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Direct Visual Signaling as a Means for Occupant Notification in Large Spaces

An Engineering Study Sponsored by the Fire Protection Research Foundation

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Report Issued:
12 January 2006

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1. EXECUTIVE SUMMARY

The requirements for the installation and performance of visible signaling in NFPA 72, the *National Fire Alarm Code*, are based on occupants being alerted by indirect signaling effects[1]. That is, they are alerted by the illumination of their surroundings, not necessarily by direct viewing of the signaling appliance.

The testing that led to the requirements in NFPA 72 was limited to classroom and office type spaces[2]. The methodology was never tested in large, well lit spaces such as warehouses, large "super stores", etc. Nevertheless, because strobes are required by other codes in these spaces, the installation and performance requirements of NFPA 72 are being enforced despite the lack of any technical foundation. In some cases, authorities are imposing their own requirements such as not allowing ceiling mounted appliances. The Annex of NFPA 72 states that there may be more efficient methods of visible signaling in large spaces such as warehouses and distribution centers.

NFPA 72 permits a performance based design approach that actually exceeds the prescriptive requirements for visible signaling[3]. Ad hoc testing in a large home supply store showed that such an approach may be effective, but not necessarily for the same reasons that it works in smaller spaces. The tests showed that high ambient light levels resulted in little or no *indirect* signaling effect in some parts of the space. The signal-to-noise ratio produced by the operating strobes was low in many locations. However, with strobes located over the aisles or unobstructed by stock, *direct* signaling and some indirect signaling was achieved.

As a result of that test, a proposal was submitted to the NFPA 72 Technical Committee on Notification Appliances for Fire Alarm Systems to add text to the Annex explaining possible direct signaling effects in large spaces. The committee accepted the proposal but requested that additional data be gathered and added in the form of a Comment on the Report on Proposals[4]. A proposal for limited research and testing was submitted to the Fire Protection Research Foundation. The proposal was accepted and the project was funded.

Tests were conducted in three different warehouse type stores. The results show that it is possible to have effective occupant notification by strobes installed per the requirements of the performance-based section of NFPA 72. Occupant alerting is achieved by a combination of direct and indirect signaling. The tests highlighted additional factors that designers, installers and owners should consider in order to increase the effectiveness of systems in large spaces. As a direct result of this project, the NFPA 72 Technical Committee on Notification Appliances drafted a Committee Comment revising the Annex text regarding visible signaling in large spaces to incorporate ideas and concepts found in the testing.

2. INTRODUCTION

The NFPA 72 Technical Committee on Notification Appliances recognized that the effectiveness of the prescriptive and the performance based requirements for visible appliances had not been tested in large volume spaces. The Fire Protection Research Foundation was asked to consider sponsoring a project to address some of the committee's concerns[5].

A two-phased research initiative was proposed. This project represents only Phase 1. In Phase 1, testing was done in large warehouse stores to test the hypothesis that the current performance based approach provides sufficient direct alerting of occupants. The principle goal of this project was to test the effectiveness of strobe systems in large volume spaces designed and installed using the performance based approach of NFPA 72, 2002. A secondary goal was to understand if occupant alerting was the result of direct or indirect signaling. The main objective was to draft text for inclusion in the Annex of the 2007 edition of NFPA 72 that would provide designers, installers and authorities some guidance on how to configure systems to provide effective alerting in these challenging spaces.

Phase 2, if approved and funded, will be a separate project. Phase 2 will extend testing to other large spaces such as malls and atria. The principle goal of Phase 2 is to test the performance based methods in more challenging visual environments. A second goal is to gather sufficient data to permit drafting of code text permitting or limiting the performance based approach as an acceptable method of occupant notification in large volume spaces. This may potentially move Annex text on suggested design and installation issues into the body of the code. Phase 2 may also consider other visible signaling methods or performance criteria.

This project (Phase 1) was intentionally designed for quick, but meaningful results. The project began in mid July 2005 and needed to be substantially complete by the end of October to provide feedback to the code committee. The project did not seek to define all variables and their required parameters for success. Instead, the systems were studied as a whole to determine if they were effective. Engineering analysis of the tests resulted in the identification of several variables that affect the success of the systems in alerting occupants. This allowed some information on design and installation practices to be proposed for inclusion in NFPA 72.

The Fire Protection Research Foundation formed a Project Technical Panel to monitor project progress, review and comment on any interim or draft reports and to release the final project report. The Project Technical Panel consisted of:

Robert Boyer	GE Security
Ray Grill	Arup Fire (Chair of the NFPA 72 NAS TC)
Dan Grosch	Underwriters Laboratories, Inc.
Rein Haus	Wheelock, Inc.
Jeffrey Klein	System Sensor, Inc.
David Lowry	Boulder Fire Department
Issac Papier	Honeywell Life Safety
Jack Poole	Poole Consulting Services, Inc.
Lee Richardson	National Fire Protection Association, NFPA 72 Liaison

3. PROJECT PARTNERS

The Fire Protection Research Foundation is the principle sponsor for this project. They have provided a grant to R.P. Schifiliti Associates, Inc. to conduct tests, draft code language and write a report.

One of the principle goals for this project was a quick turn-around and a second was low cost. To achieve these goals the help of other organizations was solicited. Project Partners were solicited to provide facilities for testing, technicians to assist in the tests and other services necessary to move the project forward. Several Project Partners have provided in-kind donations of time, facilities and services. In addition to the corporate support, several individuals within these companies have been instrumental in setting up and conducting the strobe tests.

TVA Fire & Life Safety, Inc. offers comprehensive fire protection, life safety, security, engineering, risk management, and loss control services to Fortune 500 companies including Home Depot and Wal*Mart stores. They donated time and assisted in setting up tests at Home Depot locations. In addition, they provided engineering information about the installed systems and coordinated technicians from FMG for conducting the tests at the Home Depot test sites.

The Home Depot is the world's largest home improvement retailer and second largest retailer in the United States. They donated the use of their stores as test sites.

Fire Materials Group (FMG) provides professionally managed fire and life safety services. They provide fire alarm inspection, testing and maintenance services for the Home Depot. FMG donated the services of their technicians for conducting tests at Home Depot locations.

Wal-Mart Stores, Inc. is the world’s largest retailer. They have donated time and permitted testing in their stores. Wal-Mart Security Services donated time and assisted in setting up testing at the Kissimmee, FL test location. They have also provided Wal-Mart fire alarm technicians for conducting tests.

American Sign Language Interpreting Services (ASL Services) is a nationwide company dedicated to providing the highest quality of professional and ethical Sign Language services at reasonable prices to the community in accordance with the communication preferences of the Deaf and Hard of Hearing persons they serve. ASL provided the services of an interpreter during the testing in Kissimmee, Fl.

4. TEST PLAN

The test plan began with the development of a detailed *Test Protocol*. A copy of the protocol is reproduced in Section 14 to this report. The protocol was used as a checklist for each test. In summary, participants were solicited and asked to walk around the store. The fire alarm system was then activated. Pre and post test surveys were used to gather data.

For each site, information was gathered concerning the design and installation of the strobe alerting system. Ceiling heights were either obtained from plans or measured. The mounting height of strobes, relative to the floor, the ceiling and lighting fixtures was measured. Stock heights, aisle widths and rack widths were measured in several locations. Ambient light measurements were taken throughout the stores.

At each test location a reception/gathering point for participants was established outside, in front of the main entrance to the store. Refreshments were provided for the participants. Because the project used human test subjects, an Informed Consent Form was required. Section 15 contains a copy of the *Participant Information Sheet & Consent Form*. As each person arrived, they were given a numbered nametag. Their participant number was used on all forms as the means of tracking the participant. Each person was asked to read, initial and sign a consent form. The form was checked for completeness and the person was asked if the had any questions, which were then answered.

A tool was developed to gather pertinent information about the test participants. A blank copy of the *Participant Survey – Pre-Test* is included as Section 16. After completing the Consent Form, they were given the Pre-Test Survey to complete. Each survey form was checked to determine if there were any conditions that might be cause for a person to not participate. (None were noted for any of the tests.)

Test participants were each given a small note card with instructions and reminders about what they were to do during the tests. A copy of the card is reproduced in Section 17. The group was given verbal instructions and asked to enter the store and go "shopping".

The store's paging systems were used to make verbal announcements that a test was in progress. After participants had been in the store for 10 to 20 minutes, the fire alarm system was activated. The group returned to the gathering point where they were given a Post-Test survey (*Participant Survey – Post-Test*, Section 18). Each Post-Test Survey was checked for completeness and, if necessary, questions were asked and the form marked for clarity or completeness.

After all forms had been gathered a group discussion was initiated to gather addition feedback and information. The group discussions were valuable in getting qualitative information about the pros and cons for each test scenario. This was particularly valuable for participants that took part in more than one test.

5. TEST LOCATIONS

The first two test sites were Home Depot stores located in Reading, MA and Danvers, MA. Invitations to participate were sent to members of the NFPA Technical Committee, NFPA staff, members and affiliates of the New England Chapter of the Society of Fire Protection Engineers and several deaf and hard-of-hearing organizations, including Self Help for the Hard of Hearing (SHHH).

A third test was planned for a Home Depot in Plaistow, NH and a fourth was planned for a Wal*Mart in Plymouth, MA. Both tests were cancelled after receiving only a few responses from persons invited to participate. A test was then scheduled to coincide with the NFPA 72 Report on Comments meeting taking place in Orlando, Fl.

Because the tests were taking place in businesses that were already occupied and open for business, the owners required testing to be done during early morning hours (6:30 – 7:30 AM) when there were few public customers in the stores. While this limited the ability to include "walk-in" participants, it did minimize the "Cry Wolf Syndrome" impact of the testing[6]. The early test time also affected the ability to get participants. In some cases it helped to get persons to come before or on their way to work. However, the time probably caused some people to decline participation.

Lighting in each of the locations was provided by fluorescent lamps. The Wal*Mart store also had skylights. The Illuminating Engineering Society of North America (IESNA) defines these spaces as "High Activity Spaces" with minimal sales assistance and products that are easily recognizable[7]. The recommended lighting level varies with the specific use of the space. IESNA recommends the following levels:

Area	**Level**	
	lux	**ft-candles**
Circulation	323	30
Merchandise	1,076	100
Feature displays	5,382	500

Lighting levels for all three locations were within the range for general circulation and merchandise areas. The highest levels were found in the carpet and lighting displays of the two Home Depot stores. Ranges were on the order of 431 – 1937 lux (40 – 180 ft-candles).

5.1. Home Depot, Reading, MA

The test at this location took place on August 24, 2005. There were 13 participants. The fire alarm system at this location was designed and installed to permit the audible signal to be disabled separate from the visible signals. This allowed the strobe lights to be activated without any audible signal.

Table 1 is a summary of relevant building and environmental information. Table 2 summarizes information about the strobe light system.

Nominal ceiling height:	27 ft
Nominal height to top of storage:	16 ft
Range of ambient light level:	538 – 1,937 lux 50 – 180 ft-candles
Ceiling configuration:	Metal deck (white/gray) on I beams. All utilities exposed.

Table 1 - Building Information

Strobe location:	Mounted below the ceiling, 23 ft above the floor at the same level as the fluorescent light fixtures.
Strobe spacing:	Varies. Nominal 45 - 48 ft spacing in open areas and in aisles.
Strobe intensity:	75 cd. eff. per drawings (one unit found to be only 15 cd eff.)

Table 2 - System Information

The strobes at this location are located below the ceiling, at about the same level of the hanging fluorescent lights. The original design called for the strobes to be located over the aisles, between racks. Within each aisle, the strobes are spaced approximately 45 to 48 ft. Rack spacing varies with most 16 ft on center and some as much as 30 ft on center. Thus, strobe coverage might be 45 ft x 16 ft in order to provide a line of strobes in each rack aisle. However, after the system was installed, the rack layout was altered resulting in many lines of strobes not falling directly over an aisle.

The strobes at this location are the multi-candela type that is field adjustable. After the test it was found that at least one strobe was never changed from the nominal 15 cd eff. out-of-the-box setting.

Photo 1 shows a picture of a typical rack aisle with a strobe located directly overhead. A close-up of the strobe in Photo 2 shows the ceiling configuration and the location of the strobe relative to the building lights and structural steel.

Photo 1 - Strobe Over Aisle (Reading, MA)

Photo 2 - Close-up of Strobe (Reading, MA)

5.2. Home Depot, Danvers, MA

The test at this location took place on August 25, 2005. There were 12 participants, eight of whom also participated in the Reading test. The fire alarm system at this location did not permit the audible signal to be disabled separate from the visible signals.

Table 3 is a summary of relevant building and environmental information. Table 4 summarizes information about the strobe light system.

Nominal ceiling height:	21.5 ft
Nominal height to top of storage:	16 ft
Range of ambient light level:	431 – 1,722 lux 40 – 160 ft-candles
Ceiling configuration:	Suspended acoustical tiles (white) with recessed fluorescent light fixtures. Most utilities hidden above the suspended ceiling.

Table 3 - Building Information

Strobe location:	Mounted on the ceiling, 21.5 ft above the floor.
Strobe spacing:	48 ft spacing in open areas and in aisles.
Strobe intensity:	115 cd. eff.

Table 4 - System Information

The strobes at this location are located on a suspended acoustical tile ceiling at the same level of the building's fluorescent lights. The design and installation resulted in most strobes being located over the aisles, between racks. Within each aisle, the strobes are spaced approximately 48 ft. Rack spacing varies with most 16 ft on center and some as much as 30 ft on center. Thus, strobe coverage might be as low as 48 ft x 16 ft in order to provide a line of strobes in each rack aisle.

Photo 3 shows lines of strobes on the ceiling. Photo 4 shows an aisle with strobes directly overhead. Photo 5 is a close-up of a strobe on the suspended ceiling.

Photo 3 - Lines of Strobes

Photo 4 - Strobes Over Aisle

Photo 5 - Close-up of Strobe (Danvers, MA)

5.3. Wal*Mart, Kissimmee, FL

The test at this location took place on October 28, 2005. There were 22 participants. Two participants had also taken part in both the Reading and Danvers tests. This test coincided with the Report on Proposals meetings of the NFPA 72 Technical Committees. The participants were all Technical Committee members and included almost all members of the Notification Appliances Committee.

The fire alarm system at this location was designed and installed to permit the audible signal to be disabled separate from the visible signals. However, the manner in which this is effected results in a single audible chirp when the system was activated. After that first chirp, the audible signals stop and the strobes continued to operate.

Table 5 is a summary of relevant building and environmental information. Table 6 summarizes information about the strobe light system.

