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TECHNICAL NOTES

Fire Alarms and At Risk Populations

FINAL REPORT BY:

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FOREWORD

Many individuals with autism spectrum disorders (ASDs) are hypersensitive to sound and light. Fire alarms, whether through a regular fire drill or sounding in the event of a fire, can affect these individuals adversely.

To understand the impact of fire alarm notification signals on individuals with sound and light sensitivities, the Foundation conducted an initial literature review to determine what information could be found on this topic. This literature review discovered that there was very limited information on the topic and the NFPA 72, *National Fire Alarm Code,* Technical Committee needed more technical information to develop guidance on how to address this issue. This project gathers additional information on how fire alarm notification signals impact high risk populations by conducting targeted interviews with experts (e.g. teachers, therapists, etc.)

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The Fire Protection Research Foundation plans, manages, and communicates research on a broad range of fire safety issues in collaboration with scientists and laboratories around the world. The Foundation is an affiliate of NFPA.

About the National Fire Protection Association (NFPA)

Founded in 1896, NFPA is a global, nonprofit organization devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards. The association delivers information and knowledge through more than 300 consensus codes and standards, research, training, education, outreach and advocacy; and by partnering with others who share an interest in furthering the NFPA mission.

All NFPA codes and standards can be viewed online for free.

NFPA's membership totals more than 65,000 individuals around the world.

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Fire Alarms and At-Risk Populations

From Literature and One-on-One Interviews

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Student research project sponsored by Fire Protection Research Foundation

Abstract

Current fire alarm and notification devices in facilities that house and educate students with special needs are designed in the same way as systems for all other occupancies. Oftentimes, current systems can cause panic and fear for students in special education classrooms. Throughout the United States, more and more individuals are attending this type of classroom environment, where a varying assortment and degree of different diagnoses are present. Greater difficulty in emergency evacuation has been recorded regarding these instances. This study is intended to help to understand some of the more common diagnosis and evaluates possible recommendations for further study and implementation, as well as, code evaluation.

Current educational facilities in America are educating students of every nationality, background, and ethnicity in the world. As of 2012, there were 36,429,431 students in the United Sates between the ages of 3 to 21 with a disability. The diagnosis and needs of these students varies considerably. These individual diagnoses are independent and may be different for every individual and how to best aid each individual student may also be different. The purpose of this study is to help identify and suggest modifications to current fire notification appliance design to help improve and/or resolve evacuation issues for these individuals. The intent of this study is to identify whether educators and parents believe that notification appliances in classrooms provide adequate and effective warnings for students with special needs. The results are an opinion survey and data needs to be collected to determine how effective current and modified systems are. Notification devices, in some instances, can cause anxiety, fear, and other undesirable responses by some individuals with certain disabilities. This in turn may slow any evacuation for them. This can also impact others that are with them or responsible for helping them.

Current Code Requirements

The requirements for buildings are based on a jurisdiction's adoptions of a code or codes and standards, as well as the Federal "Americans with Disabilities Act" and DOJ's 2010 ADA Standards. The model codes are available for adoption from the National Fire Protection Association (NFPA), International Code Council (ICC), as well as some mandatory standards drafted by government agencies. Typically, the specifics in each code are relatively equivalent and all strive to keep life safety concepts at the forefront. Ensuring life safety and usability as well as minimizing property damage are the mission of these codes and standards. Evaluating

the effects of certain code criteria helps to determine changes that may be desirable for future editions of the codes and standards. For example, ***NFPA 72: National Fire Alarm and Signaling Code*** covers the requirements for alarm notification devices for various occupancies.

Current notification devices covered include a combination of audible alarms and strobe lighting.

> ***10.2. NFPA 72 (2013)*** states that the purpose of fire alarm and signaling systems shall be primarily to provide notification of alarm, supervisory, and trouble conditions; alert the occupants; to summon aid; and to control emergency control functions.

The performance requirements for these systems are not only to visually notify the occupant, but audibly alert the individual as well. Some audible alarm systems provide information delivered by voice instruction for the evacuation. Typically, informative notifications are not required or used in educational facilities. Appliances with horns that deliver certain tones in certain patterns are prevalent in these institutions. Requirements for these audible notification devices are present in NFPA 72.

> ***18.4.3.1. NFPA 72 (2013)*** states that to ensure that audible public mode signals are clearly heard, unless otherwise permitted by 18.4.3.2 through 18.4.3.5, they shall have a sound level at least 15 dB above the average ambient sound level or 5 dB above the maximum sound level having a duration of at least 60 seconds, whichever is greater, measured 5 ft (1.5 m) above the floor in the area required to be served by the system using the A-weighted scale (dBA).

