Which Smoke Alarm Technology is recommended for the City of South Euclid: Ionization v. Photoelectric

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Author Note

This paper was prepared for Political & Legal Foundations of Fire, taught by Professor Larry Bennett.
Certification Statement

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed: Scott A. Sebastian - Scott A. Sebastian
ABSTRACT

The problem the City of South Euclid is facing is that we are lacking the needed photoelectric technology smoke alarms that will give our citizens the needed early warning detection that will notify them when a smoldering fire is occurring. The purpose was to conduct research that would give the author clarification of which of the two smoke alarm sensor technology would be best for our community. It was also the author’s intent to use the developed information to implement a residential photoelectric smoke alarm Codified Ordinance that will help to reduce injuries and death from fire and smoke conditions. This research project was to utilize descriptive research method and approach. For this project the author reviewed vast amounts of literature reviews, sent out questionnaires, watched smoke alarm activation testing videos, and conducted an interview to assist in the completion of the research project. The results from the research and data collected have proven the final hypothesis that photoelectric technology is the smoke alarm of choice for the City of South Euclid. We have come to this conclusion because it was proved through extensive research that photoelectric smoke alarms respond quicker to smoke and have produced less false nuisance alarms.
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Introduction

When working in the industry of fire safety and trying to get the best product on the market to help keep families safe it is very important that they have some type of fire and or smoke alarm early warning detection in their homes. In the United States, the National Fire Protection Association (NFPA) estimates that nearly two-thirds of deaths from home fires occur in properties without working smoke alarms/detectors. (USFA, 2014) The problem the City of South Euclid is facing is that the citizens are lacking the needed photoelectric technology smoke alarms that will give them the needed early warning detection that will notify them when a smoldering fire is occurring. The reasons there are so many homes in this community that have ionization technology alarms this is because: A) they were given to them for free B) they were purchased because they wanted to be safe in their home and were not educated on the difference between the two technologies C) because it was cheaper to purchase an ionization alarm over a photoelectric alarm D) the ionization alarms were purchased 5, 10, or 20 years ago before photoelectric technology was popular.

The debate between these two types of detectors can be read about on many different forums across North America all the way to Australia. The battle even goes on in my State of Ohio; I belong to the North Eastern Ohio Fire Prevention Association (NEOFPA). Our organization has been on the forefront of researching debate between Photoelectric vs. Ionization. Representatives from our organization have sent letters to State Fire Marshal Larry Flowers office and to the state residential code committee. They have done this to make photoelectric detectors the only one that is used in this state. In this discussion many states are now mandating that all residential homes have one smoke detector installed on every floor of the
home to provide the proper needed early warning protection. In the City of South Euclid I provide a smoke alarm program for the community through the Red Cross called “Operation Save a Life.” The make-up of this program is to go into the community to install and or replace older smoke alarms. By being involved with this program over 94% of the smoke alarms we are replacing are of the ionization technology type. The purpose of this applied research project is to develop a plan to implement a residential photoelectric smoke alarm ordinance. If South Euclid Codified Ordinance legislation is put in place it will make it mandated that every home in the city have at least one photoelectric smoke alarm. With this photoelectric smoke alarm ordinance recommended the enforcement will reduce residential fire related injuries and deaths for firefighters and citizens in our community.

The descriptive method of research was used to answer the following questions: (a) What are the differences between the two different types of smoke detectors sensors and does one create more of a nuisance? (b) What are other cities across the State doing mandate photoelectric smoke alarms?

**Background/ Significance**

The City of South Euclid is one of a dozen cities that border the City of Cleveland’s East side, with a population of 21,968 and average median age of our residences is 38.6 years old. (US Census, 2014) South Euclid is a rapidly evolving urban community with 9,939 homes and 60 apartment buildings that hold close to a 1,000 units that are brought together by a culturally diverse community. Our city is a residential community with some retail and light manufacturing found throughout. Our department is currently staffed with a career fire chief, assistant fire chief, fire prevention officer, 3- captains, 3- lieutenants, and 22 career firefighter/paramedics. The Fire Departments primary responsibility is to provide the highest
level of life and property safety through the extension of fire prevention, fire control, advanced
life support (ALS), and public educational services to our citizens. The South Euclid Fire
Department responded to over 3,471 calls in 2014, while 83% of those incidents were coded as
emergency medical runs. (Annual Report, 2014)