Nominal ceiling height:	16 – 21 ft
Nominal height to top of storage:	9 ft
Range of ambient light level:	510 – 1,265 lux (47 – 114 ft-candles)
Ceiling configuration:	Metal deck (white) on bar joist on trusses. All utilities exposed.

Table 5 - Building Information

Strobe location:	Mounted below the ceiling on the bottom chord of the bar joists, approximately 15 – 20 ft above the floor.
Strobe spacing:	45 ft x 45 ft
Strobe intensity:	115 cd. eff.

Table 6 - System Information

The strobes at this location are located on the bottom of the bar joists supporting the ceiling/roof. The florescent light fixtures are approximately 8 - 12 in. below the bar joists. The design and installation resulted in strobes being located over most of the main aisle and circulation areas. However, not every merchandise aisle has a row of strobes overhead. Typically, the strobes are over the main aisles and over every third to fifth stock aisle.

Photo 6 shows the ceiling configuration with strobe lights located on the bottoms of the bar joists.

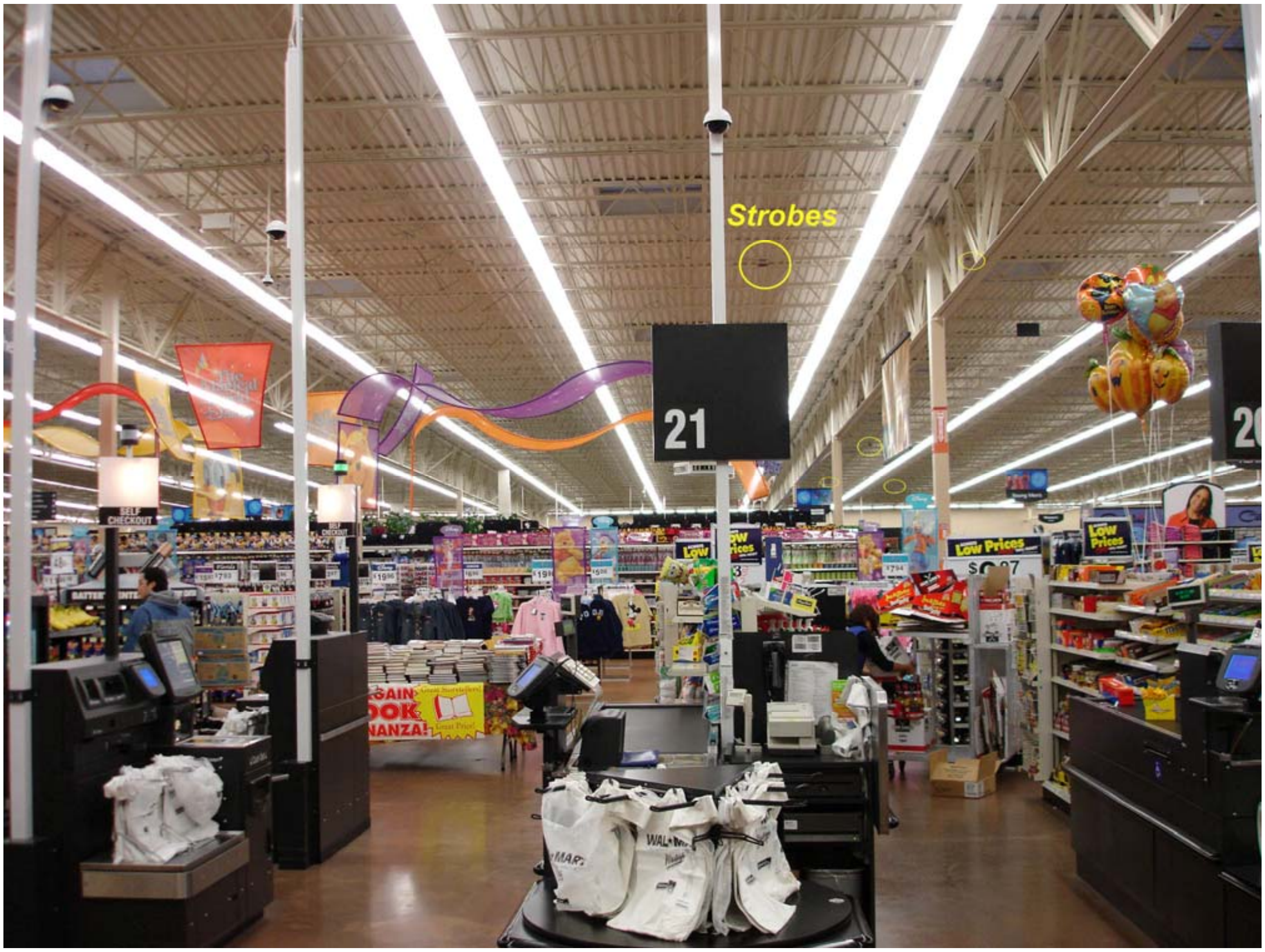


Photo 6 - Strobes Located on Bottoms of Bar Joists (Kissimmee, FL)

6. TEST PARTICIPANTS

There were 13 participants in the Reading test, 12 at Danvers and 22 at Kissimmee. Most participants were from the fire protection and fire service communities. Despite several contacts with deaf and hard-of-hearing organizations, only one (Danvers) participant was drawn from those communities. For the Kissimmee test, three different local deaf and hard-of-hearing organizations contacted their members and gave them information and an invitation to the test. The state of Florida sent the project information and invitation by email to over 8,000 persons – twice.

In Reading, three participants identified themselves as having hearing impairments. Two indicated their impairment was mild and one said it was severe. Two of these participants (one severe and one mild) wore corrective devices.

In Danvers, two participants identified themselves as having hearing impairments. One indicated their impairment was mild and one said it was severe (participant from a hard-of-hearing organization). One of these participants (severe) wore corrective devices.

In speaking with participants and with persons from the deaf and hard-of-hearing communities, it appears the early morning test times had the greatest negative impact on drawing participants. Other factors such as transportation and motivation may also have impacted participation.

7. TEST RESULTS AND ANALYSIS

This section of the report presents the results of the Post-Test Survey with some discussion of the results for each question. In section 8, Discussion, many factors are discussed relatively along with possible causes and consequences.

7.1. How were you first alerted?

As noted in the test descriptions, the test in Reading was the only one where the audible signals could be completely silenced. The system at the Wal*Mart in Kissimmee allowed the horns to be disabled separately from the strobes, but only after a single "chirp" of the audible signal. Figure 1 shows that where audible signals operate along with visible appliances, the audible signals are generally the first means of occupant notification. This is as expected due to the ability for audible signals to penetrate and fill a space. Because visible signaling relies upon a system of distributed point type "line-of-sight" appliances, the coverage volume will almost always be significantly less than audible signaling.

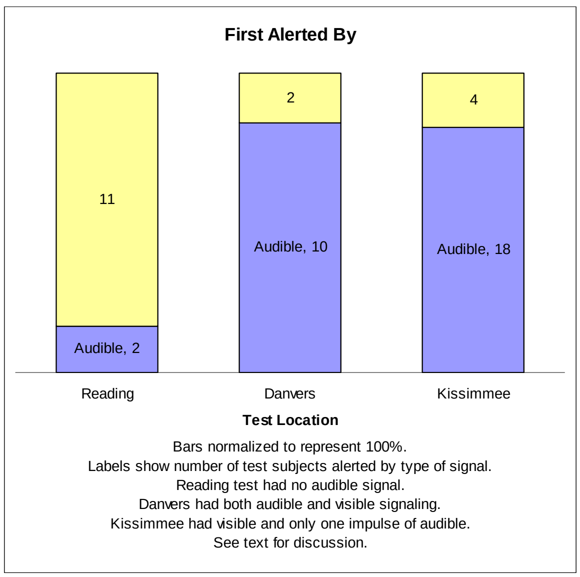


Figure 1 - First Alerted By

Interestingly, even though audible signals did not operate in the Reading Home Depot test, two participants indicated that they were first alerted by audible, not visible signals. Both indicated in their Post-Test Survey that the sound was very faint. It is possible they were alerted by the control panel audible indicator. However, the panel was located in a separate room within an enclosed vestibule and both participants were quite a distance from that room.

7.2. Indirect Strobe Effects

Participants were asked if they could see the flash of the strobes reflecting off of the floor, stock or other surface without actually seeing a strobe light directly. The results summarized in

Figure 2 show that the Danvers system was the most effective system and the Reading system was the least effective system for indirect signaling.

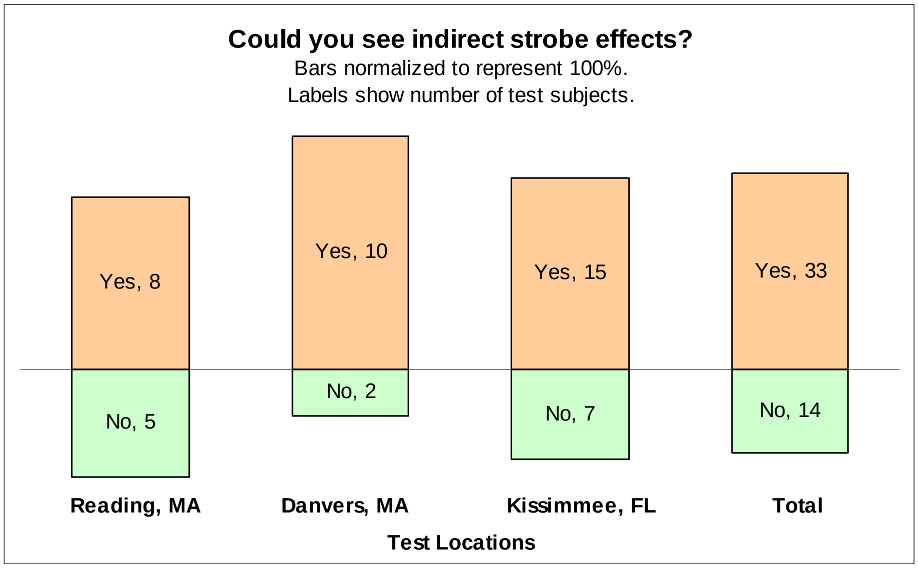


Figure 2 - Indirect Signaling Effectiveness

The variables and methods for calculating strobe illumination are presented in detail in Section 13. The discussion in the Annex notes that designers differ on whether calculations are done for a simple square or for an overlapping pattern of circular coverage areas. In addition, for each assumed area, calculations can be done for the basic distance from the strobe or corrected for the angle at which the light ray strikes a surface. Calculations for all four possibilities are included for each of the test sites for nominal heights and spacings.

Although there are many other factors involved in the actual effects of the systems (versus a strobe in an imaginary square) the calculations show the Reading system provides the lowest levels of illumination. Based on the industry standard for performance based calculations, the systems for Danvers and Kissimmee were over-designed while the Reading system most closely met the minimum requirements of the code.

In addition to strobe intensity and the resulting level of illumination, the clearance between the top of the stock/storage and the strobe lights affected indirect signaling in both the Reading and Kissimmee stores. In these stores, there were many aisles where strobes were not located directly overhead. This light had to come over the racks/shelves from adjacent lines of strobes. See Section 13.1 for more detailed discussion. In Danvers, in addition to a higher calculated level of illumination, strobes were located directly over almost all aisles. This resulted in greater indirect coverage on the surface of stock. Similarly, the greater clearance from the top of the stock to the strobes in Kissimmee versus Reading permitted greater penetration into aisles that did not have strobes directly over them. Figure 3 shows a typical warehouse store with strobe coverage providing both direct and indirect signaling to the occupants. Figure 4 is the same diagram highlighted to show the surfaces where one of the strobes provides indirect signaling by illuminating the surface of the floor and the stock on the racks or shelves. The highlighted surfaces in Figure 4 show that as the clearance between the top of the storage and the strobe is decreased, or as strobe spacing is increased, light penetration to adjacent aisles is decreased.

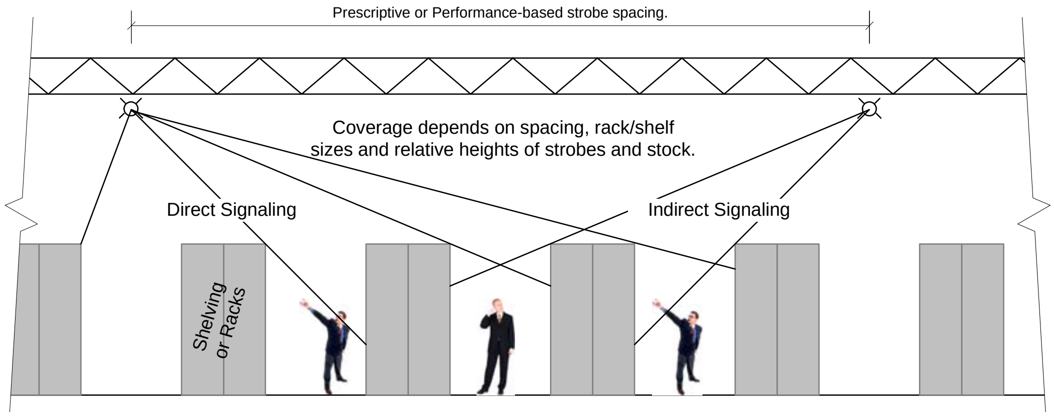


Figure 3 - Direct and Indirect Strobe Coverage in Racks

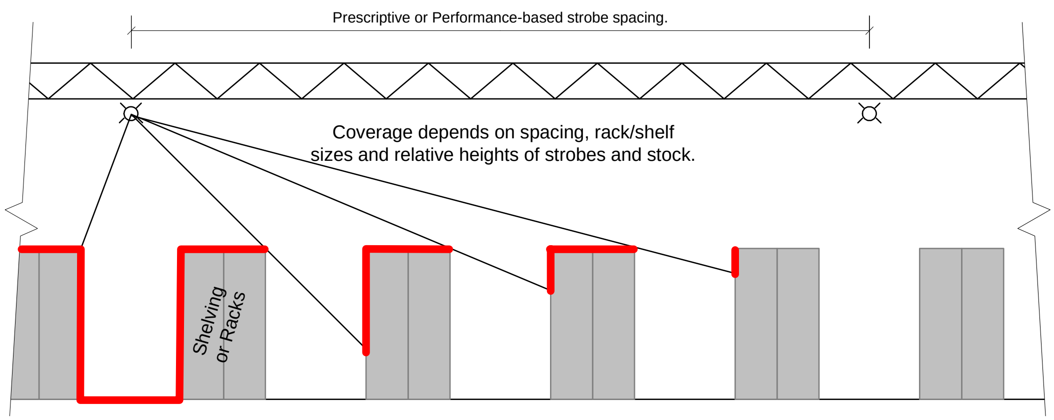


Figure 4 - Actual Strobe Penetration in Racks

7.3. Direct Signaling Effects

These types of stores have large volumes and long viewing paths. In many places, the aisles, racks and shelves focus the occupants' vision in a way similar to corridors in schools and offices. In those spaces, the National Fire Alarm code permits the use of lower intensity strobes at greater distances since occupants are likely to directly view at least one appliance as they transit the corridor. Presently, most authorities require strobe system design in warehouses and superstores to be based on NFPA 72 room coverage requirements. They do not permit the use of corridor rules.

