Facts About Smoke Detectors

. . . basic types, installation pointers, application criteria

ASK A GROUP of fire-protection experts to define the perfect fire detector and they will probably give a variety of answers. Some will flatly say that such a thing doesn't exist. They will explain that all detectors simply react to certain characteristics of combustion--smoke, heat, or flame--and trigger an alarm. Because detectors cannot tell whether these characteristics are from a fire or another source, no perfect detector exists.

Most experts agree that smoke is responsible for approximately 80 percent of the fatalities caused by fires. This fact of life has triggered the phenomenal growth in popularity of residential-type smoke detectors. In many communities, legislation has been passed requiring the installation of smoke detectors in houses and apartments. And the dramatic rise in residential smoke detector popularity is spilling over into industry--not only as life-saving devices, but also as a key part of fire protection systems for buildings and equipment

The National Electrical Manufacturers Association (NEMA) in its Standards Publication SB 9 defines a smoke detector as "a device which detects visible or invisible particles of combustion." The publication points out that the real value of such a device lies in its ability to detect a fire even before flame and large quantities of heat develop (see section, "Principles of Fire").

The two major types of smoke detectors are the ionization and photoelectric units. All smoke detectors depend on various combinations of minute liquid or solid particles suspended in a gaseous dispersion agent for their operation. Particle characteristics that affect detection thresholds include diameter, shape, internal structure, optical properties, and concentration.

Ionization Smoke Detectors

Ionization units contain small amounts of radioactive material (usually Americium-241). They emit alpha radiation that ionizes the nitrogen and oxygen molecules of air in a sensing chamber. The ionization allows a small electric current to flow across the air gap between two oppositely charged electrodes. When combustion particles enter the chamber, they attach themselves to the ions, reducing ion mobility. The reduced mobility lowers current and increases voltage. An alarm sounds when voltage rises to a predetermined level.

Ionization smoke detectors for industrial use differ from the majority of residential models in that they are powered from a central control panel instead of battery-powered, and have two sensing chambers instead of one. The second chamber is sealed from the atmosphere and serves as a reference. It monitors ambient conditions and compensates for changes in humidity, pressure, and temperature and can operate under a wide range of environmental conditions.

Photoelectric Smoke Detectors

Photoelectric units use a light-energy source and a receiver to detect smoke particles. The two basic designs--beam and spot--operate on the smoke-obscuration principle.

Beam-type detectors use a light source or laser beam directed at a photocell. Smoke is detected as the particles cause a decrease in light transmission. Smoke intercepts the beam and reduces the intensity of light reaching the photocell, causing an electrical impulse to be transmitted to control equipment that sounds an alarm.

Spot-type detectors (also called "Tyndall effect" units) are of two types. One focuses a beam of light at a 90-degree angle across the face of a photocell, which is located in a light-tight smoke chamber that permits smoke to enter. The photocell's area of view is at a right angle to the beam of light. When smoke enters the chamber, light from the beam impinges on the smoke particles and is scattered into the photocell, which reacts to the disturbance.

The other spot-type detector projects a light beam in a straight line at a photocell. A target disc in front of the photocell obscures most of the light. When smoke enters the chamber, light is refracted from the smoke particles around the disc onto the photocell surface. In both designs, when the reflected light from the smoke particles reaches the photocell, electrical conductivity changes. An alarm is triggered when voltage increases to a preset point.

Photoelectric smoke detectors can respond to particle sizes from about 10.0 microns to 0.2 micron. Solid-state circuitry and LED (light-emitting diode) light sources ensure cool operating conditions and long lamp lives. Incandescent and high-intensity strobe lamps are also used. Cost of photoelectric detectors is about the same as that of ionization units.

Selection and Application Factors

Experts agree that there is no single solution to the problem of which type of smoke detector will give the best service in a given situation, because each installation has its own characteristics. In many cases, a combination of units is warranted. Building geometry, air currents, effects of smoke stratification, dilution of smoke by fresh air, etc., all influence smoke-detector performance.

All smoke detectors listed by Underwriters' Laboratories (UL) and approved by Factory Mutual (FM) -- whether ionization or photoelectric-- must pass certain performance tests. Key criteria are smoke obscuration and response time. All detectors must respond to gray smoke concentrations of from 0.2 to 4.0 percent obscuration per foot.

Frequently, both ionization and photoelectric smoke detectors are used in the same system. However, ionization detectors are the most popular — they account for over 80 percent of the installations.

Model S250 Ionization Smoke Detectors

In general, ionization smoke detectors are the best choice in situations where there is an open flame, relatively low air turbulence, and no heavy accumulation of smoke. The units are especially popular today in offices, living quarters and high-risk areas such as computer rooms.

