

Smoke Detectors: Protect What Matters!

1. Introduction.

Smoke detectors save lives. The National Fire Protection Agency (NFPA) reports that the top causes of home fires include cooking, heating, candles, electrical failures, and smoking.¹ Everyone is at risk from at least one of those causes. You might ask, “Are smoke detectors really worth it?” You might also ask, “How do I choose the right smoke detector?” Understanding how to install and maintain your smoke detector is also essential. Let us discuss how to make your home safer and protect what matters!

2. Are smoke detectors worth it?

Smoke detectors can cost as little as ten to twenty dollars each.² **Figure 1** shows that working smoke detectors save lives. Smoke detectors also save their owners money. Most insurance companies offer a discount if you install a monitored system. Even if you cannot afford a monitored system, the early warning provided by a simple, self-installed smoke detector will give you a warning that could save your life.

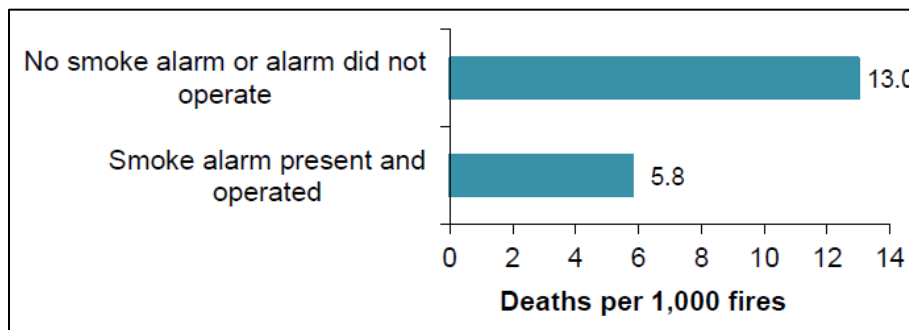


Figure 1. Deaths per one thousand fires and smoke alarm status for fires reported between 2014-2018.³ People with working smoke alarms increased their odds of surviving a fire by 54.4 percent.

Almost three of every five home fire deaths resulted from fires with no smoke alarms (41%) or no working smoke alarms (16%).⁴ Installing a smoke detector will improve you and your family’s ability to survive a fire.

3. Types of smoke detectors.

The two primary kinds of smoke detectors people use in their homes are *Photoelectric* and *Ionization* types. They work differently, and they perform differently against different fires. First, we will explore how these smoke detectors work, and then we will give you the information you need to decide which smoke detectors are best for you.

Footnotes:

1. National Fire Protection Agency (NFPA), “Public Education.” 2022.
2. HomeAdvisor, “How Much Does It Cost to Install Smoke and Carbon Monoxide Detectors?” 2022.
3. Ahrens, “Smoke Alarms in US Home Fires.” 2021.
4. NFPA, “Public Education.” 2022.

3.1. *Photoelectric* smoke detectors.

Photoelectric smoke detectors use light (*Photo*) from electricity (*electric*) to detect smoke particles with a *photoelectric cell* (a sensor that can detect light). The power source may be a battery, or it could be connected to wires in your home. **Figure 2** shows how the photoelectric smoke detector works. When smoke particles larger than 1 *micron* (0.0000393701 inches) enter the smoke detector, some of the light hits those particles. The light that hits the smoke particles gets redirected, and some of that light hits the photoelectric cell. When the cell detects light, it causes an alarm.

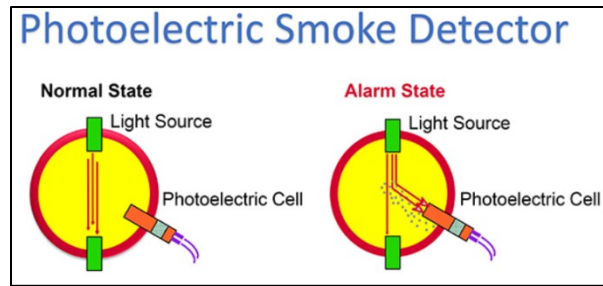


Figure 2. The photoelectric smoke detector uses light to detect smoke particles. Smoke particles larger than 1 micron enter the chamber, and they break the light beam, causing some of the light to deflect into a photoelectric cell. When light hits this cell, it causes a smoke alarm.⁵

3.2. *Ionization* smoke detectors.

Ionization smoke detectors give the air inside of them an electrical charge. *Ionization* means turning atoms into particles called *ions*. An *ion* is simply an atom that has lost or gained an electron. If the atom loses an electron, it has a positive charge. If it gains an electron, it has a negative charge. As the atoms try to become balanced (neutral, without extra positive or negative charges), electrons move between them.