Participants were asked if they were able to actually see (directly view) one or more strobe lights flashing without intentionally looking up at the ceiling. The results, summarized in Figure 5, show that the Kissimmee system was the most effective at direct signaling to occupants.

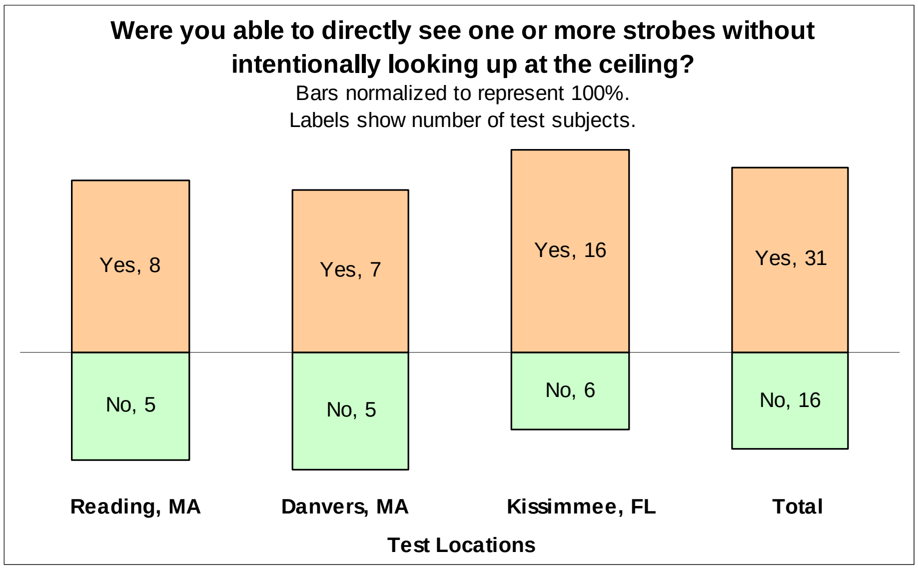


Figure 5 - Direct Signaling Effectiveness

The better outcome in the Kissimmee Wal*Mart is probably the result of a greater clearance between the top of stock/storage and the strobe lights than either of the two Home depot stores. As a result, occupants could see more of the ceiling and, hence, more strobes from most vantage points. This is discussed in more detail in Section 8. Also, there may still have been locations where strobes or their effects were not viewable – see Blind Spots.

7.4. Number of Strobes Visible

Participants were asked if as they could see more than one strobe light flashing as they moved about, and if so, how many. Figure 6 through Figure 8 show the number of strobes viewed by participants for each test location. Figure 9 sums the data for all three locations.

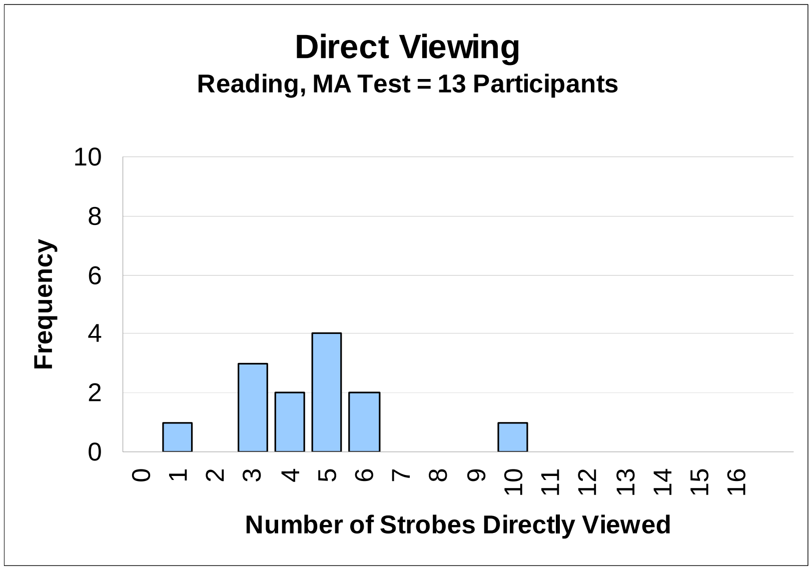


Figure 6 - Number of Strobes Directly Viewed – Reading

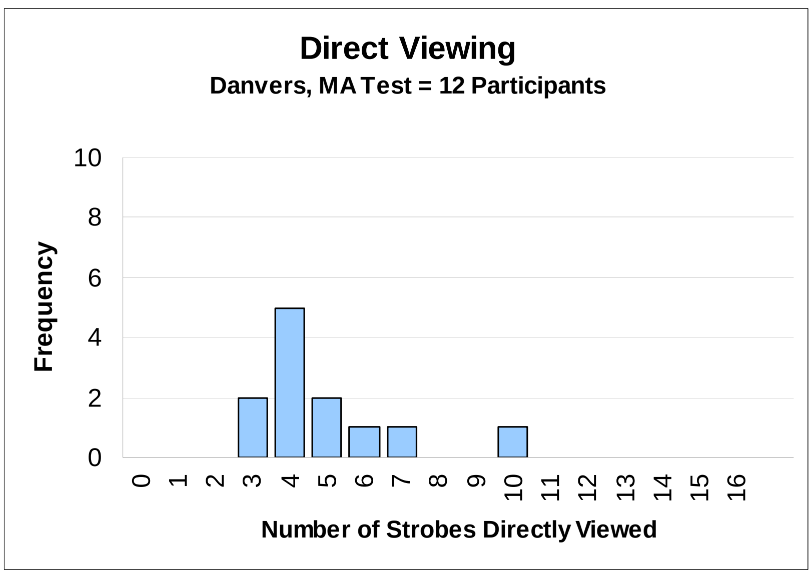


Figure 7 - Number of Strobes Directly Viewed – Danvers

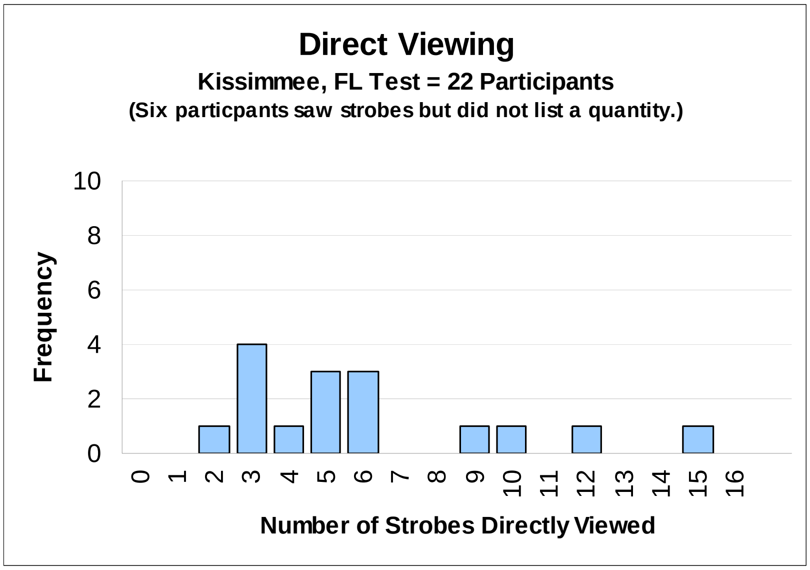


Figure 8 - Number of Strobes Directly Viewed – Kissimmee

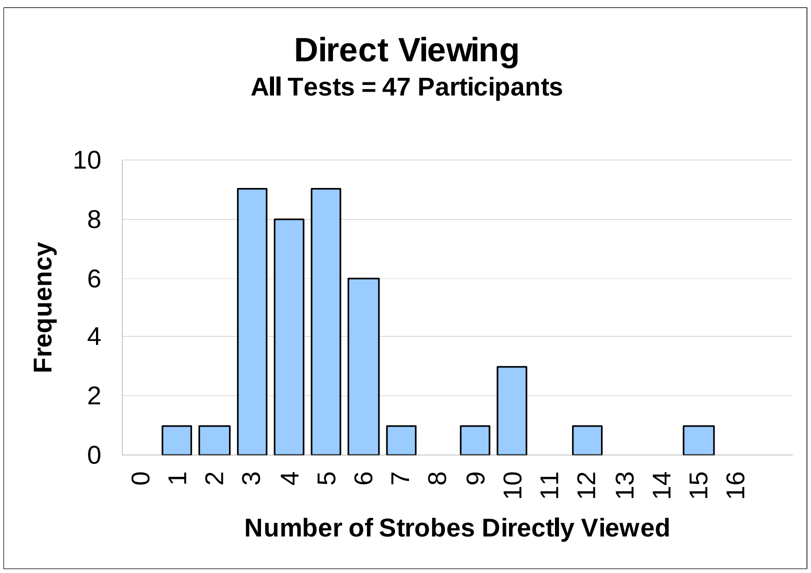


Figure 9 - Number of Strobes Directly Viewed – All Stores Combined

The data show that for these test conditions, all participants could see at least one strobe as they walked through aisles. The majority of responses indicate that three to six strobes were generally visible as the participants moved about the space.

7.5. Blind Spots

Despite there generally being three to six strobes directly visible as participants walked around the stores, there still were locations where they did not directly see a strobe or its indirect reflection. Participants were asked if there were there any locations where they could not see a strobe light or its reflection. The results are summarized for all locations in Figure 10.

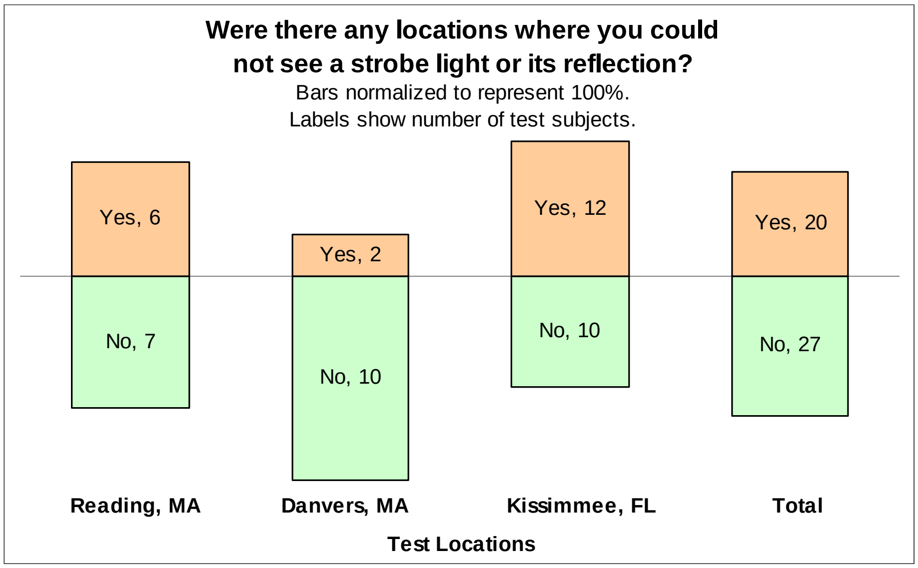


Figure 10 - Blind Spots

At the Kissimmee location, the greater clearance between stock and strobe lights increased the likelihood of direct signaling. Nevertheless, this location also had the greatest number of reported blind spots where a strobe or its effect was not visible. By most accepted standards, the system was over-designed with respect to strobe intensity for a given height and spacing. However, even with a larger strobe clearance, the aisle spacing versus the strobe spacing resulted in a single row of strobes for three to five aisles. Participants found that the strobes did not penetrate when they were more than two or three aisles away. This is discussed in more detail in Section 8.

In Reading, the ceiling was an open plan type with all structural members and utilities exposed. The strobes were located below almost all obstructions except air handling ductwork. There were several locations noted where ductwork blocked the strobes.

7.6. System Rating

For each location, participants were asked to rate the effectiveness of the fire alarm strobe light system. The results for the three test locations are shown in Figure 11 through Figure 13 and combined for all locations in Figure 14.

