Abstract

After studying NFPA 101 and 101A, a simplified inspection checklist for the components of a total exit system in hospitals and schools was created with an additional explanatory document for the Cuerpo de Bomberos de Costa Rica. Formulas calculating theoretical evacuation times and static and dynamic capacities were also developed and implemented into the checklist. Personnel preparation for emergencies, fire safety education, and political aspects of implementing the checklist were examined. Finally, recommendations based on on-site inspections were given.

Authorship Page

As confirmed by the signatures below, every section of this report is comprised of the collaborative effort from both Tanya Theriault and Michael Sao Pedro. Both students actively participated in the creation, development, and proofreading of each section equally.

Tanya Theriault   Tanya Theriault

Michael Sao Pedro

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Executive Summary

An analysis of the total exit systems in both hospitals and schools was completed in Costa Rica using the National Fire Protection Agency's Life Safety Codes 101 and 101A. A simplified checklist to be used in both hospitals and schools was created along with formulas for the calculation of evacuation times and static and dynamic capacities using Microsoft Excel. Measurements were taken of various parts of the buildings such as: the door widths, the length and widths of the corridors, and the dimensions of the building itself. Using these measurements, the formulas, and Microsoft Excel, the theoretical values were automatically calculated. These theoretical times were compared with the existing fixed times. A fire drill was additionally conducted at the school to acquire raw data on evacuation times.

The actual checklist consists of general headings of the components of an exit system. Under each main heading lists the specific requirements of that component. Each item was inspected and checked off in a yes/no format on the checklist with additional explanations written in the "comments" section of the checklist.

The objective of this project was to give the Cuerpo de Bomberos de Costa Rica a checklist and formulas such that they would be able to enter any hospital or school and conduct a proper inspection as to whether or not the building is up to code. In doing this project, an additional goal was to also give the Cuerpo de Bomberos de Costa Rica a stronger voice in fire safety related issues and to help them implement these issues into

law. Examples of such issues would be to have regular inspections of buildings and to have building plans approved before construction is allowed to begin.

In preparation for this project, our group studied the Life Safety Codes as well as any other additional codes needed for further understanding when needed. Social and political aspects of implemented and enforcing these laws was also observed. Examples of these aspects would be how knowledgeable personnel are in evacuation procedures and currently what laws are in place concerning fire codes. Interviews with experts in the fields were conducted to gain a clearer view of the present situation.

Presently Costa Rica only has laws concerning various parts of fire protection such as: classification of buildings, rules and regulations for sprinklers, and different classifications for fires. There are currently no laws for appropriately conducting fire inspections, and the authority does not exist to close a structure until the problems have been remedied.

This project is a very important first step in increasing Costa Rica's present level of fire safety as well as their overall awareness concerning this issue. There are certain constraints that accompany this project. Because these constraints are mainly financial, careful consideration was taken in giving recommendations to the fire department. After careful consideration, we developed four recommendations. These recommendations are: to acquire a competent alarm/smoke detector system, to add exit signs that clearly direct a person to safe place away from the building, to store combustible materials safely away from the means of egress, and to clear away any obstacles in discharges and hallways in the means of egress. If all of these recommendations are carried through, we believe that these buildings will enhance their egress system, thus enhancing Costa Rica's level of fire safety in the present and the future.

By studying fire standards and codes concerning all aspects of an egress system, specifically the National Fire Protection Agency's codes 101 and 101A, the *Life Safety Code*, a general yet simplified checklist was formulated to use at schools and hospitals in Costa Rica. The checklist utilized the different rules and regulations from *Life Safety Code* in order to produce a yes/no checking system for both inspecting various aspects of an egress system and for comparing measured and theoretical calculations for building capacities and evacuation times. After the standards and codes were defined, and the checklist was created, the applicability of the standards and codes within Costa Rica was determined through site assessments.

Two different building types, healthcare and educational facilities, were inspected using the checklist. Two hospitals located in Nicoya and Liberia as well as a school in Guadalupe were analyzed using the checklist. After these buildings were inspected, suggestions on how Costa Rica could enhance their already present egress systems, focusing on issues such as hazards, egress paths, identification of exits, fire detection, warning, safety systems, and occupant preparation were formulated based on the acquired information. In addition to suggestions, information on evacuation times and numbers of people who can safely exit a floor of these buildings were also presented.

