flow in the circuit which trips the actuation circuit of the extinguishing system. This device provides ultra sensitive gas detection at a variety of preset levels. It can be installed on an area basis or a per hazard basis. It is nonrestorable.

- **Fuel vapor** - Vapors from flammable and combustible gases or liquids can be detected when they are at low levels of concentration prior to their ignition.
- **Fire gases** - Vapors from combustion products and residual oxygen can be detected when they at are low levels of concentration during the smoldering stage of the fire.

Other kinds of detectors that could operate extinguishing systems include O_2 detection if operating above the upper explosion limit or any process-upset condition, such as loss of cabinet of room pressurization, presence of products that should not normally be there, or liquid level.

Detection System Selection Factors

To achieve prompt and reliable detector response, evaluate system factors using good engineering judgment. Consider the environment, economics, method of detection, and especially the detector's limitations. Consider what detectable airborne products will be in the fire compartment both before and after ignition. Pay particular attention to the following detector selection factors:

- **Sensitivity** - The speed of reacting to products of combustion. Some detectors are so responsive that they react to materials that look or act like products of combustion. Reaction to unintended similar materials can result in false alarms.
- **Stability** - A stable detector responds consistently to a set of similar hostile conditions.
- **Time delay** - Some detectors have an inherent delay as part of their operating principle. Consider the rate of flame spread in relation to detector response.
- **Verification** - Reduced stability can be compensated for by verification of the detector's operation. All detector operations do not have to be verified; verify only those that are so sensitive that the detection signal may be inappropriate. Most verification is done through cross-zoning using a second detection device. Other verification methods include multiple alarms at incrementally higher levels of detectables or by confirming the existence of the alarm condition over a repeated time interval.

- **Unit coverage** - Follow the manufacturer's equipment listing for the number and the placement of the detection devices.
- **Economics** - The cost of the detection system should be in line with the values that are protected. The same fire can be detected in many ways. Evaluate total detector cost based on:
  - Initial unit cost.
  - Cost to install.
  - Cost to test.
  - Cost to service and maintain.
- **Environment** - Function and life expectancy of a detection system can be affected by temperature, humidity, barometric pressure and air velocity. Inappropriate environmental conditions can cause false alarms. Special consideration is needed for detection systems in corrosive and hazardous atmospheres.

DETECTION SYSTEM SELECTION FACTORS

	Detection Characteristics													
			Time	Verify	Coverage	Unit	Cost to	Cost to	Cost to	Restorabl		Function	Affected by	
Type of detector	Sensitivity	Stability	Delay	Alarm	Area	Cost	Install	Test	Service	e	Temperature	Humidity	Pressure	Air velocity
THERMAL:														
Fusible	Low	High	High	No	High	Low	Avg	N/A	V low	No	N/A	No	No	No
Frangible	Low	High	High	No	High	Low	Avg	N/A	V low	No	N/A	No	No	No
Bimetallic	Low	High	Avg	No	High	Low	Avg	Low	V low	Yes	N/A	No	No	No
Linear:														
Themistor	Low	High	Avg	No	High	Low	Low	Low	Low	Yes	N/A	No	No	No
Thermostatic	Low	High	Avg	No	High	Low	Low	Low	Low	No	N/A	No	No	No
Eutectic	Low	High	Avg	No	High	Low	Low	Low	Low	Yes	N/A	No	No	No
Rate of Rise	Low	High	Avg	No	High	Low	Avg	Low	Low	Yes	N/A	No	No	No
Rate Compensated	Low	High	Avg	No	High	Avg	Avg	Low	Low	Yes	N/A	No	No	No
SMOKE:														
Ionization	High	Low	Low	Yes	Avg	Avg	Avg	Avg	Low	Yes	Low	Avg	Low	Avg
Photoelectric:														
Obscuration	High	Low	Low	Yes	Avg	Avg	Low	Low	Avg	Yes	Low	Low	No	Low
Light Scattering	High	Low	Low	Yes	Avg	Avg	Avg	Avg	Avg	Yes	Low	Low	No	Low
Air Sampling:														
Photoelectric	V high	Avg	V low	Multiple	Avg	High	Low	Low	Low	Yes	Low	Low	Low	Avg
Particle	V high	Avg	V low	Multiple	Low	High	Avg	Low	Low	Yes	Low	Low	No	Low
FLAME:														
IR	High	Low	V low	Yes	V high	Avg	Low	Low	Low	Yes	Low	No	No	No
UV	High	Low	V low	Yes	Low	Avg	Avg	Low	Avg	Yes	Low	No	No	No
Fiber Optic	High	High	V low	No	V low	Avg	Avg	Low	Low	No	N/A	N/A	N/A	N/A
PRESSURE:														
Transducer	V high	Avg	V low	No	Low	Low	Avg	Avg	N/A	Yes	Low	No	Avg	No
Tubing	Avg	V high	High	No	V low	V low	Low	N/A	Low	No	N/A	N/A	N/A	N/A
VAPOR:														
Fuel Vapor	V high	V low	V low	Multiple	Low	High	Avg	High	V high	Yes	Low	Low	No	No