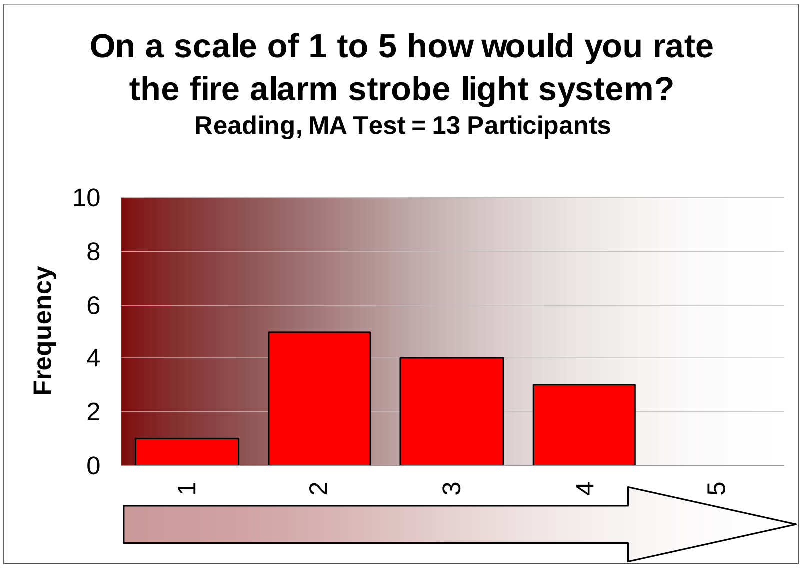


Figure 11 - Strobe Effectiveness - Reading

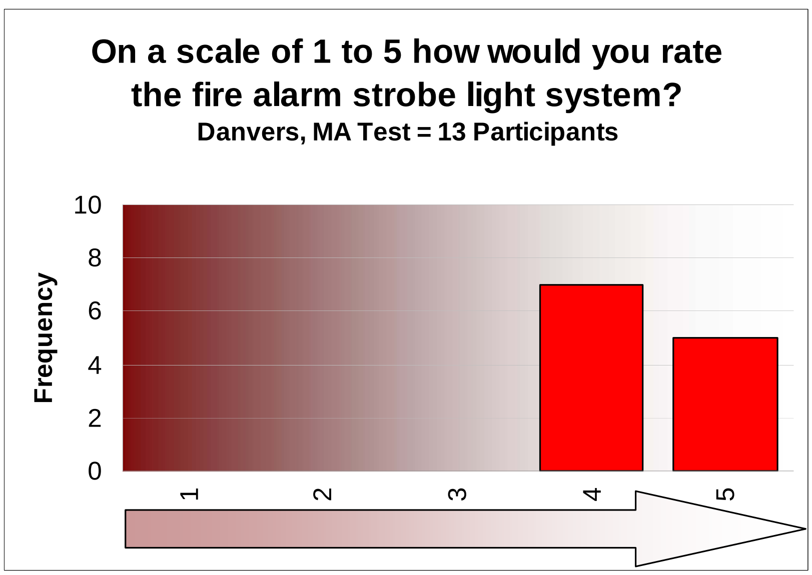


Figure 12 - Strobe Effectiveness - Danvers

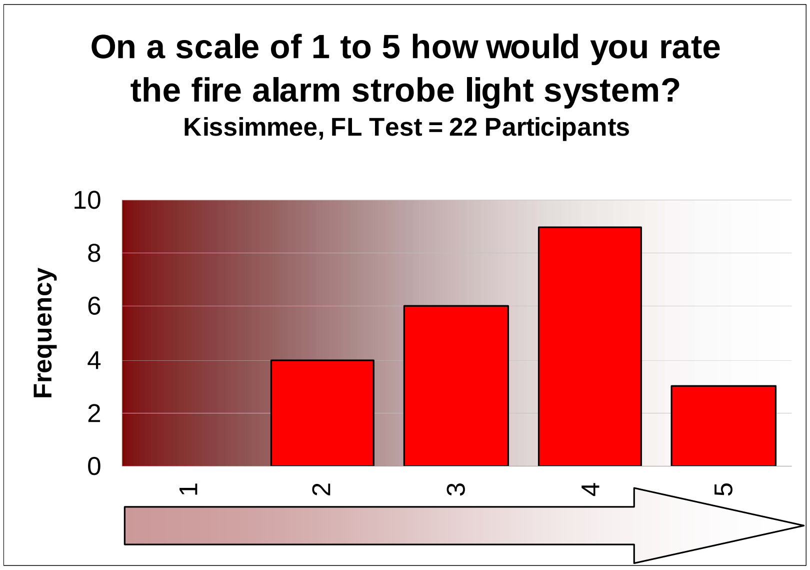


Figure 13 - Strobe Effectiveness - Kissimmee

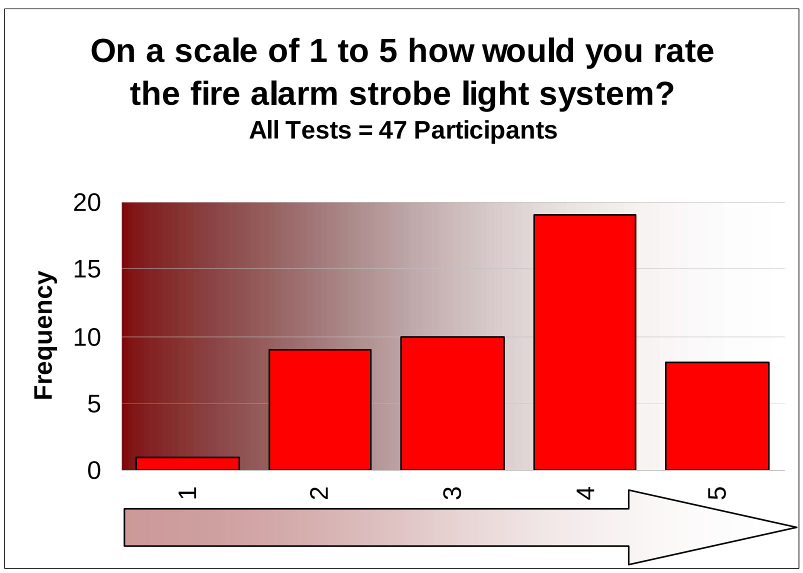


Figure 14 - Strobe Effectiveness - All Locations

In general, the systems were effective. However, clearly there were differences that made the Danvers system stand out as the most effective and the Reading system as the least effective system. The Danvers system used higher intensity strobes, on a reduced spacing and located over almost all aisles between racks. In Reading, the strobes locations were designed to be over aisles. Before completion, the rack layout changed resulting in most aisles not having a row of strobes directly overhead. In Kissimmee, most respondents felt the system was effective. Based on strobe intensity, ceiling height and strobe spacing, the system was over-designed. Nevertheless, when superimposed on aisle/stock layout, there were aisles where coverage was minimal or non-existent. This is discussed in more detail in Section 8.

For the Reading test, the three hearing impaired persons gave ratings of 1, 2 and 3 out of 5. In Danvers, both hearing impaired persons rated the system 4 out of 5. In Kissimmee the hearing impaired all rated the system at 3 or higher (3, 3, 4, 5 and 5). Thus, the hearing impaired persons rated the system effectiveness approximately the same as other participants.

7.7. Universal Effectiveness of Strobe Light Systems

Participants were asked if, in their opinion, strobe lights are an effective method for alerting deaf or hearing impaired persons. See Figure 15.

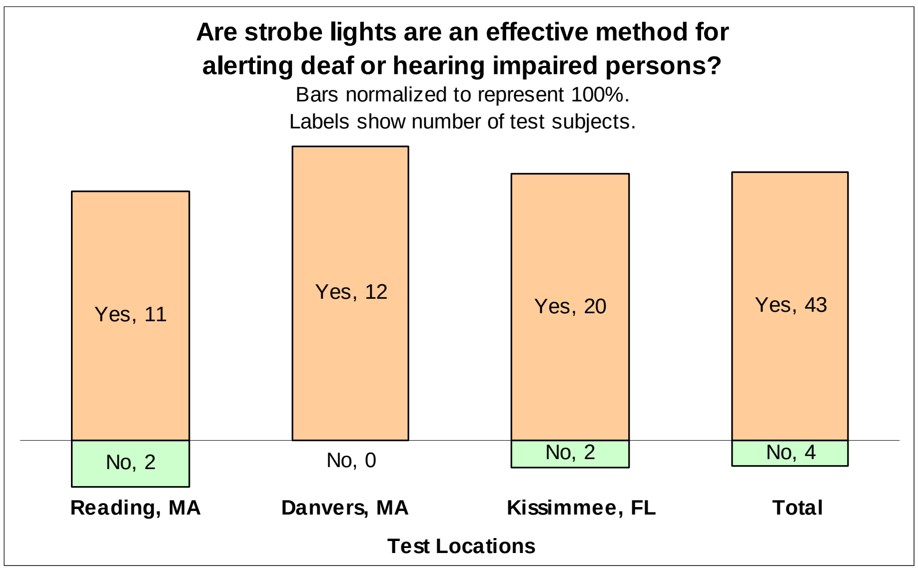


Figure 15 - Universal Effectiveness of Strobe Systems

There was general agreement among participants that strobe lights were an effective means for alerting the deaf and hearing impaired. The survey results show that the experience of the participants on that day, with a particular system, affected their opinions. Their opinions on universal effectiveness correlated with their opinions of the particular systems they just experienced. Nevertheless, they gave higher effectiveness-ratings when generalizing. Even though they may have seen faults with the system they just witnessed, they still felt that strobes were an effective method for alerting.

Although the sample size is too small to draw conclusions, it is interesting to note that in the Reading test, the two persons that felt that strobe light systems were not effective were both hearing impaired (one severe, one mild). The third person with a hearing impairment thought that the systems, in general, were effective.

In Danvers, the two hearing impaired persons thought that strobes were an effective alerting system. In Kissimmee, four of the five hearing impaired persons thought that strobes were an effective alerting system. The fifth hearing impaired person qualified their response by writing "in this case", rather than making a general evaluation. When asked, they were non-committal with respect to general strobe effectiveness.

8. DISCUSSION

To better understand the possible causes of the results of this project it is helpful to understand the existing performance based requirements of NFPA 72 and the light distribution requirements of UL 1972. The requirements, different variables and four possible ways of doing the calculations are discussed in detail in Section 13.1.

The Danvers system was generally rated higher because strobes were located over almost all aisles. The Kissimmee system showed that good performance does not require strobes over every aisle. Similarly, the Reading test showed that where aisles are moved, resulting in not having strobes directly overhead, adequate performance is still possible.

When all three tests are reviewed and compared, several significant points emerge:

1. Strobe lights are effective for both direct and direct viewing even if not located directly over an aisle, provided there is sufficient penetration to the aisle.
2. A design with strobe lights over every aisle is more effective than one where strobes serve several aisles.
3. Aisles focused the occupant's vision and improved direct signaling effects.

In Reading one strobe was found to be rated at 15 cd eff., not the intended 75 cd eff. It was not possible to inspect all the strobes as part of this test/survey. It is possible that more, or even all, of the strobes were installed at a setting of 15 cd. eff. This, combined with the outstanding results for the Danvers test, warrant investigation into the use of corridor rules for strobe selection and layout in aisles. Where strobes are located directly over aisles, it may be possible that the aisle width could be used to determine the required intensity. This might reduce the required intensity of most strobes. The coverage area would then be a long rectangle rather than a square. The distance to the far corner of the rectangle could be used as the worst case distance. Using the aisle width to determine the required intensity would mean that the resulting illumination on the floor at the far ends of the rectangle would be less than the 0.0375 lm/ft^2 currently required. Nevertheless, in that direction, it appears that corridor effects result in occupant notification by direct viewing of the strobes. Figure 16 shows this effect.

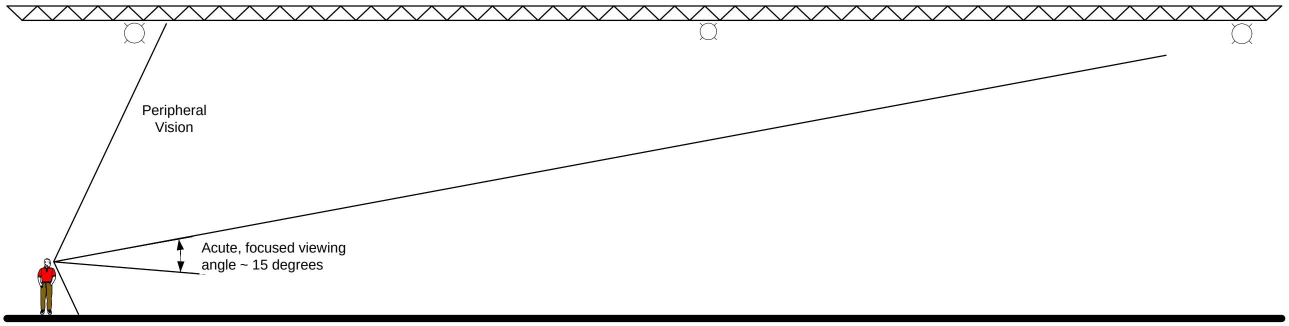


Figure 16 - Direct Viewing of Strobes

However, it must be recognized that some stores regularly change rack/shelf locations and spacings. Any reduction in strobe intensity or spacing for corridor effects would be negated if a new rack layout resulted in strobes not directly over each aisle. For those situations, the data suggest that a design based on the current requirements for performance based designs in NFPA 72 will be adequate. However, the calculated strobe spacing must be compared to the aisle spacing, rack height, rack width, stock height and strobe height to determine if there is adequate penetration into all aisles. This project did not attempt to determine what "adequate penetration" means. For example, many people shopping in an aisle may see the indirect illumination if it "paints" the stock from six to seven feet and up. This places the light in the direct or peripheral vision of most people. It may be that an even higher penetration line is acceptable, or that a lower one is required.

In the testing that led to the requirements in NFPA 72 ambient light measurements were taken in classrooms, a test room and in a typical hotel/motel room[2]. However, actual testing with human subjects was limited to the classroom environment and a fabricated test room. Lighting levels in the classroom tests varied from about 129 – 807 lux (12 – 75 foot-candles). Lighting levels in the test room varied from 29.6 – 105 lux (2.75 to 9.75 foot-candles). Thus, ambient lighting for the tests used to generate the requirements in NFPA 72 were considerably less than those in the large stores used in this project. This resulted in lower signal-to-noise ratios and reduced visibility of the strobe's effects. Nevertheless, except where strobes did not penetrate into aisles, the strobes were found to be effective on average. However, participants felt that the more brightly lit areas were marginal. This project did not attempt to determine a threshold signal-to-noise ration that would reliably alert occupants.

Since the test could not be "blind" or "double blind", the inclusion of participants that were active in the fire prevention and protection industry could have affected the data. After initial alerting, they tended to provide a more critical "inspection" of the operating systems. This more critical review was noted in the general discussions after the tests. However, the limited number of participants makes it impossible to tell if the participant's involvement in the fire industry affected their answers on the post-test with any degree of statistical significance.

The post test survey indicated that test locations had "blind" spots where a strobe or its effects were not visible. Obviously, designs should endeavor to eliminate or reduce blind spots. These blind spots occurred more frequently in the Kissimmee test where some aisles were three to five aisles away from a row of strobes. The angle and stock height combined to block direct and indirect strobe viewing in those remote aisles. Blind spots were also common in the Reading test where strobes were sometimes blocked by other utilities at the ceiling. The open ceiling plan in the Reading store differed from the uncluttered suspended ceiling in Danvers and open, but less cluttered ceiling in Kissimmee. Installing technicians need to understand the spacing rules and field modify the installation to prevent appliances from being blocked.

Similarly, it was noted that in central areas there is an opportunity for an occupant to see direct or indirect strobe coverage in all directions – 360 degrees. Closer to the outside walls of the stores the number of strobes that might contribute to direct or indirect viewing by the occupant is reduced. Corners have the potential for the least strobe coverage.

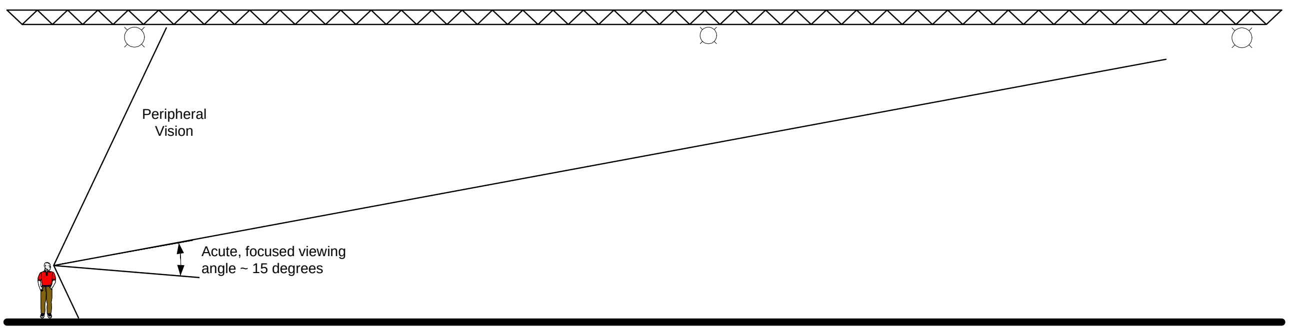
In discussions with participants after completion of the Post Test Surveys, the potential for blinds spots and marginalized coverage was discussed. All seemed to agree that designers should take steps to minimize blind spots and to anticipate rack and aisle changes (where possible). Many felt that blind spots were an inevitable result given the complex store layouts and the nature of visible signaling. Some discussion ensued as to whether blind spots constituted a "failure".