To strengthen our project and its impacts, we observed the social and political aspects of our project. We examined how closely the Costa Rican government was following or even implementing fire safety measures. Fire safety education and human behavior during emergencies were also examined by interviewing members of the Cuerpo de Bomberos de Costa Rica and staff members at the locations analyzed. These issues were observed on site in Costa Rica to acquire the most accurate picture of the current level of fire safety. Once a complete picture was obtained, we determined specifically what directions to take in order to devise a solution to any problems that would hinder fire safety in terms of egress systems. Finally, the new checklist and formulas, along with implementation strategies were presented to the Costa Rican agency in detail.

The ultimate purpose of this Fire Safety project was to assist Costa Rica in obtaining a broader knowledge of fire safety particularly in terms of egress systems. Through the four key areas of comprehension, assessment, applicability, and adaptability, Costa Rica can obtain a greater sense of fire safety.

Chapter II. Literature Review

2.0 Reader's Guide to the Literature Review

The goal of this literature review is to provide the reader with a general understanding of the background knowledge of the project. First, the history of the National Fire Protection Agency, or NFPA, is discussed. Next, an introduction to one of the NFPA's fire codes, the *Life Safety Code* is presented. Egresses in terms of this code are then be defined, and examined. Finally, building fire inspection techniques are presented. This background information is useful in explaining the concepts presented in the project.

2.1 The History of the NFPA

Perhaps the best known non-profit, fire protection organization is the National Fire Protection Association. Located in Boston, the organization has representatives from every state in the United States, from Canada, and from 79 other countries (Bush 67). Prior to its formation, more than $100 million U.S. dollars of damage had already been caused by fire (NFPA Journal May/June 1996 160). The organization, founded by 18 fire insurance industry members in 1896, had three goals: first, to promote the science and improvement protection methods; second, to prepare and distribute new information; and third, to establish safeguards against the loss of life and property by working with the members and the public. The need for fire information, safety standards, and public education were the factors that determined the growth of the organization. Thus, its involvement in the fire protection industry enlarged.

The NFPA is involved in a variety of activities and projects. Developing fire safety standards is the most important function. These standards are advisory rules for preventing potential fire hazards for certain areas and activities. In order to respond to the multitude of questions the organization receives, full-time specialists with experience work as committee secretaries. These representatives also travel frequently on "Field Service Projects," educating questioners about the standards. The NFPA also catalogs and analyzes fires. Careful inspection of fires involving large monetary loss or life loss indicates where weaknesses exist in standards, where public protection failed, or where other hazards may dwell. Finally, the NFPA participates in educating the public. Both young and old individuals learn from fire protection information and periodicals, and also from various events such as Fire Prevention Week. Fire Prevention week is a week dedicated to public education about fire safety, and the Annual Fire Prevention Contest, a contest to recognize communities and industries with an effective fire prevention program (Bush 67-71).

The NFPA develops a number of frequently revised codes that help standardize and enhance fire protection. Using these codes, a specific occupancy's level of fire protection can be determined. The codes address various issues such as fire alarm and sprinkler systems, potential hazards, and building construction in terms of fire safety. One particular code, NFPA 101, also called the *Life Safety Code*, can be used for this purpose.

2.2 The History and Goal of NFPA 101

NFPA 101, also referred to as the *Life Safety Code*, states the minimum requirements for the operation, design, and maintenance of various types of buildings for safety from emergencies like fire.

The *Life Safety Code*'s development commenced in 1913 when the NFPA's Committee on Safety to Life was appointed. The committee first began to examine the causes behind sizeable fires involving deaths. These studies yielded the preparation of standards for the construction of fire escapes and stairways, the conducting of fire drills, and the construction and layout of exits. The basis for the present code developed from the pamphlets "Outside Stairs for Fire Exits", published in 1916, and "Safeguarding Factory Workers from Fire", published in 1918, which analyzed these studies.

By 1921, the committee enlarged to develop and integrate previous publications to create a comprehensive guide to life safety features in any type of building. The first edition of the guide, entitled *Building Exits Code*, was published in 1927. As both fire knowledge and practical experience increased, new editions were produced. The *Building Exits Code* was utilized for legal and regulatory purposes after several multiple-death fires in the 1940s. However, this code could not be adopted into law, because it had been drafted as a reference document. As a result, the committee re-created the entire *Code*, now including provisions, and revealed this reconstruction in 1956.