As we look back into history of Ionization and photoelectric technology it was noted that
in 1890 Francis Upton patented the first electric fire alarm. (Wikipedia, 2014) The ionization
chamber smoke detector was invented in the early 1940s in Switzerland by Dr. Ernest Meili
when he devised an ionization chamber device capable of detecting combustible gases in mines.
These devices were later made available in the United States in 1951. (Advameg, 2015) In the
United States ionization alarms were initially used only in factories, warehouses, and public
buildings because they were expensive; found to be around $125.00 per device. But, with new
technology that occurred with ionization alarms over the next five years it reduced the cost of the
detectors by 80% and boosting sales to 8 million in 1976 and 12 million in 1977. (Advameg,
2015) As for the other smoke alarm technology, photoelectric smoke alarms were created by
Duane Pearsall and Stanley Peterson in Lakewood, Colorado in 1965. This new technology was
the first truly affordable home smoke detector of its time. The photoelectric detector featured
individual battery powered units that could be easily installed and replaced. These first units
were made from strong fire resistant steel and shaped much like a bee's hive, and then in 1975
the Statitrol Corporation came up with the idea of a way to mass produce the alarms for the
public. Today, smoke alarms are installed in 93% of US homes and 85% of UK homes. (n.d.,
2015)
Literature Review

The purpose of the literature review was to gather and review research documentation on why photoelectric smoke alarm technology will save more lives and reduce the number of injuries in fire conditions in the City of South Euclid. The use of smoke alarms has risen from less than 5% in the early 1970’s to over 93% in 2014. (NFPA, 2014) It has also been noted that many cities across the U.S. have requested through building and fire codes to make it mandatory for one of the two sensor type of smoke alarm be present in all occupancies. Several internet websites and blogs were used to research why photoelectric smoke alarm technology is better than ionization smoke alarms. Is it because it will respond quicker, produce less nuisance alarms that will assist in preventing further injuries and deaths in South Euclid’s residential districts? This literature review was collected to assist in answering the descriptive questions.

The residential homes that are in question for this review are one found in personal owned homes, rental homes and condominiums.

Research Question # 1

What are the differences between the two different types of smoke detectors and does one create more of a nuisance? Smoke alarms were created to activate when a smoke atmosphere is present, when activated it will give occupants suitable warning time to exit the hazardous and
which smoke alarm technology is recommended

Toxic location. In today’s smoke detector market you can purchase one of two types of sensor technology: ionization or photoelectric sensor technology. To better understand this technology the author has turned to Boston Fire Department Deputy Fire Chief Joseph M. Fleming’s (2011) presentation of Ion vs. Photo – Is There a “Qualitative” Difference for Life Safety? To start this debate between the two devices in a residential setting, we must first look into how each of the technologies works. Deputy Chief Fleming explains, “Ionization smoke alarms use small amounts of radioactivity that consists of two plates with a voltage across them, in this process the negative electron is attracted to the plate with a positive voltage, and the positive atom is attracted to the plate with a negative voltage current that flow all the time between the two electrodes in the chamber.” “So, when smoke enters the ionization chamber, it disrupts this current and the smoke particles attach to the ions and neutralize them. The smoke alarm senses the drop in current between the plates, which cause the alarm to activate.” (Fleming, 2011) Chief Fleming goes on to saying that, “Photoelectric technology uses a beam of light and a photocell inside the chamber, so when smoke enters the chamber it deflects the beam, causing it to strike the photocell and showing there is a smoke emergency in the occupancy.” (Fleming, 2011) The debate between the two technologies is that ionization alarms are more sensitive to the tiny particles of combustion that cannot be seen, an example would be a flash grease fire. It has been noted that in recent test done by the NEOPFA showed that the ionization alarm did go off 10 seconds faster during a flash fire than the photoelectric model. (NEOPFA, 2014) While photoelectric alarms are more sensitive to the large particles of combustion that are found in billowing smoke that occurs from a smoldering fire, such as electrical or from careless smoking.