Many, but not all, participants felt that in the context of total protection, some blinds spots or areas with marginal coverage would not be cause for concern. Several other conditions combine to protect store occupants for the short time that they might not see direct or indirect strobe signaling. First, audible signals would also provide alerting for hearing able and many hearing impaired persons. Second, the occupants are alert and mobile. If they are anywhere near a fire, other senses (smell, sight, touch) will provide additional cues. If they are not near the fire, they are not yet threatened and their normal movement means they will soon move to an area where they will be alerted by a strobe if they have not already been alerted audibly or by other occupants' behavior. Third, if they are not near a fire, the large volume of the space (to absorb smoke and heat) combined with sprinkler protection separates them from the threat. Once alerted, code compliant means of egress provides several safe ways out of the space. These occupancies differ from others, such as apartments, offices and health care in that there are typically no dead ends, they have good visibility across the space when in main aisles, and many locations have more than two ways for an occupant to move.

9. PROPOSALS AND COMMENTS TO NFPA 72

During testing in a large warehouse store in 2004, it was noticed that where indirect signaling was marginal or non-existent, there often was sufficient direct viewing of strobes to provide occupant notification. As a result of that test, a proposal was submitted to the NFPA 72 Technical Committee on Notification Appliances for Fire Alarm Systems to add text to the Annex explaining possible direct signaling effects in large spaces[4]. The following text and figure was accepted by the committee for inclusion in the existing Annex section A.7.5.3:

> Tests of a system in a large warehouse/super store designed using the prescriptive approach of 7.5.4.3 showed that high ambient light levels resulted in little or no indirect signaling effect. The signal-to-noise ratio produced by the operating strobes was too low. However, with strobes located over the aisles or unobstructed by stock, direct signaling was achieved. This occurs even when occupants do not look up towards the ceiling mounted strobes due to the extended cone of vision shown in Figure A.7.5.3. The strobe intensity and spacing resulting from the prescriptive design is sufficient for occupant notification by direct signaling.



The committee accepted the proposal but requested that additional data be gathered and added in the form of a Comment on the Report on Proposals. That request spawned this research project and report. As a direct result of this project, in October of 2005 the Technical Committee on Notification Appliances submitted a Committee Comment revising the above text and adding a second figure as follows:

> Tests of systems in large warehouse/super stores designed using the prescriptive approach of 7.5.4.3 showed that high ambient light levels resulted in both indirect and direct signaling effects. The signal-to-noise ratio produced by the operating visible notification appliances was low in many locations. However, with visible notification appliances located over the aisles or unobstructed by stock, indirect and some direct notification was sometimes achieved. Direct notification occurs even when occupants do not look up towards the ceiling-mounted visible notification appliances due to the extended cone of vision shown in Figure A.7.5.3(a). The visible notification appliance intensity and spacing resulting from the prescriptive design was generally sufficient for occupant notification by a combination of direct and indirect signaling. Testing showed that the best performance was achieved where visible notification appliances were directly over aisles or where visible notification appliances in adjacent aisles were not obstructed by stock. The performance-based design method will almost always result in aisles not having a line of visible notification appliances in them since the spacing of visible notification appliances can be greater than the spacing of aisles. Also, it is recognized that aisles may be relocated after installation of the system. Good design practice is to place visible notification appliances over aisles, especially those that are likely to remain unchanged such as main aisles and over checkout areas. Where reorganization of aisles results in visible notification appliances not in or over an aisle, or where that is

the base design, it is important to have a clear view from that aisle to a nearby visible notification appliance. See Figure A.7.5.3(b). Some spaces may have marginal visible notification appliance effect (direct or indirect). However occupants in these large stores and storage occupancies move frequently and place themselves in a position where they receive notification via the visible notification appliances. In addition, complete synchronization of the visible notification appliances in the space produced a desirable effect.

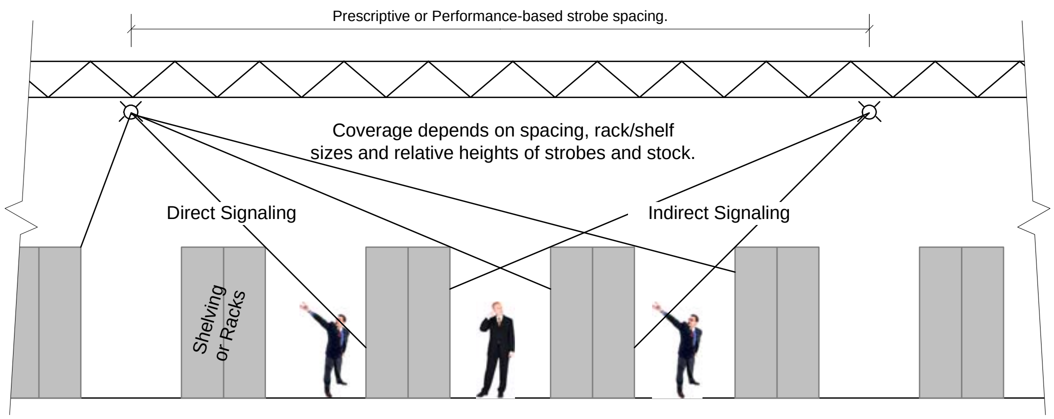


Figure 17 - New Figure A.7.5.3(b)

10. RECOMMENDATIONS

The following recommendations are separated into those related to the development of codes and standards and general design practice and those recommendations for future research.

10.1. Recommendations for Codes, Standards and General Design Practice

The Technical Committee on Notification Appliances should consider adding text, either in the code or in the annex, describing how much of the vertical and horizontal surfaces in an aisle need to be illuminated to provide sufficient indirect signaling to occupants. While it would be desirable to base the requirements or suggestions on actual test data, it may be reasonable to use simple geometry and human ergonomics in drafting the language. A Task Group should be formed to study the issues and make formal recommendation to the committee on how to proceed.

It is not recommended that the code require strobes in every aisle. While that would improve system performance, the tests showed that it was not necessary if the stock height, strobe height and aisle spacing allowed strobes in one aisle to penetrate and provide indirect signaling on the surfaces of stock in adjacent aisles. In addition, it must be recognized that the normal use of these stores may result in a rack/shelving reconfiguration after the strobe system has been designed and installed. The goal for flexible-use spaces should be a visible system that works for different rack layouts given the height of the strobes, allowed height of stock and the spacing of strobes and aisles. Nevertheless, wherever possible, designers should place strobes directly over aisles or in a manner that ensures penetration into adjacent aisles.

The committee should also consider adding text permitting the use of corridor rules in the aisles of stores and warehouses. A Task Group should study the issues involved in the use of ceiling mounted strobes in corridors at mounting heights higher than the nominal 80 to 96 inches used for wall mounting. The tests for this project showed that direct signaling did take place from strobes located farther down an aisle. However, those strobes were at a higher intensity than the 15 cd eff. currently allowed for corridor signaling[8].

Clarification is needed on the calculations required to meet the intent of NFPA 72 section 7.5.4.3. As noted in Annex 13, there are several different methods being used by the industry to calculate the size space covered by a strobe. For ceiling strobes, should the coverage area be a square or a circle? Is it necessary to include Lambert's Cosine Law correction for the illumination of surfaces?

Following the Danvers test, one participant (a member of the NFPA 72 Technical Committee on Fundamentals) sent a letter asking about the possibility of flashing some or all of the building's lighting fixtures[9]. That concept was considered and rejected by various NFPA 72 committees in the 1996 and 1999 code cycles. However, testing conducted by Underwriters Laboratories, both in the laboratory and in the field, showed that flashing some building lights to produce as little as a 5 to 15 % change in ambient lighting was sufficient to alert occupants[10].

Issues cited in the rejections by various code committees included how occupants would know what the flashing of building lights meant, emergency/secondary power issues, and the effects of long term testing on light fixtures and ballasts. It may be possible that the use of building lighting systems in conjunction with strobes will result in more reliable and complete visible communication to the occupants. The building lighting may be a supplemental system in addition to code designed strobe systems, or it may be an integral part of the signaling strategy.

In addition to the new text being added to the next edition of the code, NFPA should add additional commentary to the handbook edition of the code and to NFPA's Fire Protection Handbook. That commentary should elaborate on the concepts of direct and indirect signaling and other factors discussed in the Test Results and Analysis and Discussion sections of this report.

Designs should begin with strobes located directly over aisles. This should include all main aisles and peripheral aisles that not likely to be altered during future store layout changes. Where the heights of the strobes and the stock are such that strobes can penetrate into multiple aisles, it is not necessary to provide strobes over every aisle.

10.2. Recommendations for Future Research

The original proposal for this project envisioned a second phase to address visible signaling in other large spaces such as malls and atria. One goal of Phase 2 is to test the performance design method in more challenging visual environments. A second goal is to gather sufficient data to permit drafting of code text either permitting or limiting the performance based approach as an acceptable method of occupant notification for different scenarios. It is recommended that Phase 2 also include additional tests in warehouses and stores. Additional testing could help to better understand how much of the vertical and horizontal surfaces in an aisle need to be illuminated in order to provide sufficient indirect signaling to occupants.

A greater number of deaf and hearing impaired participants would be beneficial for future testing. In addition to "solicited" test participants, canvassing the regular users of the space using a well designed questionnaire would also be beneficial. This would be particularly true in spaces such as airports, malls and atria where the number of survey respondents could be quite high, adding to the statistical validity of the data. Future tests should be scheduled for different times of the day to attract a wider range and a larger number of test participants.

Participants felt that strobe effects were marginalized in brightly lit areas. These areas had much higher ambient light conditions than was used in the testing that led to NFPA 72. Future testing might include specific tests or survey methods to determine reliable threshold levels for signal-to-noise ratios.

One of the test locations had strobes installed on smooth, suspended ceilings (Danvers). Another had an open plan ceiling, but with very little clutter and no large obstructions (Kissimmee). The third location had an open plan that left all of the building structural members and utilities exposed (Reading). The strobes at that location were generally below the level of most structural members and service utilities except air handling ductwork. There were several locations where ductwork blocked strobes. Future testing should include a mix of ceiling configurations to try and determine if ceiling clutter might also be a factor in a strobe system's ability to provide direct signaling.

11. CONCLUSIONS

This project did not attempt to answer specific scientific questions, such as what threshold level of illumination over what area was necessary to alert occupants. Instead, it sought to simply find out if strobe systems could effectively alert persons in certain large volume spaces.

This project demonstrated that use of performance based design methods for strobe alerting systems is viable in large warehouse and super store type occupancies. The results showed that both direct and indirect signaling contribute to occupant notification, but only where strobes could penetrate into the aisles.

The tests identified variables that are important to the successful design and installation of strobe systems in these types of spaces. As a direct result, NFPA 72, the National Fire Alarm Code, has been modified to incorporate some of the findings of this project.

12. REFERENCES

[1] NFPA 72, *National Fire Alarm Code*, National Fire Protection Association, Quincy, MA 1993 through 2002 editions.
[2] F. DeVoss, "Report of Research on Emergency Signaling Devices For Use By the Hearing Impaired", Underwriters Laboratories, Inc., Northbrook, IL, 1991.
[3] Section 7.5.4.3, NFPA 72, *National Fire Alarm Code*, National Fire Protection Association, Quincy, MA 2002.
[4] *Report on Proposals*, NFPA 72, 2007 edition, National Fire Protection Association, Quincy, MA.
[5] The idea for the testing program was first considered by the Fire Detection Institute (FDI), a non-profit corporation dedicated to improving the fire detection and alarm standards through testing programs and research. The FDI is working with the Fire Protection Research Foundation to leverage efforts to improve fire detection and alarm systems through research and codes.
[6] R. Schifiliti, "Fire Alarm Testing Strategies Can Improve Occupant Response and Reduce the "Cry Wolf" Syndrome", NEMA Supplement in Fire Protection Engineering, Society of Fire Protection Engineers, Bethesda, MD 20814, Fall 2003.
[7] "Design Factors and Retail Space Types", The Lighting Design Lab, Seattle, WA, www.lightingdesignlab.com, December 2005.
[8] The possibility that the strobes in the Reading test were 15 cd eff. may affect this concept and support reduced intensity strobes in aisles.
[9] Letter from Robert Hill, Beacon Fire Alarms, dated August 25, 2005 to Robert Schifiliti, R.P. Schifiliti Associates, Inc.
[10] Proposal 72-685, NFPA 72, National Fire Alarm Code, report on Proposals, 1999 edition.

13. ANNEX: PERFORMANCE BASED CALCULATIONS

13.1. General

NFPA 72, Section 7.5.4.3 permits strobe system design using performance based calculations in lieu of the prescriptive requirements. The code states that "Any design that provides a minimum of 0.4036 lumens/m2 (0.0375 lumens/ft2) of illumination at any point within the covered area as calculated for the maximum distance from the nearest visual notification appliance to any point within the covered area shall be permitted …"

Inverse square law calculations must be done for each of the vertical and horizontal polar distribution angles in ANSI/UL 1971, *Standard for Safety Signaling Devices for Hearing Impaired*, or equivalent. The calculations are based on the inverse square law equation:

$$E = \frac{I}{d^2} \quad \mathrm{lm}/\mathrm{ft}^2 \quad \text{or} \quad \mathrm{lm}/\mathrm{m}^2$$

where E is the illumination in lumens per square foot, I is the intensity in candela (candela effective, cd eff. for strobes) and d is the distance.

There are several different factors that result in designers using different approaches to solve the performance based calculations.

For ceiling-mount applications, most designers assume that the strobe is on the ceiling (or a horizontal plane below the ceiling) in the center of a large, square room. Figure 18 is an elevation view showing the angles and distances involved in the calculations. Figure 19 is a plan view of the same single strobe coverage area.

One variable that is often chosen differently for the calculations is the distance, d. Looking at the plan view, some designers perform calculations only for vertical planes that are perpendicular to the surrounding walls (where they exist) or imaginary walls (for coverage of large spaces). Thus, looking at the elevation view, the distance d at an off-axis angle of 90 degrees would be one half of the room width, W. This is the most common method used in the industry for calculating strobe coverage in large spaces even when the actual strobe coverage area has no walls.