Notification appliances in public areas and educational facilities create sound pressures measuring between 45 and 120 decibels, commonly referred to as a device's volume. This

allows devices to be set 15-decibel above the ambient sound levels in the area in order for occupants to hear them above the background noise.

Visual notification (strobes) are required in addition to audible notification in certain occupancies. ***Chapter 18 of NFPA 72*** contains the requirements these notification devices. The code has strict requirements for the pulsation rate, frequency, color and types of lights required.

> ***18.5.3.1. NFPA 72 (2013)*** states that the flash rate shall not exceed two flashes per second (2 Hz) nor be less than one flash every second (1 Hz) throughout the listed voltage range of the appliance.

Notification of people that are deaf or hard of hearing is the primary function of the strobe flash. Keeping strobes between one and two flashes per second helps to assure that the light is appropriate for individuals who are deaf or hard of hearing, while not causing seizures during an evacuation emergency or drill is critical.

> ***18.5.3.4 NFPA 72 (2013)*** states that lights used for fire alarm signaling only or to signal intent for complete evacuation shall be clear or nominal white and shall not exceed 1000 cd (effective intensity).

> ***18.5.3.5. NFPA 72 (2013)*** states that lights used to signal occupants to seek information or instructions shall be clear, nominal white, or other color as required by the emergency plan and the authority having jurisdiction for the area or building.

Clear or nominal white lights are used for strobes. Synchronization is required for all strobes that are located in a given sight area. Synchronization also helps to mitigate epileptic

episodes. The system's primary purpose is to get people's attention and to notify them of an imminent threat requiring them to evacuate. The location of wall and ceiling mounted appliances are controlled by various tables and charts in NFPA 72.

These notification devices work well in public areas that serve individuals that have no to minimal diagnosed disabilities. There are no known studies that have explicitly tested how these devices are responded to in occupancies by people with significant disabilities. Schools can, and typically do, have students with a wide range of needs and disabilities. Some of these disabilities include; hearing impairments, deaf-blindness, learning disabilities, visual impairments, cognitive disabilities and developmental delays. Although all of these categories are important, autism and epilepsy are the focus of this study. Unpredictable timing, loud audible notifications, and bright white strobe notifications are primary areas of concern.

Special Education Classrooms

Many students in special education classrooms suffer from a wide variety of differing disabilities. Students in these classrooms can have autism, epilepsy, and other disabilities. There might be one to two teachers present in the classroom with the possibility of one or two teacher's aides. There could be a minimum number of staff required to be present based on the level and degree of students with disabilities present in their classrooms. Non-special needs education rooms on average only have one teacher who is responsible for the entire classroom even when there are students with less severe disabilities present in their classroom. Both State and Federal Governments require periodic testing and activation of the fire alarm system while the school is in session. The purpose of these drills is to familiarize students with the proper procedure in an emergency where evacuation is required (e.g. a fire). During emergencies, the reactions from the

students in the classroom can hinder proper evacuation of the facility. Being unprepared and un-rehearsed can have devastating consequences. The alarm system can have adverse effects on the students in the classroom. Strobe lighting frequency and loud audible notifications has the potential to cause confusion, panic, and fear.

Participants

The research conducted was to help understand the current effects that fire alarms have on the students in special education classrooms. The ultimate goal of the research is to determine possible alternatives to the current alarm systems for these facilities. Questions, see Appendix A, that asked about many of the current building practices as well as how current code requirements are evaluated and implemented were asked to help understand problem areas within the special education classrooms. The questions helped focus on the current practices in facilities such as, how students respond to the alarm and strobe notifications, and how the current practices might be improved. Approximately 40 parents and educators throughout the United States received the survey. The survey responses came from the public school sector, higher education, and private care facilities representing sectors that only implement required codes from the local, state, and federal levels. Parents selected for the survey all have students with differing disability diagnoses that are currently enrolled in education facilities. Criteria for acceptance of individual survey results required that these parents and professionals are dealing with varying types of diagnosed disorders.

The primary focus for parents when answering the survey relates to how it affects their child and not necessarily the broad relationship of everyone in the classroom. Parents often have the best understanding of their specific child.

The educators surveyed all worked in the special education field from 2-15 years. They have an understanding of the policies and procedures or their school as well as the general needs of the overall classroom. Observations of day-to-day activities were made and one-on-one interviews were conducted for the study. The majority of participants in this study had students that were under the age of 10.