In August of 1995, the University of Texas A&M conducted a three year smoke alarm study because they were concerned with the results that came out of the Underwriters
Laboratories test results. For UL smoke alarm test they used a wooden box with a smoke alarm inside of it, then place hot smoke in the box to get their results. As for the University of Texas A&M wanted an open room test that used the fault-tree-analysis model designed by Bell Laboratories.

The research of this three year test showed that ionization alarms failed to provide adequate egress time in smoldering fire scenarios over 55% of the time versus a 4% failure rate with photoelectric alarms. In fast-flame fire scenarios, the study found that ionization alarms failed to provide adequate egress time about 20% of the time versus 4% with photoelectric alarms. The research demonstrates that when all factors are taken into account, i.e.; how often each alarm gets disabled due to nuisance tripping, how they respond across the full spectrum of fires, etc., photoelectric alarms have a clear advantage. (Texas A&M University Study, 1995)

In Skip Walker’s (2012) article *Ionization versus Photoelectric Smoke Alarms: In Real-World Fires the Differences Are Deadly* he explains, “Imagine your car air bags deploying randomly when you hit a pothole, but failing over half the time in a collision. As unthinkable as this seems, that is the harsh reality with the smoke alarms found in most American homes.” “The smoke alarm industry is quick to point out that all smoke alarms must meet the UL 217 and UL 268 standards developed by UL, but the current UL alarm standards are the same as those developed in the 1970’s. The UL tests use two test scenario’s the fast flame fire and the smoldering fire.” (Walker, 2012) A “fast flame” fire is a fire that is based on accelerants, such as gasoline, cooking oils, grease, and paper fire. A smoldering fire is the early stages before open flames develop and is characterized as slow moving with significant smoke. Walker expresses, “Today, virtually all furnishings and a large percentage of the building materials are synthetic and engineered materials. Yet the UL standards have not been adjusted to account for this shift.
In tests, ionization alarms will typically respond about 30 to 90 seconds faster to “fast-flame” fires than photoelectric smoke alarms. However, in smoldering fires ionization alarms respond an average of 15 to 50 minutes slower than photoelectric alarms. Several studies indicate that they will outright fail to activate up to 20-25% of the time.” (Walker, 2012)

Skip Walker’s (2012) clarifies, “In 2007; UL published the “Smoke Characterization Study”. This study tested both types of smoke alarms using current UL testing standards and materials. The results are frightening. Ionization alarms failed the UL 217 test 20% of the time using the current standard test materials. “When tested using synthetic materials, ionization alarms DID NOT TRIGGER (DNT) in 7 out of 8 synthetic test scenarios. In the one test where the ionization alarm did trigger, it activated at a level exceeding maximum allowed under the UL standard and nearly 43 minutes after the photoelectric alarm in the same test. In the same tests, photoelectric alarms activated 100% of the time using the UL 217 test and materials.” (Walker, 2012)

In Skip Walker’s final thoughts he felt that, “Since photoelectric responded 100% of the time it was test and responded faster than the ionization detector.” “With everything we know, all the facts tell us that photoelectric alarms provide superior protection in real-world fatal fires.” (Walker, 2012)

In Thomas Fazzini study (2000) Ionization and Photoelectric Smoke Alarms in Rural Alaskan Homes, Mr. Fazzini conducted a six (6) month study of Alaskan Eskimo villages. At the end of the six month study he found that ionization smoke alarms had a significantly higher number of nuisance alarms than photoelectric smoke alarms when installed 10 to 15 feet from a nuisance source. (Fazzini, Perkins & Grossman, 2000) In this study, the researchers installed
both ionization and photoelectric type smoke alarms in homes with less than 1,000 square feet of living space. Both types of smoke alarms were installed on the ceiling between 10 to 15 feet from a cooking and the heating sources. The study found 92% of homes with ionization smoke alarms experienced nuisance alarms compared with only 11% of homes with photoelectric smoke alarms, a ratio of more than 8 to 1. After six months, 19% of the installed ionization smoke alarms had been disconnected compared to only 4% of the installed photoelectric smoke alarms. Thomas Fazzini indicated that, “Even though the ionization smoke alarms had silencing or hush buttons that allowed quieting the unit for 10 minutes, the batteries were still removed from the unit because of frequent nuisance alarming.” Thomas Fazzini concluded with, “In small rural residence, photoelectric smoke alarms have lower rates of false alarms and disconnections. Photoelectric alarms may be the preferred choice for dwellings with limited living spaces or frequent false alarms.” (Fazzini, Perkins & Grossman, 2000)