However, this ignores the fact that the chosen coverage area is a square with a diagonal that is greater than W/2. This is similar to the circle of coverage permitted by NFPA 72, 5.6.5.1.1(2) for initiating devices. Figure 20 shows a plan view of a large space broken down into smaller square coverage areas. The circles show that strobes in the center of the square coverage areas actually form a pattern of overlapping circular coverage areas. The worst case distance in plan view is not the distance measured perpendicular to a wall. It is the distance, r, to the far corner of the required coverage area. This is the second most common method used in the industry for calculating strobe coverage in large spaces even when the actual strobe coverage area has no walls.

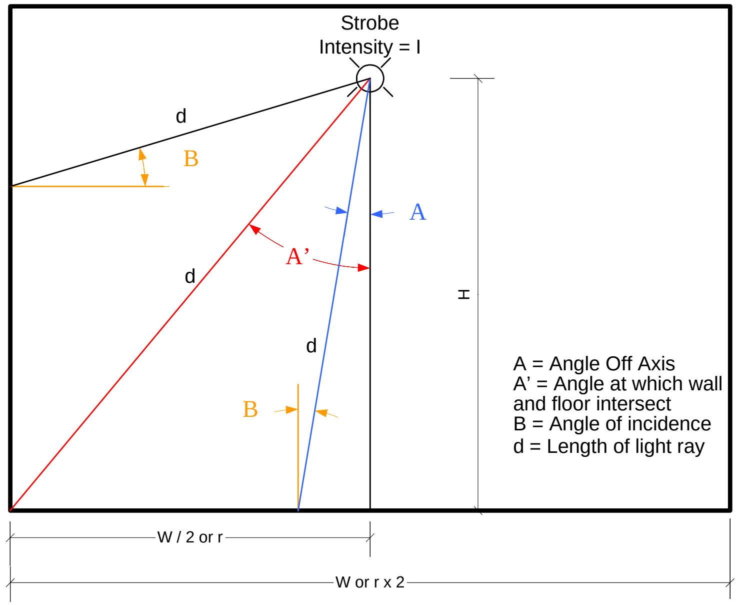


Figure 18 - Strobe Calculations (Elevation View)

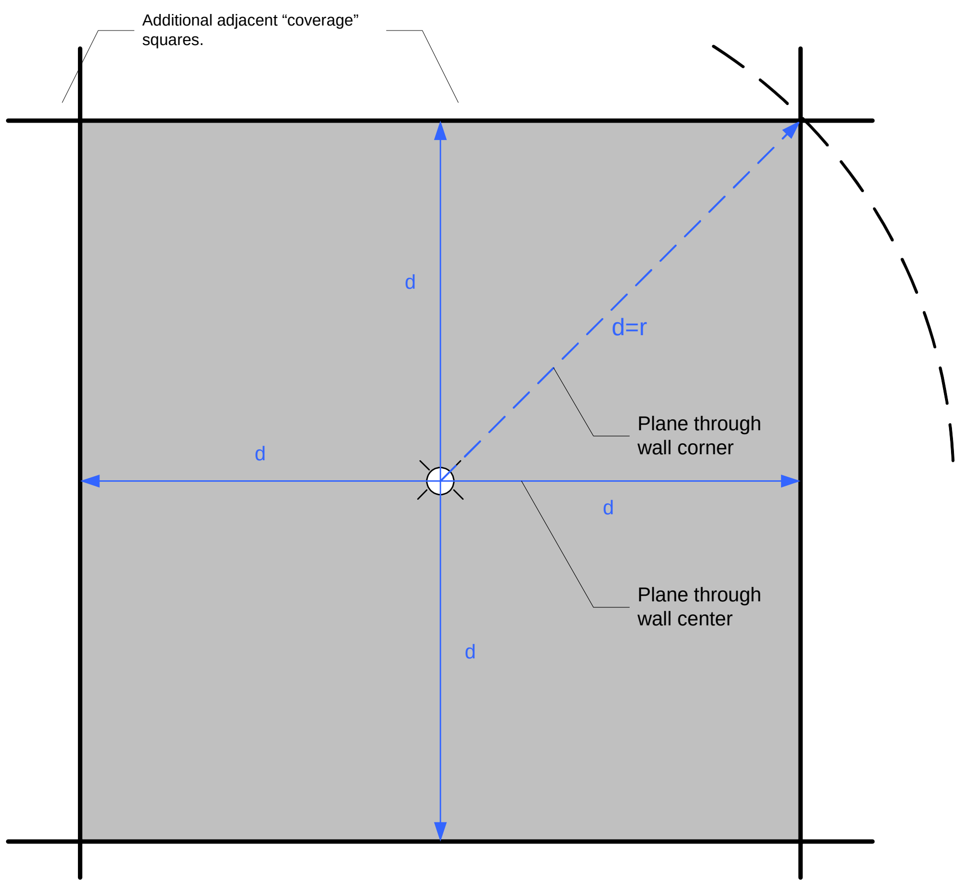


Figure 19 - Strobe Calculations (Plan View)

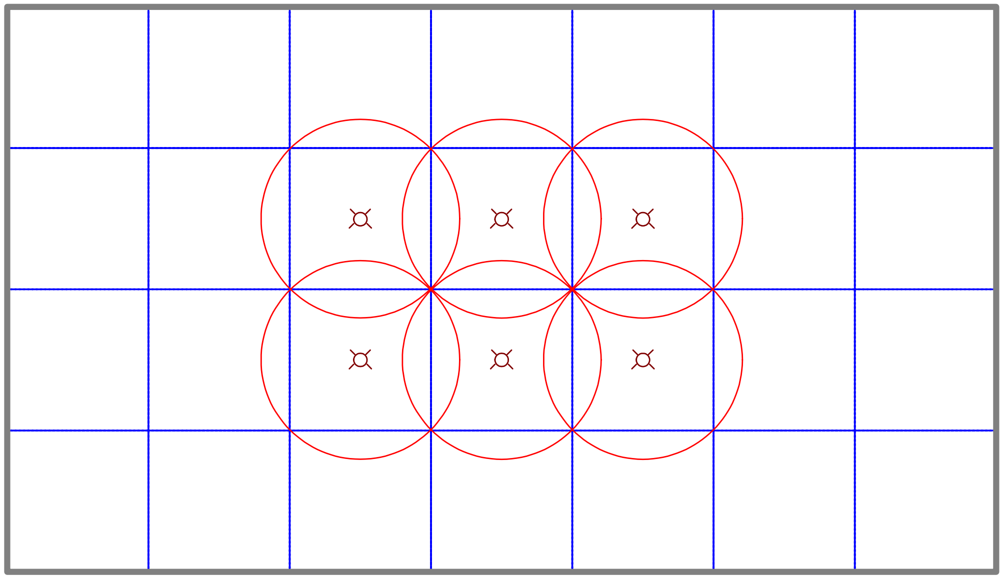


Figure 20 - Large Space Showing Square and Circular Areas of Coverage

Regardless of whether calculations are done for a plane that passes through a wall center or through a wall corner, a common point of confusion and error often noted in performance based calculations is the calculation of the distance to the floor or wall in a vertical section. Looking at the elevation view in Figure 18, the on-axis ($A = 0^0$) distance (d) is equal to the strobe mounting height H. As the off-axis angle (A) increases, the distance a light ray travels to reach a surface (first the floor) increases until it reaches the point where it starts to travel up the vertical surface. The angle, A', at which the light ray transitions from the floor to the wall of an enclosed space varies depending on the height and width (or radius) of the coverage area. Note that equations are presented for both types of solution discussed above: 1) calculations for a plane through a wall center or 2) calculations for a plane through a wall corner.

$$A' = \arctan\frac{W/2}{H} \quad \text{or} \quad A' = \arctan\frac{r}{H} \qquad \text{degrees}$$

For off-axis angles up to A = A':

$$d = \frac{H}{\cos(A)} \qquad \text{ft or m}$$

For off-axis angles greater than A':

$$d = \frac{W/2}{\cos(90 - A)} \quad \text{or} \quad d = \frac{r}{\cos(90 - A)} \quad \text{ft or m}$$

The calculation of the distance, d, for each inverse square law calculation is further complicated by the fact that the strobes are often being used in large open plan spaces without walls or in warehouses and "super stores" with racks and shelving. Figure 21 shows a typical warehouse store with strobe coverage providing both direct and indirect signaling to the occupants. Figure 22 is the same diagram highlighted to show the surfaces where one of the strobes provides illumination. These highlighted surfaces define the points at which NFPA 72 would require calculation of the illumination, E.

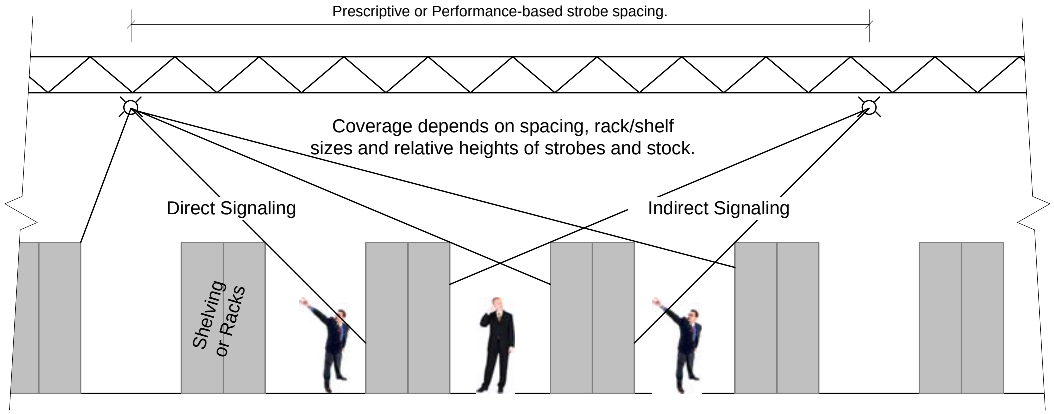


Figure 21 - Direct and Indirect Strobe Coverage in Racks

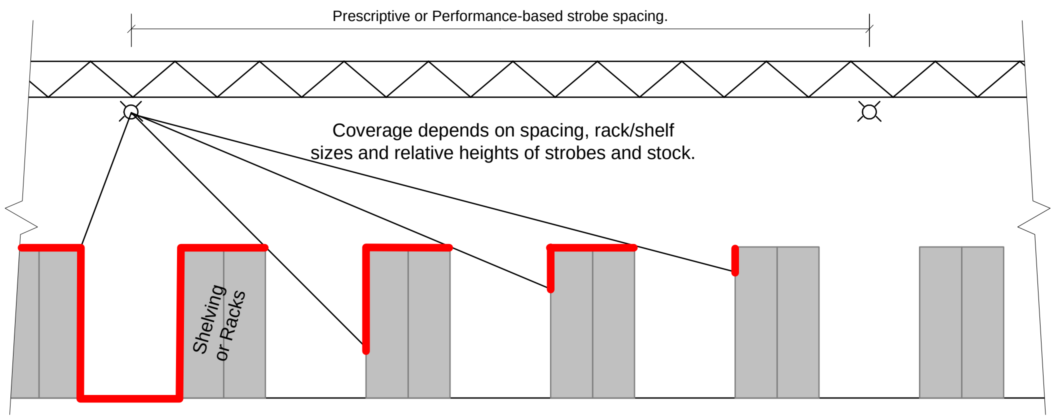


Figure 22 - Actual Strobe Penetration in Racks

It would be reasonable to not provide calculations for the top surfaces of the stock on the racks since that is not a surface that occupants see during the normal use of the space. In most cases calculations for a square space using the distance to the corner will be conservative. Nevertheless, performing calculations for the actual illuminated surfaces and coverage distances may be warranted in some instances and may result in in either fewer strobes or lower strobe intensities being required.

The actual illumination of a surface must be adjusted for the angle at which the light ray strikes the surface. Lambert's Cosine law states that the amount of reflected light is *proportional* to the cosine of the angle of incidence. Commercially available calculation programs do not include this correction and designers rarely make the correction.

Figure 23 shows that a light flux striking a surface at an angle (other than 0^0) illuminates an area larger than the plane normal to the ray. Since the quantity of light flux is distributed over a larger area, the resulting illumination is less. Using basic trigonometry it can be shown that the adjustment factor is the cosine of the angle of incidence. At 0^0, the correction is Cos (0) = 1.0. That is, no correction on-axis. At 90^0 the correction is Cos (90) = 0. That is, no illumination for a ray that is parallel to the surface. Therefore, the correction factor will always vary from zero to one. This is sometimes referred to as the Cosine Cubed Law. This is because if all calculations for the distance (height, off axis angle and angle of incidence) are combined, the equation will include the cosine of the off axis angle cubed. Note that in Figure 18 as the light ray reaches the corner and turns to trace up the wall, the calculation of the angle of incidence (B) changes. Up to the corner, B = A. On a vertical surface, B = 90 – A.

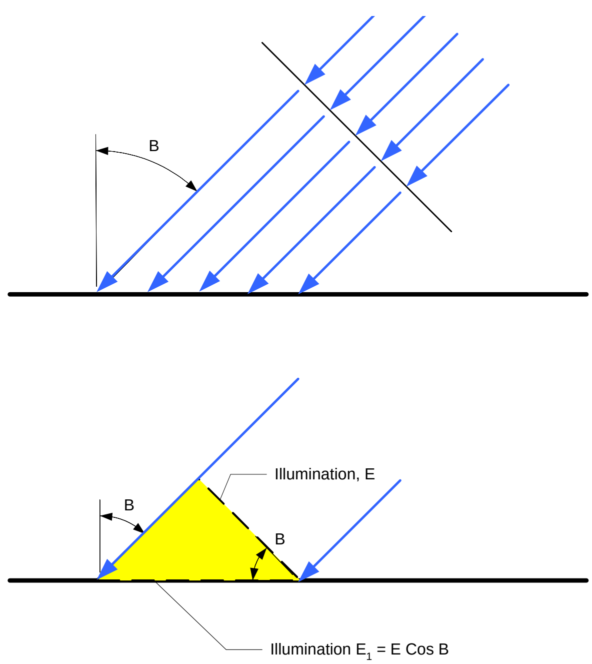


Figure 23 - Lambert Cosine Law

The final complicating factor affecting strobe visibility is that people do not see the illumination that a strobe light creates on a surface. It is the light that is reflected off of the surface in the direction of the eye that is perceived. The reflectance of the surface, the angle of incidence and the angle of to the observer's eye are all factors affecting what is actually perceived. The National Fire Alarm Code does not require consideration of these factors.