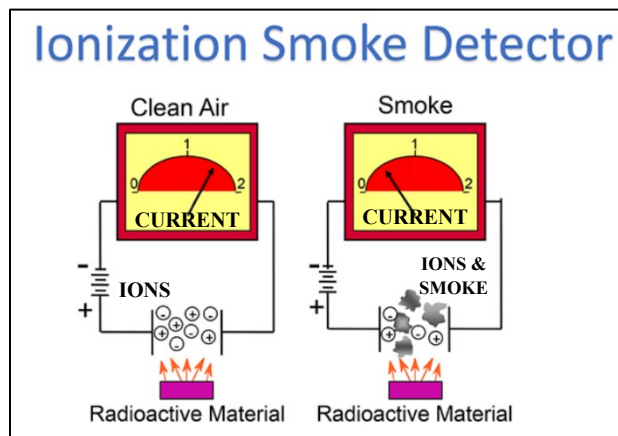


Figure 3. In an ionization smoke detector, a small amount of radioactive material ionizes the air inside the detector. The tightly packed ions fill a gap, creating an electrical circuit. When smoke particles enter the detector, the smoke particles displace ions, and electricity can no longer cross the gap. The drop in current indicates smoke and causes the alarm to sound.⁶

Electricity is made of electrons. If enough of these *ions* are close to each other, electricity can move through the air. **Figure 3** shows how ionization smoke detectors use a tiny amount of radioactive material to create ions. Radioactive materials release energy called radiation, which knocks some of the electrons in the air away, and that is how ionization smoke detectors make ions. Ions need to be packed together tightly for electricity to move through them. When smoke particles enter the ionization smoke detector, it displaces some of these ions, and because they are no longer packed together tightly, electricity cannot pass. This break in the flow of electricity, caused by smoke particles pushing ions out of their way, causes the smoke alarm to sound. These smoke detectors still require a battery or a wired power source for the electric current and the alarm.

Footnotes:

5. Mahoney, "A Guide to Fire Alarm Basics – Initiation." 2021.

6. Mahoney, Fire Alarm Basics, 2021.

4. What kind of smoke detector should I buy?

Choosing the best smoke detector can seem overwhelming. Factors you might consider include detection, fire response times, and cost. Two types of fires should concern you. The first type is a *smoldering* fire. A *smoldering* fire is a slow-burning heat that creates large smoke particles and has not yet made a flame. An overheating electric plug that has started making smoke or a lit cigarette that has begun to burn a mattress are examples of smoldering fires. After burning for as long as hours, days, or even weeks,⁷ a smoldering fire can get hot enough to turn into a *flaming* fire. A *flaming* fire is a hot, fast-burning fire that releases small smoke particles. Flaming fires are so hot that the burning material produces gases, or vapors, which fuel the fire. Flaming fires include *clear* fires. A *clear* fire is a flaming fire that produces little visible smoke, and the flame can be hard to see or even invisible. Burning gases such as ethanol or propane create clear fires. Different smoke detectors perform differently against various kinds of fires.

4.1. Detection. Photoelectric smoke detectors perform better against smoldering fires. Ionization smoke detectors perform better against flaming fires. The U.S. Fire Administration (USFA) does not consider one type of alarm better because every fire differs.⁸

4.2. Response Time. A study by the National Institute of Standards and Technology (NIST) reported that photoelectric detectors gave an average of 31 minutes earlier warning for smoldering fires; the same study said that ionization detectors gave an average of 48 seconds earlier warning for flaming fires.⁹

4.3. Cost. Ionization smoke detectors range in price from \$10 to \$40. Photoelectric models range from \$20 to \$60. Models that combine ionization and photoelectric smoke detection into a single unit cost \$40 to \$75.¹⁰ Based on these prices, it is possible to place an ionization smoke detector next to a photoelectric model for less than the cost of a single combined unit. When considering cost, remember that your home will require more than one smoke detector to achieve the most protection (we will discuss this later in the article).

4.4. Which one is best? Both kinds of alarms perform best against specific kinds of fires. **USFA and NFPA recommend having both types of detectors in one's home.**

5. How to install and maintain smoke detectors.

5.1. Installation. For your safety, install smoke alarms inside and outside each bedroom and sleeping area, on each level of your home, and high on a ceiling or wall.¹¹ Each detector should connect with others in the home so that if one sounds, they all sound. Fire departments sometimes install battery-powered smoke detectors for free; check with them by calling their non-emergency number. Finally, only a qualified electrician should install wired smoke detectors in your home. **Figure 4** shows an example of smoke detector placement.