Research Question # 2

What are other cities across the State of Ohio doing mandate photoelectric smoke alarms? For this section of literary review the author researched what other cities were doing to mandate photoelectric smoke alarms and found three cities in Cuyahoga County that created photoelectric residential Codified Ordinances. The cities that were reviewed were the City of Shaker Heights, Village of Mayfield and Village of Chagrin Falls. Throughout this search the author found that many departments had applied the correct language to properly implement City Codified Ordinances to require the installation of photoelectric smoke detectors. In the review of noted three cities their Codified Ordinances explained that there was a problem in each of their cities and need to mandate the ordinance because most smoke alarms were found to be ionization technology. (City of Shaker Heights, 2011)
Their stance on creating this ordinance was based off their research and studies that proved ionization smoke detectors respond more slowly to smoldering fires that generate heavy smoke but initially little flame than photoelectric smoke detectors. In the review it was also noted that they were implementing the ordinance to reduce the amounts of nuisance responses, which therefore more often result in occupants disabling the smoke detector by taking out the battery. In concluding this literary review was that photoelectric smoke detectors will provide greater safety in the community than dual or ionization smoke detectors. Then finally all of the cities recommended that their residents replace smoke detectors and also as a part of the point of sale; this is when a housing inspector does a final inspection of the home before it sale is final.

For this research paper a seven question survey titled, Ionization v. Photoelectric was sent out to ten Northeastern Ohio fire marshals and fire safety inspectors, along with Mr. Dean Dennis; Mr. Dennis lost his daughter to a house fire on the Ohio State campus in 2003. Listed below will be the information results received from the questionnaire.

**Question #1**: If a citizen would need to change their smoke detectors but don't know how to choose between ionization and photoelectric smoke alarms, what would be the pros and cons in choosing one or the other. Should we recommend they buy a combination detector that uses both methods, ionization and photoelectric?

**There are three types of sensor technology used in smoke alarms:**

**Photoelectric**: The sensor of choice. The photoelectric sensor responds tens of minutes faster than the ionization sensor to smoldering type fires that cause the most injuries and deaths in residences. It is also less prone to nuisance false alarms from cooking and steam than ionization.

**Ionization**: The ionization sensor responds only tenths of seconds faster to flaming type fires than a photoelectric sensor. A negligible difference. It is more prone to nuisance false alarms from cooking and steam.
**Combination or Dual Sensor**: Contains a photoelectric and ionization sensor. It is still more prone to false alarms from cooking and steam due to the ionization sensor component.

Photoelectric smoke alarms are the best choice. Almost 40 years of research has proven this. Ionization smoke alarms are alerting tens of minutes slower than photoelectric smoke alarms in the deadly smoldering stage of a fire. They are also more prone to nuisance false alarms from ordinary cooking and steam from showers. Photoelectric smoke alarms sound tens of minutes faster than ionization smoke alarms during smoldering stage fires with significantly fewer false alarms. Furthermore, their performance in flaming stage fires is comparable to ionization alarms, making the photoelectric alarm the best choice. In a phone interview with Mr. Dennis he explained, “Dual smoke alarms are no good, we are better off placing one - ionization and one - photoelectric alarm on the ceiling together; it is way better than a dual alarm”. “This is why dual alarms are bad, because then the put the two sensors in one device manufactures are moving the sensors to fit properly which is not giving you the full protection like you would get from a single stage photoelectric.” (Dennis, 2015)