Another error sometimes made in the calculations occurs when software spreadsheets are used. Generally, trigonometry functions in spreadsheets require angles to be input in radians not degrees. Failure to use the proper units results in errors.

For each of the three test sites, basic calculations were done using nominal ceiling heights and strobe spacings and the reported strobe intensities. Two simplified sets of calculations are presented. The first is for an imaginary square coverage area with the plane through the center of the wall. The second is for the vertical plane through the corner of the square. For each, the direct calculation result is presented along with the value corrected using Lambert's Cosine Law.

13.2. Home Depot, Reading, MA

The following calculation summary is based on a strobe covering an imaginary square. The calculations do not model the actual illumination on stock in racks at distances closer to the strobe than the imaginary coverage square. The calculations assume a strobe intensity of 75 cd eff. even though one strobe was found to be set at 15 cd eff. It is not known whether other strobes may also have not been adjusted to the design requirement of 75 cd. eff. Also, even though the spreadsheet notes some locations as being below the required 0.0375 lm/ft^2, some of these values may be at heights where indirect signaling is not needed. For example, the most commonly required calculation method is for a plane through a wall center without correction for Lambert's Cosine Law. The calculations show illuminations less than 0.0375 lm/ft^2 at 85 and 90 degrees off axis. A ray traveling 45 ft at 85^0 off axis would be at an elevation of four feet below the strobe (45 ft / TAN(85^0)), which is 19 ft above the floor.

Ceiling Strobe Calculations

Required Illumination 0.0375 lm/ft^2 (Can be changed for alternative goals/ calculations.)

Enter values for H, W and I			
H=	23	ft	Ht of Strobe
W=	45	ft	Sq Rm Size
I=	75	cd eff.	Strobe Intensity

Calculated Values					
A'=	0.774	Radians	44.4	Degrees	Wall/Floor Int. For Wall Ctr Calcs
r=	31.8	ft			Radius of Square Coverage Area
$A'_{r=}$	0.945	Radians	54.1	Degrees	Wall/Floor Int. For Wall Corner Calcs

Off Axis, A		UL %	UL-I	Plane Through Wall Center			Plane Through Corner		
				d	E	E_1	d	E	E_1
degrees	radians		cd eff.	ft	lm/ft^2	lm/ft^2	ft	lm/ft^2	lm/ft^2
0	0.000	100%	75.0	23.0	0.1418	0.1418	23.0	0.1418	0.1418
5	0.087	90%	67.5	23.1	0.1266	0.1261	23.1	0.1266	0.1261
10	0.175	90%	67.5	23.4	0.1238	0.1219	23.4	0.1238	0.1219
15	0.262	90%	67.5	23.8	0.1191	0.1150	23.8	0.1191	0.1150
20	0.349	90%	67.5	24.5	0.1127	0.1059	24.5	0.1127	0.1059
25	0.436	90%	67.5	25.4	0.1048	0.0950	25.4	0.1048	0.0950
30	0.524	75%	56.3	26.6	0.0797	0.0691	26.6	0.0797	0.0691
35	0.611	75%	56.3	28.1	0.0714	0.0584	28.1	0.0714	0.0584
40	0.698	75%	56.3	30.0	0.0624	0.0478	30.0	0.0624	0.0478
45	0.785	75%	56.3	31.8	0.0556	0.0393	32.5	0.0532	0.0376
50	0.873	55%	41.3	29.4	0.0478	**0.0366**	35.8	**0.0322**	**0.0207**
55	0.960	45%	33.8	27.5	0.0447	**0.0366**	38.8	**0.0224**	**0.0183**
60	1.047	40%	30.0	26.0	0.0444	0.0385	36.7	**0.0222**	**0.0192**
65	1.134	35%	26.3	24.8	0.0426	0.0386	35.1	**0.0213**	**0.0193**
70	1.222	35%	26.3	23.9	0.0458	0.0430	33.9	**0.0229**	**0.0215**
75	1.309	30%	22.5	23.3	0.0415	0.0401	32.9	**0.0207**	**0.0200**
80	1.396	30%	22.5	22.8	0.0431	0.0424	32.3	**0.0216**	**0.0212**
85	1.484	25%	18.8	22.6	**0.0368**	**0.0366**	31.9	**0.0184**	**0.0183**
90	1.571	25%	18.8	22.5	**0.0370**	**0.0370**	31.8	**0.0185**	**0.0185**

13.3. Home Depot, Danvers, MA

The following calculation summary is based on a strobe covering an imaginary square. The calculations do not model the actual illumination on stock in racks at distances closer to the strobe than the imaginary coverage square. Also, even though the spreadsheet notes some locations as being below the required 0.0375 lm/ft^2, some of these values may be at heights where indirect signaling is not needed.

Ceiling Strobe Calculations

Required Illumination 0.0375 lm/ft^2 (Can be changed for alternative goals/ calculations.)

Enter values for H, W and I			
H=	**21.5**	ft	**Ht of Strobe**
W=	**48**	ft	**Sq Rm Size**
I=	**115**	cd eff.	**Strobe Intensity**

Calculated Values				
A'=	0.840 Radians	48.1 Degrees	**Wall/Floor Int. For Wall Ctr Calcs**
r=	33.9 ft		**Radius of Square Coverage Area**
A'$_{r=}$	1.006 Radians	57.6 Degrees	**Wall/Floor Int. For Wall Corner Calcs**

Off Axis, A		UL %	UL-I	Plane Through Wall Center			Plane Through Corner		
				d	E	E_1	d	E	E_1
degrees	radians		cd eff.	ft	lm/ft^2	lm/ft^2	ft	lm/ft^2	lm/ft^2
0	0.000	100%	115.0	21.5	0.2488	0.2488	21.5	0.2488	0.2488
5	0.087	90%	103.5	21.6	0.2222	0.2214	21.6	0.2222	0.2214
10	0.175	90%	103.5	21.8	0.2172	0.2139	21.8	0.2172	0.2139
15	0.262	90%	103.5	22.3	0.2089	0.2018	22.3	0.2089	0.2018
20	0.349	90%	103.5	22.9	0.1977	0.1858	22.9	0.1977	0.1858
25	0.436	90%	103.5	23.7	0.1839	0.1667	23.7	0.1839	0.1667
30	0.524	75%	86.3	24.8	0.1399	0.1212	24.8	0.1399	0.1212
35	0.611	75%	86.3	26.2	0.1252	0.1026	26.2	0.1252	0.1026
40	0.698	75%	86.3	28.1	0.1095	0.0839	28.1	0.1095	0.0839
45	0.785	75%	86.3	30.4	0.0933	0.0660	30.4	0.0933	0.0660
50	0.873	55%	63.3	31.3	0.0644	0.0494	33.4	0.0565	**0.0363**
55	0.960	45%	51.8	29.3	0.0603	0.0494	37.5	**0.0368**	**0.0211**
60	1.047	40%	46.0	27.7	0.0599	0.0519	39.2	**0.0299**	**0.0259**
65	1.134	35%	40.3	26.5	0.0574	0.0520	37.4	**0.0287**	**0.0260**
70	1.222	35%	40.3	25.5	0.0617	0.0580	36.1	**0.0309**	**0.0290**
75	1.309	30%	34.5	24.8	0.0559	0.0540	35.1	**0.0279**	**0.0270**
80	1.396	30%	34.5	24.4	0.0581	0.0572	34.5	**0.0290**	**0.0286**
85	1.484	25%	28.8	24.1	0.0495	0.0493	34.1	**0.0248**	**0.0247**
90	1.571	25%	28.8	24.0	0.0499	0.0499	33.9	**0.0250**	**0.0250**

13.4. Wal*Mart, Kissimmee, FL

The following calculation summary is based on a strobe covering an imaginary square. The calculations do not model the actual illumination on stock in racks at distances closer to the strobe than the imaginary coverage square. Also, even though the spreadsheet notes some locations as being below the required 0.0375 lm/ft^2, some of these values may be at heights where indirect signaling is not needed.

Ceiling Strobe Calculations

Required Illumination 0.0375 **lm/ft^2** **(Can be changed for alternative goals/ calculations.)**

Enter values for H, W and I			
H=	**21**	ft	**Ht of Strobe**
W=	**45**	ft	**Sq Rm Size**
I=	**115**	cd eff.	**Strobe Intensity**

	Calculated Values				
A'=	0.820	Radians	47.0	Degrees	**Wall/Floor Int. For Wall Ctr Calcs**
r=	31.8	ft			**Radius of Square Coverage Area**
A'$_{r=}$	0.987	Radians	56.6	Degrees	**Wall/Floor Int. For Wall Corner Calcs**

Off Axis, A		**UL %**	**UL-I**	**Plane Through Wall Center**			**Plane Through Corner**		
				d	**E**	**E_1**	**d**	**E**	**E_1**
degrees	**radians**		**cd eff.**	**ft**	**lm/ft^2**	**lm/ft^2**	**ft**	**lm/ft^2**	**lm/ft^2**
0	0.000	100%	115.0	21.0	0.2608	0.2608	21.0	0.2608	0.2608
5	0.087	90%	103.5	21.1	0.2329	0.2320	21.1	0.2329	0.2320
10	0.175	90%	103.5	21.3	0.2276	0.2242	21.3	0.2276	0.2242
15	0.262	90%	103.5	21.7	0.2190	0.2115	21.7	0.2190	0.2115
20	0.349	90%	103.5	22.3	0.2072	0.1947	22.3	0.2072	0.1947
25	0.436	90%	103.5	23.2	0.1928	0.1747	23.2	0.1928	0.1747
30	0.524	75%	86.3	24.2	0.1467	0.1270	24.2	0.1467	0.1270
35	0.611	75%	86.3	25.6	0.1312	0.1075	25.6	0.1312	0.1075
40	0.698	75%	86.3	27.4	0.1148	0.0879	27.4	0.1148	0.0879
45	0.785	75%	86.3	29.7	0.0978	0.0691	29.7	0.0978	0.0691
50	0.873	55%	63.3	29.4	0.0733	0.0562	32.7	0.0593	0.0381
55	0.960	45%	51.8	27.5	0.0686	0.0562	36.6	0.0386	**0.0221**
60	1.047	40%	46.0	26.0	0.0681	0.0590	36.7	**0.0341**	**0.0295**
65	1.134	35%	40.3	24.8	0.0653	0.0592	35.1	**0.0327**	**0.0296**
70	1.222	35%	40.3	23.9	0.0702	0.0660	33.9	**0.0351**	**0.0330**
75	1.309	30%	34.5	23.3	0.0636	0.0614	32.9	**0.0318**	**0.0307**
80	1.396	30%	34.5	22.8	0.0661	0.0651	32.3	**0.0330**	**0.0325**
85	1.484	25%	28.8	22.6	0.0564	0.0561	31.9	**0.0282**	**0.0281**
90	1.571	25%	28.8	22.5	0.0568	0.0568	31.8	**0.0284**	**0.0284**

14. ANNEX: TEST PROTOCOL

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Fire Alarm Test Protocol
Direct Visual Signaling as a Means for Occupant Notification in Large Spaces

Purpose

This protocol is only for Phase 1. In Phase 1, testing will be done in large warehouse stores to test the hypothesis that the current performance based approach provides sufficient direct alerting of occupants. The goal of Phase 1 is to draft material for inclusion in the Annex of the 2006 edition of NFPA 72. Phase 2 (not yet proposed or approved) will extend testing to other large spaces such as malls and atria. One goal of Phase 2 is to test the method in more challenging visual environments. A second goal is to gather sufficient data to permit drafting of code text permitting or limiting the performance based approach as an acceptable method of occupant notification. See the project **Technical Description** for additional information.

General

1. This protocol includes:
   1.1. Pre-test documentation.
   1.2. Notifications.
   1.3. Emergency plan.
   1.4. Test preparation.
   1.5. Participant Registration
   1.6. Preparation and training of test subjects.
   1.7. System test.
   1.8. Post test survey and interviews.
   1.9. Post test review.
   1.10. Return to normal.

> **Schedule:**
>
> 1. Weds. August 24, 2005, 6:30 AM Reading, MA Home Depot
> 2. Thurs. August 25, 2005, 6:30 AM Danvers, MA Home Depot
> 3. Fri., October 28, 2005, 7:00 AM (6:30 set-up) Kissimmee, FL Wal*Mart
>
> Technical Panel members and other interested people are welcome to attend and participate. Please contact me by email and let me know if you will be present for a test.

2. Subsequent protocols:
   Following the first set of test, this protocol; will be reviewed and revised if necessary.
3. Suggestions for changes or additions to this protocol are welcome. Please send your comments by email to Bob Schifiliti, rps@rpsa-fire.com.
4. Requests for changes to this protocol while on-site for implementation of the protocol will be considered as needed to achieve thoroughness, safety to personnel, and data collection.
5. These tests are intended to simply determine whether or not the current performance based methods within NFPA 72, 2002 provide reasonable occupant notification in large spaces. Because of time limitation s imposed by the code development cycle, this project is not designed to gather large amounts of data or to analyze exact causal relationships. A second test phase will be proposed to test other spaces and variations on the existing performance based solutions contained in NFPA 72, 2002.
6. Testing is planned to take place in several different stores. They provide different ceiling heights and configurations. We will gather for the tests at 6:30 AM. Volunteers should plan to be there by 7:00 AM.

Equipment, Materials and Information Needed

1. Owner's technician authorized and equipped to perform system testing of audible and visible occupant notification.
2. Store layout drawings showing racks and aisles.
3. Fire alarm drawings showing location of audible and visible notification appliances.
4. Hand tools. Provided by site and by an independent contractor/technician.
5. System contractor level password/passcode.
6. Light meter.
7. Cameras
8. Nametags
9. Tables for registration and for follow-up survey.
10. Pencils & pens
11. Note cards for participants
12. Consent Forms (two sided)
13. Pre-Test Survey forms.
14. Post-Test Survey forms.
15. Clipboards
16. Traffic cones
17. Posters
    - 17.1. Registration
    - 17.2. Test and emergency information
18. Coffee, snacks, cups, napkins, water

Tasks

1. Pre-test documentation.

    1.1. Obtain as-built drawings or other available documentation for the test site.

    1.2. Photograph representative areas of the test building.

    1.3. Document condition of the system before altering or testing. In the event that the system is found to not be in a trouble free condition, the technician, Project Manager and owner will discuss the status of the system and make a determination on whether the test should continue.