Changes in atmospheric pressure, humidity, and temperature can influence their sensitivity. Normal changes of atmospheric pressure are compensated for within most ionization detectors and do not affect sensitivity. However, the lower air pressure at higher altitudes decreases sensitivity and an adjustment is necessary. An increase in relative humidity can also increase the detector's sensitivity. Ionization detectors will operate at temperatures between 32 and 120 °F. In general, the lower the temperature, the more sensitive the detector is. However, protection must be provided against water condensation at low temperatures. Air velocity definitely affects detector sensitivity. Ionization detectors become more or less sensitive as velocity changes. Normally, ionization units should not be used when air velocity exceeds 1000 fpm.

The Model S250 Smoke Detector is intended for installation per NFPA Standard 72 on a ceiling, on a wall near the ceiling, or under a raised floor. NFPA 72 recommends Ionization Smoke Detection where **flaming fires that produce invisible products of combustion** are expected. (Where smoldering fires are also expected, SST Model S260 Photoelectric Smoke Detectors may be mixed with Ionization detectors to secure the earliest possible detection.) Ionization detectors are not suitable for installation in kitchens, areas with excessive exhaust fumes, furnace rooms, near fireplaces, or within 3 feet of air supply registers or diffusers.

The Model S250 is to be installed on maximum 30 foot centers, typically on smooth ceilings up to 15 feet high with minimum air circulation. This results in a 900 square foot coverage area which may be used as a guideline for coverage. Where special conditions exist (ceiling obstructions, high air exchange rates, etc.), reduced square footage spacing must be used to achieve adequate protection. Computer Rooms and other such installations may require spacing with maximum 200 square feet due to high air exchange rates. Complete application guidelines are in NFPA Standard 72.

The Model S250 may also be installed to monitor the air in a ventilation system using a special duct mounting base. The base extracts a small sample of the air from the duct and passes it through the detector for analysis.

Model S260 Photoelectric Smoke Detectors

Photoelectric smoke detectors are usually recommended if visible smoke may be expected from a fire, or if environmental conditions make ionization units impractical. Most photoelectric units are suitable for continuous operation in an ambient-humidity range up to 93 percent and a temperature range from 32 to 120 °F. Photoelectric units are highly sensitive to the start of a fire and are not overly sensitive to normal variations in temperature, humidity, and air movement.

The Model S260 Smoke Detector is intended for installation per NFPA Standard 72 on a ceiling, on a wall near the ceiling, or under a raised floor. NFPA 72 recommends Photoelectric Smoke Detection where **smoldering fires that produce visible smoke** are expected. (Where flaming fires that produce invisible products of combustion are also expected, SST Model S250 Ionization Smoke Detectors may be mixed with Photoelectric detectors to secure the earliest possible detection.) The S260

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Releasing Systems

Smoke detectors can be connected to automatic releasing devices to perform a variety of operations. For example, fire-suppression systems can be quickly activated. Because of their high sensitivity, smoke detectors are seldom used to activate water-spray or water-deluge systems. However, gaseous fire-suppression systems, such as FE-13 or carbon dioxide, and foam or dry chemical systems are becoming quite common. FE-13 fire-suppression systems are often used in computer rooms, electrical control rooms, microwave relay stations, and other high-value, high risk areas. The main reasons for the popularity of FE-13 are its favorable life-safety aspects and the absence of residue or adverse effects on equipment after the agent has been released.

Fire doors and windows can also be activated by smoke-detection devices. Fans and blowers in air ducts can be shut down by smoke detectors to prevent smoke from spreading into other areas. Detectors can also be used to activate smoke-control and exhaust systems.

Principles of Fire

Stated in the simplest terms, fire results from the combination of fuel, heat, and oxygen in the proper proportions. The burning process, however, is much more complicated, involving a series of complex chemical reactions. *Pyrolysis* -- the chemical decomposition of matter through the action of heat -- occurs as ambient temperatures are exceeded. For example, when heat is applied to wood:

- Decomposition begins, causing gases and water vapor to evolve. The surface of wood is attacked first. Liberation of the combustible components of the gases increases. As charring occurs, the reaction moves deeper into the wood.
- Gas evolution increases, and ignition occurs when the lower flammability limit of the gases is reached. Fire becomes self-sustaining.
- Secondary pyrolysis process begins. Gas evolution intensifies, temperature continues to rise, and the char begins to slow. The volume of air drawn into fire increases, helping to support combustion.
- The fire continues to burn as long as a positive heat balance exists and more heat is generated than is lost through conduction, convection, or radiation. If more heat is lost than is generated, the fire will go out.

All fires can be extinguished by removing the fuel, limiting the oxygen supply, reducing the heat, or inhibiting the chemical reactions.