Survey

The basis of this research focused on a survey of administrators, teachers, other professionals, and parents of students in special education classes. The survey aimed to discover problem areas in the way current fire alarms might hinder and challenge the evacuation of special education classrooms. Survey results pointed to three main areas of concern: strobe color and frequency, audible notification, and unpredictability (for the students) when the alarm would sound along with a lack of evacuation practice. Design of survey questions indicated areas of importance for facilities that operate with high-risk occupants. Question criteria were based on the current code requirements of differing codes and how they relate to individuals with these diagnoses. Do the devices themselves cause panic when it is not an emergency? Do the devices cause the individual to shut down and hide?

The first question of the survey asked about the disorder that the students(s) the respondent is familiar with has. Survey participants are kept confidential. Clarifying if students have auditory hypersensitivity and/or visual sensitivities helped to direct the survey. Audible issues included pitch, frequency, volume, and tone of the audible sounds. Alternative suggestions accompanied indication questions in order to help develop the recommended action in order to help improve and change current code recommendations. Documenting the

frequency of strobes, color of the lights, audible notification devices, and the importance of repetition helped to decipher primary areas of concern from the families and experts in the field. A copy of the survey is in appendix A.

The primary focus was on autism, epilepsy, and emotional / behavioral disorders. Identification of these disorders was the result of the compiled surveys.

Autism

Autism spectrum disorder is a common, although wide ranging disorder that tends to have some common characteristics including an individual's inability to accurately communicate and socially interact with their peers. Ross (1974) states that, "In its original sense, autism refers to a distorted, self-centered form of thinking that is controlled by the thinker's needs or desires and bears little relation to external reality; the form of thinking which takes pace in dreams, daydreams, and fantasy" (p. 65). Individuals who are diagnosed with this disorder are generally quiet and like to keep to themselves. Repetition and routine are keys to an individual's daily life. The disability has many varying levels dependent of the individual. Most young children with the disorder grab on and run with a current hobby. Their lack of social interaction is replaced with their ability to learn everything and anything about a given subject. Interests can change over time but remain the focus of the student's life for stretches of time.

Autism is linked, and often used, to describe a group of other related disorders. Some of these disorders are Asperger's syndrome, childhood disintegrative disorder, Rett's disorder, and PDD. All of these disorders are characterized by the individual's inability to effectively interact

socially and communicate effectively. Social skills for these disorders do commonly develop, but time frames and the extent of which these skills develop are unique to each individual.

In the classroom setting individuals with autism can take up a high percentage of a teacher's time and efforts. Keeping students focused on tasks and following with the class can be difficult. Being unable to hold a student's attention during daily instruction can cause issues during emergency situations. High importance on routine and repetition are important to students who have disorders similar to autism.

The alarm and notification process that is currently used in facilities provides a unique range of difficulties for the instructors in the classroom. The loud audible notifications can cause students to become confused, scared and un-cooperative. Common occurrences during these emergencies are the student hiding in corners, under desks, or completely ignoring instruction. The chaos that can become relatively common during emergency situations is amplified for these classrooms. Bright strobe lighting can also have adverse effects on these individuals. The unpredictability of the alarm changes the routine and requires a change for the student.

Epilepsy

Hazledine (1986), "Epilepsy is a very old disease. It is mentioned in the Code of Hammurabi, written some 4,000 years ago, and is the subject of the earliest work of scientific medicine to survive" (p. 0- Introduction). It is caused by many attributing factors. Some are physical traumas that the individual has been a part of, others are neurological diseases and episodes that are just part of an individual's genetic makeup.

Epilepsy in of itself has been directly linked to individuals who have suffered from a form of traumatic brain injury. Hauser (1999) indicates that, "Although one can never assume cause and effect with certainty, there are a number of characteristics that suggest a causal association between a particular event (such as a traumatic brain insult) and an outcome (such as the development of epilepsy) from an epidemiologic standpoint. These include factors such as time order (the head injury must have preceded the epilepsy), biologic plausibility (we suspect that the insult can establish a plausible pathologic and neurophysiologic mechanism for the epilepsy, or consistency of the observation (epilepsy follows brain trauma in many different settings)" (p. 1). These indications show reference to possible PTSD associations along with neurological disorders. An individual who has had at least two seizures that were not preventable are requirements for the diagnosis of epilepsy. Epilepsy is a seizure disorder that can be brought on by many different triggers. Sleep deprivation, flashing bright lights, unusual amounts of stress, poor eating habits, different medication use, and other food products are all possible triggers for the seizures. For the purpose of this research, concern over the bright flashing strobes and the frequency with which they flash were the primary focus.

Students who are diagnosed with epilepsy require special attention only during times of an epileptic event. Without other special needs, these individuals will likely be in general education classrooms. The difficulty lies in being able to help and assist these students during an epileptic event.