In 1963, the committee shrank and split into seven sectional committees which included only those with special knowledge and interest in various portions of the *Code*.

The sectional committees revised the code, placing all explanatory notes in an appendix. By 1966, the newly written *Code* surfaced with a title change: the *Code for Safety to Life from Fire in Buildings and Structures*. The code, commonly referred to as the *Life Safety Code*, was then placed on a three-year revision schedule to incorporate any new discoveries in fire prevention.

The Committee on Safety to Life restructured into a technical committee with an executive committee and standing subcommittees, each responsible for certain sections and chapters in 1977. A new release in 1981 featured the juxtaposition of the occupancy chapters as well as the chapter separation of the requirements for new and existing buildings. The additions also contained new chapters on ambulatory health-care centers and detention and correctional facilities. By 1995, the *Life Safety Code* grew to 316 pages and addressed issues such as mandatory sprinklers, residential board and care buildings, and agreement with the Americans with Disabilities Act Accessibility Guidelines (NFPA Journal September/October 1995 82).

The *Life Safety Code*'s objective is to provide safety to human life in emergencies. The minimum requirements for the design, operation, and maintenance of buildings and other structures for safety to life from fire and similar emergencies are defined in the Code. This code requires that both new and existing buildings plan and allow for "prompt escape" or to provide people with a reasonable degree of safety through other means (http://www.nfpa.org/standards/factsheets.html).

The *Life Safety Code* accomplishes this task of providing safety using two approaches. Hazards, the general requirements for the means of egresses, fire protection features, and building service and fire protection equipment are first defined. Next, the life safety requirements that vary with a building's use are illustrated. Building requirements differ for different occupancies; therefore improper classification of occupancy may result in wrongfully spending money on safety features that are either not needed or an of inadequate safety level.

In our project, the 7th edition of *Life Safety Code*, printed in 1997, will be examined. This was our primary source of information for definitions and analyses of all integral parts of the egress system. The text in Sections 2.3 through 2.18 are based on the *Life Safety Code*. Figures 1 through 13 found in Sections 2.3 through 2.18 were acquired directly from the *Life Safety Code*.

2.3 Introduction to Egresses in Accordance with NFPA 101

An egress is a public pathway leading to an exit outside the premises. The following are general rules associated with egresses:

• Portable ladders, rope, and fire escapes are *not* reliable, because not everyone can access them. Most people do not know how to climb down ropes or use portable ladders. Having these as a primary source of escape creates a false sense of security. Egresses such as stairs, doors, and ramps are devices that can be used by everyone to evacuate a building during a fire.

• Anything that can be temporarily used as an egress is called an area of refuge. They provide relative safety while evacuation is in progress. Areas of refuge must be reachable by an unassisted handicapped person. This refuge therefore must be reached without taking stairs. Examples of this include: another building connected by a bridge or a balcony, an elevator lobby, a compartment of the subdivided story, and an enlarged story-level exit stairway landing.

• Elevators are a *second means of egress* in a tower with limited occupant load, because they are electrically driven. If the electricity fails during a fire, there is no guarantee that the passengers inside will be able to escape safely.

• An exit is defined as a doorway or a door opening directly to the exterior at grade. An exit other than a door to the outside provides a protected path of travel. Exit doors must have a full range of swing in both directions. When exiting, the door must push open out to the hallway.

• An exit stairway is defined as the exit door to the stairway, everything between the two doors, and the door to the exit outside.

• Any door used as a means of egress must be either hinged or pivoted at the side, and swing open and close. Its operation also must be readily understood.

• Only certain parts of the building are allowed to flow into and out of an exit. These include: electrical devices serving the stairway, exit doors, equipment necessary for

2.4 Determining Occupancy Classification

Egress needs vary depending on the classification of occupancy. Some occupancies include: assembly, educational, health care, detention and correctional, residential, mercantile, business, industrial, storage, and daycare. Definitions for each of these will now be presented:

• Assembly- "Assembly occupancies generally contain large numbers of people who are unfamiliar with the space and therefore are subject to indecision regarding the best means of egress in an emergency."

• Educational- "Educational occupancies primarily include the large numbers of young people found in school buildings."