**Question # 2**: Is there a smoke alarm technology that you would recommend over the other and why?

All 100% of the fire marshals, fire safety inspectors, and Mr. Dennis have recommended photoelectric smoke alarm over ionization alarms. Dean Dennis added, “Because you only need one type of smoke alarm.” “What type of fires is ionization good for, answer: flash kitchen fires. We have never had people died in a kitchen fire while awake and cooking.” “This is why you need a photoelectric alarm to notify you during the day or to awake you at night when you are in bed sleeping.” (Dennis, 2015)
Question # 3: Does one device react quicker than the other during fire or smoke conditions?
Yes, in flash fire phase ionization is 30 seconds faster, examples are kitchen grease fires or in an arson situation. But, for the common house fire photoelectric will respond 30-50 minutes faster than ionization alarms.

Question # 4: How many do I need and where is the best place to put them?
Photoelectric smoke alarms should be placed, at a minimum, on every level of the home including the basement, outside every sleeping area and in every bedroom. On all floors, an alarm should be placed at the base of the stairs to the floor above. Smoke alarms should be mounted on the ceiling or high on the wall (smoke rises). Always follow the manufacturer’s instructions. Additional smoke alarms can be added to increase your protection for long stretches of 25 feet or longer. Mr. Dennis states, “It does matter how many you have, but when they cause a nuisance problem and they take the batteries out of them.” “In we looked at 100% of fires that someone dies in fire: 40% - do not have at detector, 60 % have working alarms, but of the 60%, 40 % have the battery taken out due to nuisance alarms.” (Dennis, 2015)

Question # 5: Can one or both of the devices give off a false alarm when mounted in different locations?
Yes, although ionization alarms are more prone to these nuisance false alarms from ordinary cooking and shower steam than the photoelectric alarm. Manufacturer’s guidelines should be followed regarding proper distances to place smoke alarms from cooking appliances and bathrooms. Mr. Dennis explained, “Yes, ionization will take in moisture from droplets from shower steam and it will be detected.” (Dennis, 2015)
**Question # 6:** Is there a life expectancy of a smoke alarm or when is the right time to replace the device?

All smoke alarms have a recommended service life of 10 years. Replace your smoke alarms at this time or sooner if they are not functioning properly.

**Question # 7:** Is one detector more sensitive to smoldering smoke particles than the other device?

Photoelectric alarms are more sensitive to large particles of combustion that obscure light. Mr. Dennis added, “Yes, it is a single staged photoelectric smoke alarm. From me to you, if you are allowing members of your community to use anything else they are playing Russian Roulette with their lives when they go to bed at night.” (Dennis, 2015)

In summary the literature review provided research documentation that smoke alarms installed in this city will have to be investigated and corrected by providing a smoke alarm replacement program. The literature review focused on a majority of the research on the difference between the two alarms, which alarm responded quicker in fire and smoke conditions than the other, and which alarm was less of a nuisance than the other smoke alarm. It was learned through this literary review that along with replacing ionization smoke alarms with photoelectric smoke alarms, this department will also have to educate the community on why the change is needed. Finally, with the adoption of new residential photoelectric smoke alarm ordinance and needed fire safety smoke alarm education this department will reduce death and injuries from residential fires.

**Testing**

The testing conducted for this applied research project was results found from a smoke alarm testing conducted by my association the North Eastern Ohio Fire Prevention Association
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(NEOFPA). In May 2014, NEOFPA conducted an investigation with ABC’s Good Morning America investigator to find out the realities between the two smoke alarm technologies. For this demonstration six new alarms from two leading manufacturers were bought and nine cameras were placed to capture all angles. Of the six smoke alarms: two were ionization, two were photoelectric and two were combination alarms that use both technologies. During the demonstration a fast, flaming fire and a smoldering fire were started in a vacant home that was set for future demolition. The finding for this smoke alarm testing will be found in the results section of this applied research.