    1.4. Check several strobes for conformance with the as-built documentation.

    1.5. Check installation for general conformance to the performance based requirements of NFPA 72, 2002.

    1.6. Document any special conditions.

2. Notifications

    2.1. If acceptable to the owner, notify and invite the local fire department to participate in the testing.

    2.2. The owner will notify employees in advance of the test schedule.

    2.3. On the morning of the tests, orange traffic cones with signs will be posted at all entrances.

    2.4. Voice announcement will be made prior to activation of the strobes.

3. Emergency plan.

    3.1. Personnel with radios and/or cell phones will be located at the fire alarm panel.

    3.2. In the event that the system is activated by a manual box, flow switch or automatic fire detector, the fire department will be immediately contacted and the audible fire alarm signal will be activated. In addition, manual voice announcements will be made to initiate evacuation.

    3.3. Employees will follow their pre-emergency plan.

    3.4. Members of the test team will meet at a designated location outside of the store.

4. Test Preparation.

    4.1. Place traffic cones and signs.

    4.2. Measure and document ambient light.

5. Participant Registration

    5.1. Greet and hand out Participant Information Sheet & Consent Form.

    5.2. Review Consent form for initials on each page and initials, signature and date on last page. Person reviewing the Consent form adds their name after answering any questions or concerns.

    5.3. Upon acceptance of the signed Consent form, give participant a Pre-Test Survey.

    5.4. Review Pre-Test Survey. If anyone checks Yes for epilepsy or seizures they should be asked to not participate in the test.

    5.5. Assign Participant Number (R-01, R-02, for Reading, D-01, D-02 for Danvers, etc.) and write in box on the Pre-Test Survey form.

    5.6. Provide participants with a Test Note Card and pencil to take notes during the test. Write their Participant Number on the top, right corner of the card.

6. Preparation and training of test subjects.

    6.1. The participation of hearing impaired persons is being solicited from local organizations. In addition, we will ask employees, fire department personnel and anyone else who is interested to take part in the tests.

    6.2. Test subjects will be told that the test is intended to determine if the operation of the strobes interferes with their ability safely and comfortably walk to the exits.

    6.3. Test subjects will not be told that the fire alarm audible signals will be disabled (if the system is capable of this).

    6.4. Test subjects will be sent to specific aisles and asked to "shop" in those aisles.

    6.5. They will be asked to await the start of the test and to note approximately where they were and what direction they were facing when the system activated.

    6.6. Subjects will be instructed to walk to a designated gathering location when the fire alarm system activates.

7. System Test.

    7.1. The owner's fire alarm technician will:

        7.1.1. Disable the audible fire alarm circuits.
        (We are certain this is possible in the Reading store. It has been reported, but not confirmed, as possible at the Danvers store. It is uncertain in the Kissimmee store.)

        7.1.2. Disable any off-site signal transmission or notify the supervising station to place the system "on test".

        7.1.3. Notify the fire department that testing will take place for a designated time period.

    7.2. Make paging announcement that testing is about to begin.

    7.3. Activate the visible signals.

    7.4. Observe occupant response.

    7.5. Record the arrival time of test subjects at the designated gathering location(s).

    7.6. Once all test subjects respond, the signals will be turned off.

8. Post test survey and interviews.

    8.1. As each participant returns to the gathering location, note their Participant Number and arrival time.

    8.2. Provide each participant with a Post-Test Survey form and a pencil. Write their Participant Number on the top, right corner of the form.

    8.3. Review each participants form and comments. Ask questions about their responses and overall opinion of the system and of the test. Add reviewer's notes on the back of the Post-Test Survey form.

    8.4. Using a diagram of the store, record the location and the direction the subject was facing.

    8.5. Take each subject back to the location and ask them to identify the strobe(s) they saw, if any.

9. Post test review.

    9.1. What worked?

    9.2. What needs to be changed for future tests?

    9.3. Should additional tests be done at this location before returning the system to normal and before the store opens?

10. Return to normal.

    10.1. Remove traffic cones and signs.

    10.2. The owner's fire alarm technician will:

        10.2.1. Re-connect or re-activate the audible fire alarm circuits.

        10.2.2. Re-enable any off-site signal transmission or notify the supervising station that testing has been completed.

        10.2.3. Notify the fire department that testing has been completed.

    10.3. Make paging announcement that testing has been completed.

    10.4. Document that the system has been retuned to normal operational status.

END OF TEST PROTOCOL

15. ANNEX: PARTICIPANT INFORMATION SHEET AND CONSENT FORM (BLANK)

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PARTICIPANT INFORMATION SHEET & CONSENT FORM

Project Title:	Direct Visual Signaling as a Means for Occupant Notification in Large Spaces
Principal Investigator:	Robert P. Schifiliti, P.E. R.P. Schifiliti Associates, Inc.
Protocol:	rpsa File: Test Protocol rev 1.doc
Sponsor & Financial Support:	The Fire Protection Research Foundation Kathleen H. Almand, P.E., Executive Director 1 Batterymarch Park, Quincy, MA 02169 617.984.7282
In-kind Support	Wal*Mart, TVA Fire & Life Safety, Inc., Fire Materials Group, LLC, The Home Depot

Please read this form carefully. Take time to ask as many questions as you want. If there are any words or information you do not fully understand, the project staff will explain them to you. *Each page of this form (total number of pages = 4) must be initialed and the last page must be signed and dated before you participate in the study.*

INTRODUCTION

You are invited to participate in a research study of fire alarm strobe light effectiveness in large volume spaces. We hope to learn whether or not the current code requirements for visible fire alarm signaling are effective in large spaces such as warehouse stores.

Your participation in this study is entirely voluntary. If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time. This research study is looking for number of people who are both hearing able and hearing impaired. Volunteers are not being financially compensated. Nor will they receive any type of medical care or advice.

PURPOSE

The purpose of the study is to determine the effectiveness of fire alarm strobe lights as a means for occupant notification. This phase (Phase 1) is limited to testing in large volume stores with high ceilings. The systems being used in the tests have been designed and installed in compliance with the requirements of the 2002 edition of NFPA 72, the *National Fire Alarm Code* [1].

Initials:

DURATION

Volunteers are asked to participate in at least one scheduled test. The test will take place between 7:00 AM and 7:30 AM. Afterwards, volunteers will complete a follow-up survey. It is expected that volunteers will be finished by 8:00 AM. After completing the follow-up survey, volunteers are finished with their participation in the study. There is no long term follow-up planned.

WHAT DO YOU HAVE TO DO?

If you choose to participate in this study, after signing this consent form you will be asked to complete a short pre-test survey. Next you will be escorted to a specific area of the test store to "shop" in specific aisles. You will be given a notepad with instructions and a space for notes.

At some point the fire alarm system will be activated. If you are alerted by the fire alarm, you should note your location and write down how you were first alerted. The form will ask specific questions. You should then proceed to the gathering location in the front of the store.

Finally, you will be interviewed about your experience and perceptions.

If at any time you have questions, concerns, or decide to end your participation, simply come to the registration area and let one of the staff know.

WHAT ARE THE POSSIBLE RISKS OF TAKING PART?

The only known risk involved in this test is to persons with a certain type of epilepsy.

Approximately one in two hundred people have epilepsy. Of those, 3 to 5 % may have seizures induced by flashing lights, such as strobe lights[2]. Thus, approximately one to three people out of every 10,000 may have photosensitive epilepsy.

The frequency of the flashing light is an important trigger for photosensitive epilepsy. Generally, the flash rate must be between 5 and 30 flashes per second (hertz). Some people may be sensitive at higher frequencies. It is uncommon to have photosensitivity below 5 hertz.

The National Fire Alarm Code requires strobe lights to flash between one and two times per second (1 – 2 hertz). This is well below the 5 hertz threshold. In addition, the code requires systems to be designed and installed such that a person can not see more than two strobe lights at a time unless their flashing is synchronized. The systems being utilized in these tests have been designed and installed conform to these requirements.

Testing of photosensitivity is not a part of this study. If you suffer from any form of epilepsy please do take part in this study. If you have had seizures in the past, but are unsure if you have epilepsy, you should not participate in this study and you should seek medical advice.

Initials:

WHAT ARE THE POSSIBLE BENEFITS OF TAKING PART?

There are no personal benefits to you as an individual as a result of participating in this study. The only possible benefit is the effect that this research may have on future fire alarm system designs.

COMPENSATION / REIMBURSEMENT

Volunteers are not being financially compensated or reimbursed for expenses. If notified in advance, we may be able to provide transportation to and from the test location.

COMPENSATION FOR STUDY RELATED INJURY

If you are injured or harmed as a result of your participation in this research project, you should seek medical help immediately. There are no special compensation arrangements as a part of this study. If you are harmed due to someone's negligence, then you may have grounds for a legal action but you may have to pay for it.

WHAT IF SOMETHING GOES WRONG?

During the test, if at any time you feel any discomfort or disorientation, inform one of the test staff of store employees immediately and the test will be stopped.

During the test, if you discover a real fire or if you are informed that there is a real fire emergency leave the store immediately by the nearest exit. If you discover a fire, inform staff and operate a manual fire alarm station on your way out of the building. During testing, the store paging system and radio system will be used to alert occupants and staff if a real emergency exists.

WILL MY TAKING PART IN THIS STUDY BE KEPT CONFIDENTIAL?

Yes. All information which is collected about you during the course of the research will be kept strictly confidential. Your name and personal information will not be used in any reports and will not be given out to anyone.

WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY?

A presentation of preliminary results will be made to the NFPA 72 Notification Appliances Technical Committee during their meeting October 27 through 29. A draft report will be issues for review by the Project Technical Panel. A final report will be issued to The Fire Protection Research Foundation by November 28, 2005.

It is expected that the NFPA technical committee will use the results of the study to support or change existing requirements and explanatory materials in the National Fire Alarm Code.

Initials:

FINANCIAL SUPPORT

Financial support is being provided by a grant to R.P. Schifiliti Associates, Inc. from The National Fire Protection Research Foundation, Quincy, MA. Additional support is being provided by the donation of time and resources by The Home Depot, Wal*Mart, Fire Materials Group, LLC and by TVA Fire & Life Safety, Inc.

CONTACT FOR FURTHER INFORMATION?

For more information contact the Project Manager or the Executive Director of the Foundation:

Robert P. Schifiliti, P.E. R.P. Schifiliti Associates, Inc. P.O. Box 297 Reading, MA 01867 781-942-7500 rps@rpsa-fire.com	Kathleen H. Almand, P.E. Executive Director, The Fire Protection Research Foundation 1 Batterymarch Park, Quincy, MA 02169 617-984-7282 kalmand@nfpa.org

STATEMENT OF CONSENT AND AUTHORIZATION

1. I confirm that I have read and understand this form (4 pages) and have had the opportunity to ask questions.

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.

3. I agree to take part in the above study.

____________________ ______________ _________________

Name of Volunteer/Participant — Date — Signature

[1] NFPA 72, *National Fire Alarm Code*, National Fire Protection Association, Quincy, MA 2002.
[2] *The National Society for Epilepsy*, The United Kingdom, http://www.epilepsynse.org, September 2002.

16. ANNEX: PARTICIPANT SURVEY – PRE-TEST (BLANK)

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PROJECT: 1213b:
Direct Visual Signaling as a Means for Occupant Notification in Large Spaces

Participant # assigned for use in reports.

Participant Survey – Pre-Test

(To be completed after reading and signing the Participant Information Sheet & Consent Form.)

Name: ____ Age:_______

Address: ________________ City: ___________________ ST: ______ Zip: ____________

Contact Phone #: _____________________ email:___________________________________

					Circle One	
1.	Have you participated in other tests of fire alarm strobe light effectiveness?				Yes	No
2.	Do you have a hearing impairment? (If No, skip to Question 3.)				Yes	No
	If you have a hearing impairment, has it been evaluated by trained medical personnel (doctor, audiologist, etc.)?				Yes	No
	In general, what is the severity of your hearing impairment:					
	Mild	Moderate	Severe	Total (Deaf)		
3.	Do you have a vision impairment? (If No, skip to Question 4.)				Yes	No
	If you have a vision impairment, has it been evaluated by trained medical personnel (doctor, optomologist, etc.)?				Yes	No
	In general, what is the severity of your vision impairment:					
	Mild	Moderate	Severe	Total (Blind)		
	Are you wearing corrective glasses or contact lenses?				Yes	No
4.	Do you have any form of epilepsy?				Yes	No
5.	Have you ever had a seizure?				Yes	No

17. ANNEX: TEST NOTE CARD

rpsa

FIRE PROTECTION ENGINEERS
www.rpsa-fire.com
Fire Alarm Strobe Test Note Card

Use the front and back of this card for notes during the test. After you are alerted:

1. How were you first alerted – by sound, strobe lights, other occupants?
2. Note your location when first alerted.
3. As you stand normally, looking down or straight ahead can you see one or more strobe lights flashing?
4. As you walk to the gathering point, look down, straight ahead and all around.
5. At the gathering point, you will be given a post-test survey form to complete.

18. ANNEX: PARTICIPANT SURVEY – POST-TEST (BLANK)

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FIRE PROTECTION ENGINEERS
www.rpsa-fire.com

R.P. SCHIFILITI ASSOCIATES, INC.
P.O. Box 297
Reading, MA 01867 - 0497
USA
781.944.9300 Fax / Data
781.942.7500 Telephone

Participant # assigned for use in reports.

Participant Survey – Post-Test

(To be completed after the test.)

1. How were you first alerted?

Fire alarm sound   Fire alarm strobe   Other occupants   Other – explain ________________

____

2. Where were you located when you were first alerted? Main aisle, stock aisle? Use aisle number or stock description. ____

____

____

3. What direction were you facing – towards stock shelves, up or down the aisle? ____________

____

4. Could you see the flash of the strobes reflecting off of the floor, stock or other surface without actually seeing a strobe light directly? Yes No

   If Yes, describe:____

   ____

5. Were you able to actually see (directly view) one or more strobe lights flashing without intentionally looking up at the ceiling? Yes No

6. Generally, as you moved about could you see more than one strobe light flashing? Yes No

   About how many? ____

7. Were there any locations where you could not see a strobe light or its reflection? Yes No

   If Yes, describe:____

   ____

CONTINUED ON BACK

8. Did the flashing strobe lights cause you any discomfort or disorientation at any time? Yes No

   If Yes, describe:____

   ____

9. Based on your experience in this test, on a scale of 1 (Not Effective) to 5 (Very Effective) how would rate the effectiveness of the fire alarm strobe light system?

Not Effective				Effective
1	2	3	4	5

10. In your opinion, are strobe lights are an effective method for alerting deaf or hearing impaired persons? Yes No

11. Comments (about strobes, this test, the surveys, etc.): ____________________________

____

____

____

____

____

____

____

____

____

____

____

12. Do you wish to receive a summary report of the study? Yes No

<u>THANK YOU FOR YOUR PARTICIPATION</u>