• Health care- "Health care occupancies are characterized by occupants who are incapable of self-preservation. In this occupancy, regardless of how many exits are provided, the occupants are not necessarily able to use them. They might be immobile, perhaps wired to monitoring equipment, debilitated, or recovering from surgery; or they might be in some other way disabled. The Code, in this instance, calls for a defend-in-place design strategy that utilizes horizontal movement and compartmentation. It recognizes that the occupants must be provided enough protection to enable them to survive the fire by remaining in the structure, at least temporarily."

• Detention and Correctional- "Detention and Correctional occupancies are similar to health care occupancies. In this case, however, the incapability for self-preservation is due to security imposed on the occupants. Because doors will not be unlocked to permit free egress to the public way, the defend-in-place design strategy is used."

• Residential- "Residential occupancies are characterized by occupants who will be asleep for a portion of the time they occupy the building. Thus, they may be unaware of an incipient fire and might be trapped before egress can occur. This occupancy grouping is further divided into one-and two-family dwellings, lodging and rooming houses, hotels and dormitories, apartment buildings, and board and care facilities. Each has characteristic needs different from the others."

• Mercantile- "Mercantile occupancies are similar to assembly occupancies. These occupancies are characterized by large numbers of people who gather in a relatively unfamiliar space. Further, mercantile occupancies often have sizable quantities of combustible contents present and circuitous egress paths deliberately arranged to force occupants to travel around displays of materials available for sale."

• Business- "Business occupancies generally have a lower occupant density than mercantile occupancies, and the occupants are usually more familiar with their surroundings. However, confusing and indirect egress paths are often developed because of office layouts and arrangement of tenanted spaces. The code requirements also address the needs of visitors unfamiliar with the building."

• Industrial- "Industrial occupancies expose occupants to a wide range of processes and materials of varying hazard. Special purpose industrial occupancies, characterized by large installations of equipment that dominate the space, are addressed differently than general purpose industrial facilities with higher densities of human occupancy."

• Storage- "Storage occupancies are characterized by relatively low densities of human occupancy and by varied hazards associated with the materials stored."

• Daycare- "Daycare occupancies are similar to educational. They contain both young and old occupants, who are under the supervision of adults other than their relatives or legal guardians. In cases where day-care centers cater to preschool age children, the occupants may have to be carried out of the facility during evacuation."

2.4.1 Examples of Each Type of Occupancy

There are multiple examples of these classifications. Different common buildings fall under each category. Some examples are:

• Assembly: armories, assembly halls, auditoriums, bowling alleys, club rooms, college and university classrooms of size greater than 50 people, conference rooms, courtrooms, dance halls, drinking establishments, exhibition halls, gymnasiums, libraries, mortuary chapels, motion picture theaters, museums, passenger stations and terminals of air, surface, underground, and marine public transportation facilities, places of religious worship, pool halls, recreation piers, restaurants, skating rinks, theaters.

• Educational: academies, kindergartens, nursery schools, schools.

• Health Care: hospitals, limited care facilities, nursing homes.

• Detention and Correctional: adult and juvenile substance abuse centers, adult and juvenile work camps, adult community residential centers, adult correctional institutions, adult local detention facilities, juvenile community residential centers, juvenile detention facilities, juvenile training schools.

• Residential: There are five sub-classes of residential occupancies that are more profoundly defined in the *Life Safety Code*. The following is a list of these sub-classes:

- hotels, motels, and dormitories
- apartment buildings
- lodging or rooming houses
- one- and two-family dwellings
- board and care facilities

• Mercantile: auction rooms, department stores, drugstores, shopping centers, supermarkets.

• Business: air traffic control towers (ATCTs), city halls, college and university instructional buildings, classrooms with less than 50 people present, and instructional laboratories, courthouses, dentists' offices, doctors' offices, general offices, outpatient clinics, ambulatory, town halls.

• Industrial: dry cleaning plants, factories of all kinds, food processing plants, gas plants, hangars for servicing and maintenance, laundries, power plants, pumping stations, refineries, sawmills, and telephone exchanges.

• Storage: barns, bulk oil storage, cold storage, freight terminals, grain elevators, hangars for storage only, parking structures, stables, truck and marine terminals, warehouses.

• Day-Care: child day-care occupancies, adult day-care occupancies, except where part of a health care occupancy, nursery schools, day-care homes, kindergarten classes that are incidental to a child day-care occupancy.