Results

As the fast, blazing fire was set the ionization alarm went off in 45 seconds and the first photoelectric alarm went off at 4:30 and 5:19 minutes into the fast, blazing fire. In the next demonstration the smoldering fire test was started by lighting up a couch on fire by placing an electric heating element between two sets of cushions. For this demonstration we witnessed different results that had indicated that the first and second photoelectric alarms went off at 12:15 and 13:33, at that time visibility was good and occupants would be able to evacuate the home. Then at 22:15 and 49:20 minute mark the dual photoelectric and ionization alarms went off, by this time the smoke would be thick, visibility is close to zero, and conditions would be life threatening. Finally at one hour and ten minutes the Fire Chief in charge of the demonstration stops the test with either of the single ionization detector failed to respond to the residential smoke conditions. In concluding the results have been confirmed that photoelectric smoke alarm research and data collected have proven that photoelectric technology is the smoke alarm of choice for the City of South Euclid.
Discussion

Can smoke detectors take all of the credit for the reduction in fire deaths by half in commercial and residential? Yes and No! Yes, because NFPA states that in 1975 10% of occupants had devices and in 2000 almost 95% have at least one smoke alarm in their business or homes. But no because since the 70’s there have been organizations like Underwriters Laboratory, University fire science professor, and NIST that have conducted proven research that has helped to reduce the materials of combustion in the American home. Other important factors that have reduced the total number of fire deaths is the number of citizens that no longer smoke, the enforcement of fire prevention codes, city’s starting fire inspection programs, and the needed fire retardants on highly flammable material that are found in today’s occupied spaces.

Recommendation

Currently the City of South Euclid provides smoke alarm education to our members of the community but it is felt that more people in the community could be reached. It will be important to have members of the community know the findings of this research and that we recommend that if they were to purchase a smoke alarm that photoelectric technology be their alarm of choice. The purpose of this applied research project was to identify the difference between the two technologies and which smoke alarm would be best to be installed throughout our community.

The first recommendation would be to create a smoke alarm campaign to distribute need to know information on why the South Euclid Fire Department have chosen photoelectric technology over ionization technology. This campaign will help to bring more awareness to the community about the importance of have a photoelectric smoke alarm in their residence. This information will consist of research that was conducted by the University of Texas A&M and the
Northeast Ohio Fire Prevention Association explaining how photoelectric technology is better suited for the residential setting.

The second recommendation is to start recording residential smoke alarm activations when responding to residential structure fires. When fire department members on the fire scene they can document if a smoke alarm was present, if it was photoelectric or ionization, if it responded properly, and if it was removed or the battery was removed. This research data will help in the future when writing photoelectric smoke alarm grants to help protect the community.

**Conclusion**

In conclusion the research that was conducted has proved the photoelectric technology is better suited then ionization technology in a residential setting. We have come to this conclusion because it was proved through extensive research that photoelectric smoke alarms respond quicker to smoke and have produced less false nuisance alarms. Through the research ionization technology leads to a delayed warning in smoldering fires that can lead to greater loss of life among people and firefighters in a burning structure as a result of a more developed fire. A delayed warning during a smoldering fire, especially at night, can incapacitate people who are sleeping, which can lead to more fire related injuries and death as fire spreads. With the needed residential photoelectric smoke alarm Codified Ordinance and the proper life safety education to the community it can reduce fire related injuries and deaths for firefighters and citizens in our community.
Reference


Dennis, Dean. February 12, 2015. Personal Oral Interview


South Euclid Fire Department. 2014. Annual Report. South Euclid, Ohio


  http://www.propertyevaluation.net/Photoelectric%20vs%20Ionization%20Smoke%20Alarms%20-%20Deadly%20Differences.html

  http://en.wikipedia.org/wiki/Francis_Robbins_Upton
Appendix A

Ionization v. Photoelectric Technology Questionnaire

1) If a citizen would need to change their smoke detectors but don't know how to choose between ionization and photoelectric smoke alarms; what would be the pros and cons in choosing one or the other?

2) Should we recommend they buy a combination detector that uses both methods, ionization and photoelectric?

3) If their a smoke alarm technology that you would recommend and why?

4) Does one device react quicker than the other during fire condition?

5) How many do I need and where is the best place to put them?

6) Can one or both of the devices give off a false alarm when mounted in different locations?

7) Is there a life expectancy of a Smoke alarm or when is the right time to replace the device?

8) Is not detector more sensitive than the other device?