Events can vary depending on the level of epilepsy that the student has. Absence seizures are minimal seizures sometimes consisting of the student just starring off into space with slight eye and or lip movement. This seizure activity will last on average a few seconds and is

followed by a slight postictal phase. The postictal phase can take seconds to minutes to wear off and is a period of unknowingness and confusion for the patient. Other individuals can have many episodes during the course of the day. These students often come out of the seizure on their own and require no immediate aid by teachers or other adults in the classroom. Students who have a wide range of episodes can go into grand mal seizure. Tonic-clonic seizures that feature a loss of consciousness accompanied by violent muscle contractions.

The varying level of epileptic activity in a classroom is hard to predict. As discussed above, individuals with epilepsy may go through phases of seizures at different times throughout the day. Most of the time regular doses of anti-seizure medication can help to prevent an episode. Educators are given specific instructions for each individual case.

Results

Nineteen out twenty six participants surveyed agreed that the current color of strobes is a problem for their child. The seven that did not have a problem reported that their child or student did not have a sensitivity to light. Based on the survey results, the bright white and rapid frequency in which the strobes activate may cause more harm than the desired effect of the design. The lights can be irritating, especially for individuals that are diagnosed with epilepsy and autism. The students can begin to lose focus and cling to whatever is near to them. Common reactions are hiding in a corner, climbing under a table, and running in abstract directions. The frequency and rate at which the strobes are functioning cause confusion in the students. This in turn can lead to children becoming uncooperative and possibly even setting off

an epileptic event. Of the nineteen participants that reported sensitivity to light, eighteen recommend a blue or green light would be more beneficial. None indicated a preference for white light and one explicitly said that white light was the worst possible choice. The surveyed participants indicated that changing the strobe color to blue or green would possibly initiate a calming reaction in their child because they find blue to be a more soothing color. Ninety percent of the surveyed participants indicated that their opinion was that slowing down the frequency of strobe lighting would possibly help mitigate reaction issues during an evacuation.

The long audible sounds, without words, were indicated by respondents to have disruptive tendencies for these occupants. Respondents indicated that including informative instruction in combination with distinct audible tones would be beneficial during required evacuation. Informative instruction is imperative to the occupants in these facilities. Loud audible notifications contribute to the confusion and misunderstanding that ensues during the practiced drills, thus contributing to the adverse effects to the teacher's instructions. Confusion and misunderstanding during the scenarios make following orders difficult. Specific pitch, frequency, and volume of current audible notifications is of primary concern. Students with Autism are indicated to have differing responses to sounds that vary in pitch. The rate of which the common audible alarms are sounded and the pitch and frequency of the sound help to frighten individuals that are in these classrooms.

Anecdotal accounts collected as part of this study indicate that the use of audible alarms with verbal instructions result in better responses from students. In schools with just alarm tones there were routinely incidents with students acting out during the fire drills. However, when the schools changed to a voice alarm system, the students were not acting out as they had previously.

The unexpected manner of these alarm activations are also areas of concern. No one can predict the time of an emergency. These events are unplanned and often times happen at the worst possible time. High priority has been given in the survey to practice drills being performed more frequently. Lack of preparation from some facilities and overall real life activation of the alarms help to reverse any progress previously made.

Recommended Actions

Further study is needed. All of these conclusions are based on a single opinion based survey focused on young children in schools. Any recommendations should be tested to validate that the opinions expressed by the respondents match how individuals with special needs will actually respond during an emergency.

Changing the color of strobes and possibly elongating the lights is a possible solution to the light effects of commonly used strobes. The survey respondents indicated a high priority given to the colors blue and green. Both blue and green are as soft colors. While the change was viewed as something that would be beneficial, concerns were raised that having a different system in the classroom than in other locations would not be beneficial. One of the main benefits to having fire drills in the classroom is to elicit the same response when the students are in other locations. If the color of the light is different, it is not known how well the training will be generalized.

The common bright white of current strobes is harsh and distracting. The light itself makes it difficult for us to focus and follow order. The frequency with which strobes produce this light makes it difficult for individuals with certain disabilities to focus on the task of

evacuation. It can induce pain, and confusion during emergencies. Self-evacuations are not feasible if an individual is experiencing an epileptic event.

By slowing down the frequency of the strobe and changing the color, it may be possible to allow a calm and stimulating effect. Slowing the lights will also reduce the possibility of causing and chaos.

Changing the audible notifications to an informative message instead beeping noises would allow a calmer situation to ensue as based on information gathered from participants in this project. The data collected indicated no preference between a male or female voice allowing for a quicker and more calming response. Roughly, half of the participants felt that a female voice would be helpful while the other half felt that a male voice would aide in successful evacuation.