Our project will focus on observing egresses in schools and hospitals. Therefore, our group will be primarily concerned with educational and health care occupancies when evaluating the various aspects of egresses.

2.5 Egresses

The following information provides the necessary facts concerning all aspects of egress analysis. The basic requirements for a means of egress in all occupancy classifications will be established. Additions and exceptions to specific occupancies will also be discussed. These requirements apply to buildings that already exist as well as those under new construction. NFPA 101A, a more brief and mathematical compilation of the *Life Safety Code*, will be used primarily with supplemental information from NFPA 101 to assist in clarifying any vague points.

The term *means of egress* is defined to include the exit access, the exit, and the exit discharge. The components, number, size, arrangement of, lighting, identification, resistance ratings, and interior finish of egresses will all be covered.

The code relies on standard components such as stairs, ramps, and doors to create a reliable means of egress to be used by persons of all ages and abilities. Portable ladders, rope fire escapes, and similar devices are unreliable and cannot be used by all. These devices therefore are not recognized by the code as satisfying a means of egress. They give a false sense of security and therefore should not be used as a primary source of egress in a fire.

An *Area of Refuge* serves as a temporary staging area during evacuation of occupants. It provides relative safety to its occupants from the effects of a fire while potential emergencies are assessed, decisions made, and mitigating activities are begun. It is only a temporary place and therefore is only a part of the total egress system.

Examples might be a bridge or balcony, a compartment of a subdivided story, an elevator lobby, or an enlarged story-level exit stair landing. Areas of Refuge must be accessible by a horizontal mean of travel. Automatic sprinkler systems must be installed.

2.6 Exits

An exit is that portion of a means of egress that is separated from all other spaces of the building or structure by construction or equipment in accordance with (5-1.3.2) to provide a protected way of travel to the exit discharge.

Exits include:

- exterior exit doors
- exit passage ways
- horizontal exits
- separated exit stairs
- separated exit ramps
- stairway exits, which include the stairs, the doors to and from the stairs, and any exit passageway in between.

In doors leading directly from the street floor to the street or open air, the exit comprises only the door. Doors of individual small rooms, as in hotels, are not referred to as exits unless they lead directly to a public way or another equivalent area of such. Where an exit opens into a courtyard, park, alley or some other such area, a safe path of travel must be available to a public way.

Exits must provide protection form fire originating inside or outside the exit. Protection from fire originating within the enclosure is accomplished by prohibiting the use of the enclosure for any other purpose than the means of exit. This includes anything that could possibly interfere with the exit functioning as a protected path of travel. This includes using the exit for any other purpose such as storage or installation of equipment not necessary for safety. Exit passageways must receive their heating and cooling by systems independent of those serving the remainder of the building. Duct work serving other parts of the floor must be routed around and not through the exit. "The intent is that the exit enclosure essentially be 'sterile' with respect to fire safety hazards."

The following Figures 1, 2, and 3 depict examples of the different aspects of exits:

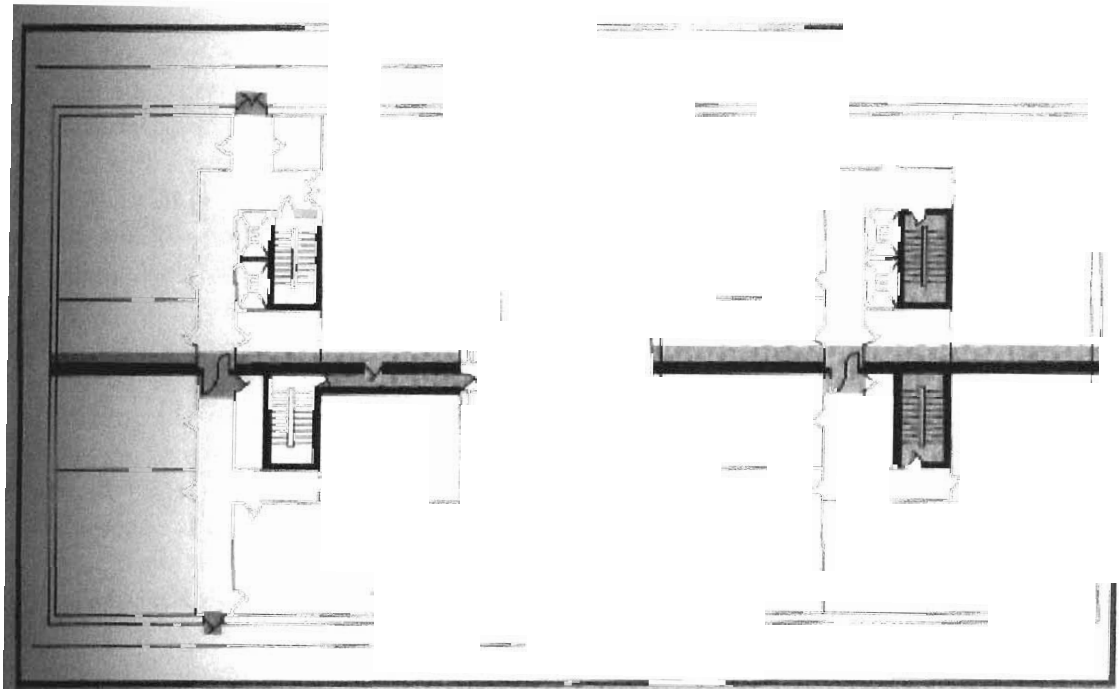

Figure 5-1. *Various forms of exits. On the second floor exits include (a) two exit stairs enclosed by fire-rated barriers including a rated self-closing door, and (b) a horizontal exit consisting of a fire-rated barrier, including rated self-closing doors, completely dividing the floor into two fire compartments. On the first floor exits include (a) two doors from the corridor directly to the outside at grade level, (b) a horizontal exit that is a vertical extension of and therefore similar to the horizontal exit on the second floor, and (c) an exit passageway connecting [illegible] of the second floor exit stairs directly with the outside, separated from the remainder of the floor by fire-rated barriers, including rated self-closing doors.*

Figure 2. Spaces constituting exit access.

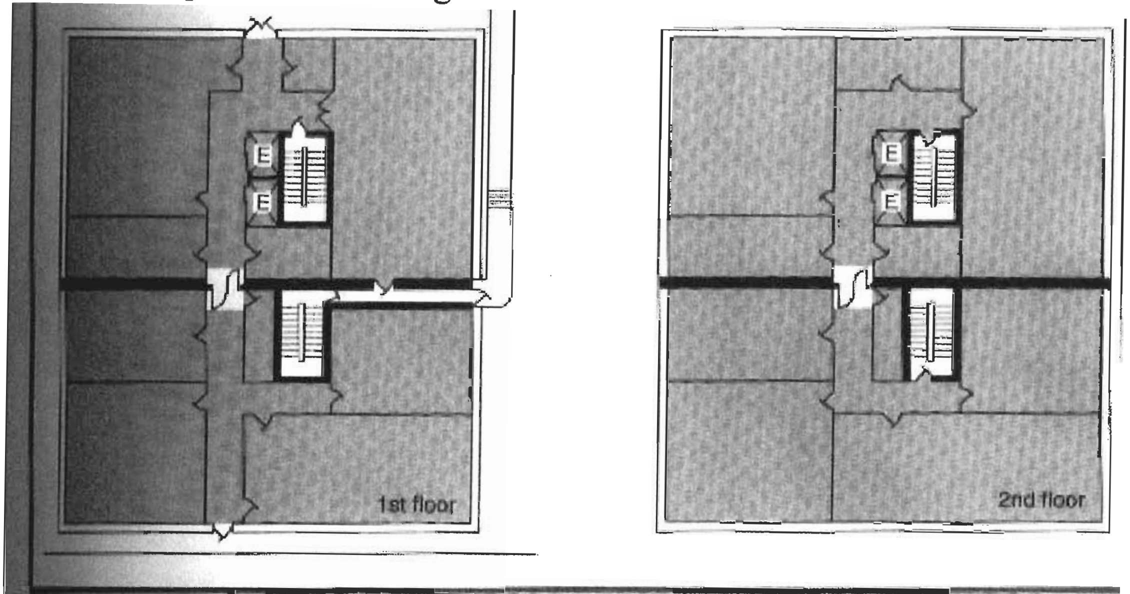

Figure 5-2. Spaces constituting exit access. All spaces occupied and traversed in reaching an exit are considered the exit access portion of the means of egress. From the shading shown in the figures, it is apparent that exit access comprises more floor area than either of the other components of means of egress—the exit and exit discharge.

