**Smoke Detector Sensors**

* Optical Detector/Photoelectric Type Overview
  + Slow smoldering fires
  + Works as an “eye”
  + Most commonly used in public areas fit for larger domains
  + Known as Photoelectric Type Sensor, using a light source to detect smoke
  + Using infra-red LED, a lens shoots a beam over a large area
  + If smoke is present, it will enter optical chamber, having smoke particles scatter and the alarm is activated
  + In some cases, in large areas there may be a two-part optical sensor, a sender and a receiver will have a straight line infra-red beam, when broken activates alarm
  + Less sensitive to false alarm fire, resulting from minor smoke from candles, steam and cooking
  + Must be on ceiling as smoke rises
  + This detector will have a large opening on bottom leading into detection chamber
  + Infra-red light shoots across chamber from an LED to a photocell, when contact is made circuit is well, and no action is taken
  + Light is shot at 90 degree angle of receiver, smoke will scatter light and make it hit the sensor to trigger alarm (conflicting account with above) (asecurelife)
  + Smoke interrupts beam in chamber, cutting out the current generated by the photocell, and the circuit notices immediately, triggering alarm
  + Reacts quickly to a fire in its smoldering phase, more sensible to large combustion particles (asecurelife)
  + Consists of a source of infrared or uv light, such as an LED, as well as a lens and a photoelectric rreceiver such as a photodiode.
  + These are arranged in a chamber, where outside air flows.
* Ionization Detector Overview
  + Fast raging fires
  + Works as a “nose”
  + Cheaper Alternative
  + Like Optical, can sense smoke particles in air too small to see with naked eye
  + Using alpha radiation, the ionization smoke detector passes through an air-filled chamber allowing a flow of electrodes
  + If any smoke gets inside and absorbs the alpha particles, the level of ionization is lowered, thus affecting the flow of electrodes and activating alarm
  + Inexpensive and used in individual homes, rather than larger public areas
  + Inside has ionization chamber open to the air filled with ions, that comes from a small amount of americium-241, that constantly leaks out radioactive “alpha particles” in to detection chamber
  + As the alpha particles collide with air molecules, positively charged ions and electrons are both produced
  + The ions and electrons move in opposite directions between two electrodes, as long as the two move, a current is flows through the electrodes and into the circuit, letting the detector knows there is no issue
  + Smoke particles in ionization chamber will attach themselves to the ions and stop the current between the electrodes, thus setting off the alarm
  + Once the smoke clears, the chamber will clear and the ions will begin to move between electrodes, thus shutting off the alarm
  + Can quickly detect small amounts of smoke, produced by flaming fires such as fueled by paper and flammable liquids (asecurelife)
  + Prone to nuisance tripping (asecurelife)
  + Has 2 ionization chambers, one open to air other as reference that has no particle entry. Americium emits alpha particles into both chambers, ionizing air molecules.
  + There is a potential difference bw pairs of electrodes in chambers, the electric charge on the ions allows current to flow/
  + Current in both chambers should be the same as they have the same air pressure, temp and aging of the source. So if any smoke particles enter the open test chamber, ions will begin attaching to those particles and not carry the current in the chamber, the circuit will then detect the current difference between the two chambers and activate the alarm. (Cote)
  + Current draw of ionization sensor is low, a small battery can be used as the only powr supply, lasting years
* Carbon Monoxide Sensor
  + Responds to all scenarios, in NIST page 246 table 29, while it is faster response for flaming compared to smoldering, it greatly increases response time for smoldering fires compared to both smoke sensors
* Heat Alarms (thermistors)
  + Slower Response for both Smoldering and flaming fires (table 29, NIST)
  + Tend to respond to later stages of tests page 246, not good for fast response times
  + Uses the following methods: thermistor,
  + Features detecting element inside that activates when reaching predetermined temperature or when a specified increase in temperature occurs (grainger)
  + Best applications are small confined spaces where rapidly burning, high heat fires are expected (grainger) or when detection time is not a priority or the use of smoke detectors is not possible
  + Low false alarm rate, but slow detection time (grainger), not as effective in residential fires
* Dual Sensor
  + Formerly recommended as it allows for a functionality that quickly detects flaming and smoldering fires, now only photoelectric is recommended
  + May be more expensive
  + Includes both photoelectric and ionization sensors
* Comparison
  + “Consistent with prior findings, ionization type alarms provided somewhat better response to flaming fires than photoelectric alarms, and photoelectric alarms provide (often) considerably faster response to smoldering fires than ionization type alarms” from NIST
  + NIST table 23: Based on average response time, it is better to target flaming fires, as these are detected much more quickly by both types of sensors, for the purpose of testing our system
  + Ionization sensors tend to be cheaper
  + Smoke alarms alone may not provide protection for those in direct proximity of the initiation of the fire page 259
  + IAFF recommends photoelectric sensors, stating dual sensor is no longer acceptable, technology in ionization sensors leads to delay in smoldering fires, leading to greater source of life, also weaker in high airflow environment, leading to greater delay. Also less susceptible to nuisance alarms. (asecurelife) (fireengineering)
* Additional Notes
  + We should add an LED that serves as “detector is working” display
  + Maybe we can use “test switch” to show our system works rather than using fire and real smoke
  + Research smoke detector algorithms
  + We need to notify of low battery in noticeable “smart” manner (email)
  + Research life expectancy of sensors
  + Combination algorithms of several sensors
  + http://www.ssspl.org/uploads/Products/Pdf/firealarmsystem.pdf
* To quantify
  + Sensitivity in % per meter
  + Life Expectancy of sensor
  + Accuracy of sensor
  + Response time
  + Possible to know amount of smoke/type of fire from response of sensor?
  + Sensitivity to non-fire aerosols/nuisance alarms (steam, cooking activity, smoking)

Sources used:

<http://www.explainthatstuff.com/smokedetector.html>

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<https://www.nist.gov/engineering-laboratory/home-smoke-alarm-tests>

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<http://www.fireengineering.com/articles/2008/10/iaff-advocates-photoelectric-smoke-detectors-over-ionization-detectors.html>

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