Conclusion

This study collected the opinions of educators and parents of students in special education classes. The conclusions are derived from their opinions. Further studies are needed to examine these issues in greater detail and collect data in order to determine the best code changes to recommend.

Overall revamping of the special education facilities fire notification systems is recommended by this study. Evaluation and field trials should be conducted to make changes that will aide in the evacuation of patrons and not hinder the process. Differing diagnoses makes redesign difficult, but simple changes can make all the difference. Changing the strobe light color, frequency of the flash, information provided by the audible notification, as well routine

drills and procedures may help to ensure significant and timely evacuation. Research is needed to see how these changes alter the response of all populations within all buildings. Due to repetition, having different strobes outside of the classroom than inside the classroom could lead to improper responses when students are in locations other than the classroom.

Revamping the alarm and notification systems in special needs facilities can improve responsiveness and aid in overall effectiveness of these evacuations. By designing and performing differing simulations, proper recommendations may help to improve the current code standards in use today. Specific codes for special education facilities are at the forefront of this study. The number one priority in any given situation is life safety and the ability for the limited number of educators in a given setting to get students to safety in a timely manner. Changes and experiments are indicated in order to help with these life safety issues. As facilities are constructed, the codes and standards that they are constructed to need to be improved to provide helpful and informative information during emergency evacuation.

Appendix A

Interview Questions for Teachers and Professionals

This questionnaire is to help Oklahoma State University conduct research for the National Fire Protection Association in order to create a fire code associated specifically with classrooms and occupancies that are designed for high-risk occupants. High-risk occupants are defined as individuals who have autism, epilepsy, deafness, blindness, and any other special need. The research is to determine if the current fire code is acceptable for these classrooms and buildings, or if a specific code needs to be created to support these occupancies.

Please help this research by filling out the questionnaire below. Answers will be compiled into a report for the NFPA to review. You may be contacted for further assistance if deemed necessary. Please fill out and return as soon as possible. Any pertinent information will be taken in consideration for the research. Answers will be used for a data set and names will be kept confidential. Thank you for your help.

Name:

Profession:

Phone Number:

Email Address:

1. What special need are you an authority on?
2. Do these children tend to have an auditory hypersensitivity?

If so, what types of sounds tend to cause the most fear/pain?

High pitched sharp sounds?

Deep dull sounds?

Fast paced squelching sounds?

Common fire alarm/notification sounds?

3. Would an audible notification system be more effective if it was a continuous sound?

4. Would it be more effective if it was an alternating sound?

5. Would instructive or continuous audible sounds be more productive and helpful?

6. Would audible alarms that start softly and gradually get louder be helpful or hinder an emergency?

7. Would this be effective if it were to continue on the up and down path?

8. Does a male voice or a female voice help calm the children?

9. Would a combination of instructive notification followed by an audible alarm be effective in keeping the children calm?

10. Do these children have a visual hypersensitivity?

11. Do strobes and other bright flashing lights cause discomfort/fear?

12. Do certain colors have a more calming effect?

    Blue? Red? Green? Yellow? Bright white?

13. Would a visual alarm that alternated a series of colors be more effective in calming the children?

14. Would an alarm that had a slower frequency and slower rate of visual notification, such as a strobe, in a different color result in a calmer reaction?

15. How important is repetition and routine in these children's daily lives?

16. Would a fire alarm drill, practiced more than once a month, improve responsiveness in a true emergency?

17. Would these more common drills help the children in understanding the importance of the evacuation?

18. Would a visual notification light, such as a strobe, be more effective if it were long like a fluorescent light bulb?

19. Would a slower paced rate of frequency help with keeping the children calm?

20. Could early visual notification devices mounted on the ceiling have a calmer effect than a strobe mounted on a wall?

21. LED's are easily concealed in today's world, would having multiple LED's installed throughout the facilities furniture and along the walls be an acceptable alternative to the common strobes currently in use?

22. What would be the recommended ratio of instructors to developmentally delayed students be?

23. In your opinion, what would be the maximum number of at risk individuals in a classroom?

24. Should there be stricter guidelines on the amount of developmentally delayed students allowed in a classroom?

25. In your professional opinion, what area of importance should we focus on when it comes to fire alarms and audible notification systems for these at risk populations?

26. For facilities that have higher numbers of individuals with autism and epilepsy, what other common conditions might some of the patrons have?

27. What common difficulties would we find when developing different fire alarm notification systems for these individuals?

28. Would an alarm system that made common items such as furniture and shelves vibrate, help to keep an individual calm and still maintain a sense of urgency?

Use the space below to offer any areas of importance that need to be considered in this study.

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