Footnotes:

7. Hagan and Anita, "From Smoldering to Flaming Fire: Different Modes of Transition." 2023.

8. United States Fire and Safety Administration, "Home Smoke Alarms." 2023.

9. Babrauskas, "Smoke Detectors: Technologies Are NOT of Equal Value or Interchangeable." 2008.

10. HomeAdvisor, "How Much?" 2022.

11. USFA, "Alarms." 2023.

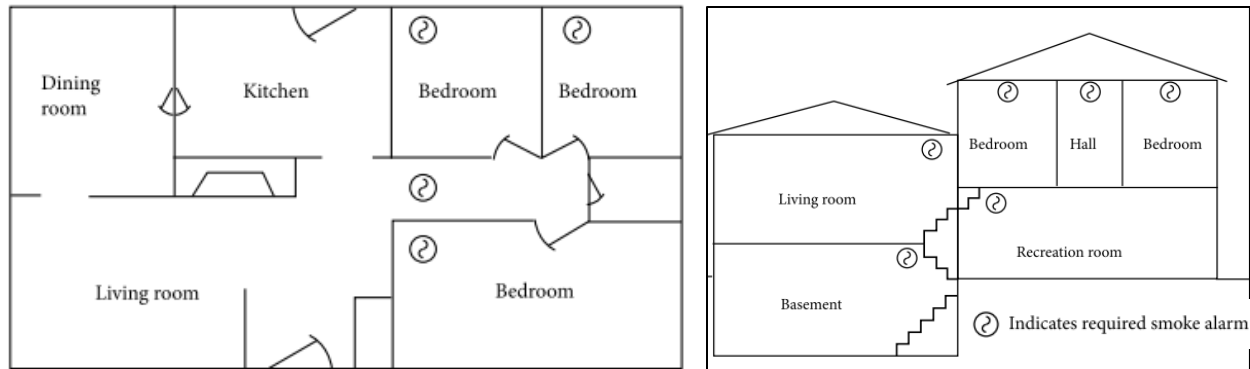


Figure 4. A single smoke detector in the hallway meets the need to have a detector outside of each bedroom. In the image of a multi-story home, you can see smoke detectors placed on each level at a high point.¹²

5.2. Maintenance. NFPA reports that when fires occurred in buildings with smoke alarms, and those alarms failed to work, 41% (two out of every five) had missing or disconnected batteries; another 25% had dead batteries.¹³ Additionally, smoke alarms should be tested each month. The manufacturer’s instructions for your alarm will tell you how to test it. Some smoke alarms have batteries that are not replaceable. Replace these alarms every ten years or when they begin to emit beeps. Trouble beeps signal a low battery.

6. Conclusion.

Smoke detectors save lives. Following the recommendations of this article will make you and your loved ones safer. There are two primary types of smoke detectors used in people’s homes. Photoelectric smoke detectors use light to detect smoke particles. Ionization detectors use ionized gas to detect smoke particles. You should install both types for maximum protection. This article’s bibliography contains other sources you may reference to learn more about smoke detectors.

Footnotes:

12. NFPA, “Planning & Implementing a Successful Smoke Alarm Installation Program.” 2023.

13. NFPA, “Public Education.” 2022.

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- Hagan, Bjarne C., and Anita K. Meyer. "From Smoldering to Flaming Fire: Different Modes of Transition." *Fire Safety Journal 121*, (2021). Accessed September 28, 2023. <https://doi.org/10.1016/j.firesaf.2021.103292>.
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- Jarry, Jonathan. "Smoke Alarms Are Not Created Equal." *McGill*. McGill University, January 8, 2022. <https://www.mcgill.ca/oss/article/technology-general-science/smoke-alarms-are-not-created-equal#:~:text=In%20many%20tests%20of%20both,even%20go%20off%20at%20all>.
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- NFPA. "Public Education." *NFPA.Org*. National Fire Protection Agency, 2022. <https://www.nfpa.org/Public-Education/Staying-safe/Safety-equipment/Smoke-alarms>.
- NFPA. "Planning & Implementing a Successful Smoke Alarm Installation Program." *NFPA.Org*. National Fire Protection Agency. Accessed September 28, 2023. <https://www.nfpa.org/-/media/Files/Public-Education/By-topic/Smoke-alarms/Smoke-Alarm-Installation-Guide.pdf>
- USFA. "Home Smoke Alarms." *Position Statements*. U.S. Fire Administration (USFA), January 26, 2023. <https://www.usfa.fema.gov/about/position-statements/>.