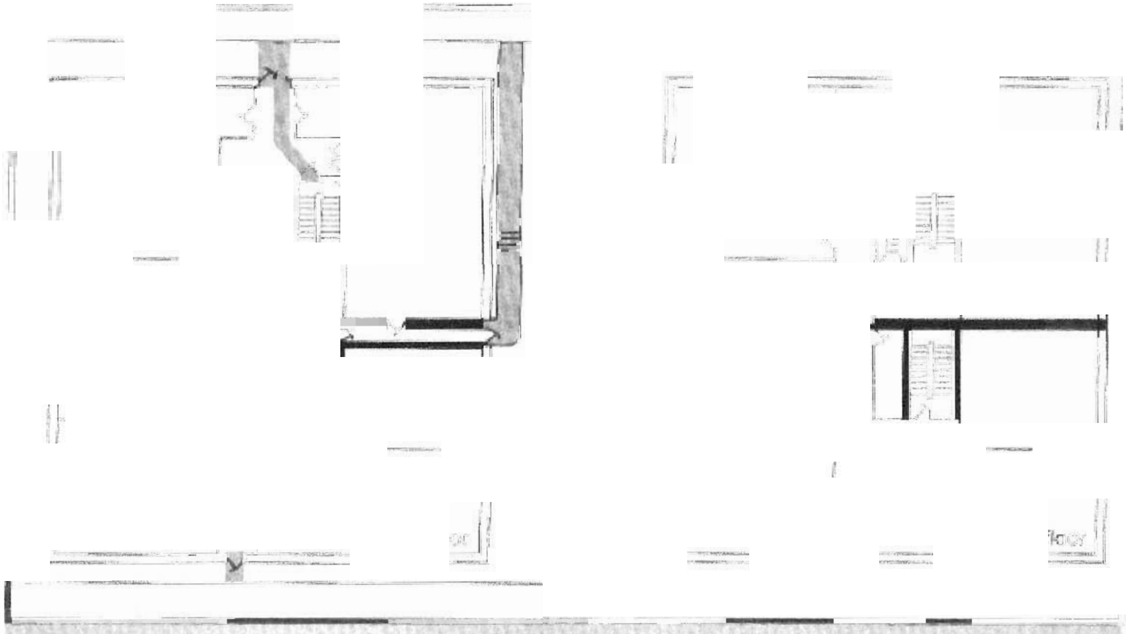

Figure 5-3. Exit discharge. Because occupants leave the building at the first floor only, no exit discharge occurs on the second floor. The first floor exit discharge includes (a) the exterior space beginning at the exit doors from the corridor and continuing to the public way (street), (b) the exterior walkway along the side of the building beginning at the door from the exit passageway and continuing to the public way, and (c) the interior path of travel from the second floor exit stair discharging through a portion of the first floor corridor. For an occupant of the second floor who must travel across a portion of the first floor, the area is considered exit discharge, yet an occupant of the first floor who travels across the same space and is considered to be within exit access. See also 5-7.2.

2.7 Determining Hazard of Contents

Hazard of contents is defined as the relative danger of the start and spread of fire, the danger of smoke or gases generated, and the danger of explosion or other occurrence potentially endangering the lives and safety of the occupants of the building or structure. There are three types of hazard levels defined as follows:

• Low Hazard: Low Hazard contents shall be classified as those of such low combustibility that no self-propagating fire therein can occur.

• Ordinary Hazard: Classified as those that are likely to burn with moderate rapidity or to give off a considerable volume of smoke.

• High Hazard: Those likely to burn with extreme rapidity or from which explosions are likely.

2.8 Fire Doors

The door is an integral part of the exit process and therefore needs attention. The door has many purposes in not only being a comfort to an occupant, but also in aiding their safety. Doors provide protection from all types of weather, disturbances and noise from other areas, drafts, unauthorized trespassing, and Fire and Smoke, which is where we are concerned. The purpose of a tight-fitting door is not only to control the flow of smoke but also provide some protection to the occupant during the exit process.

There are some factors that comprise the analysis of fire doors. Every door and prominent entrance that is required to serve as an exit should be designed and constructed so that the way of egress is apparent and direct. In determining the egress capacity width for a doorway, only the width of the door in full open position should be measured, as shown in Figure 4.

Figure 4. Clear door width.

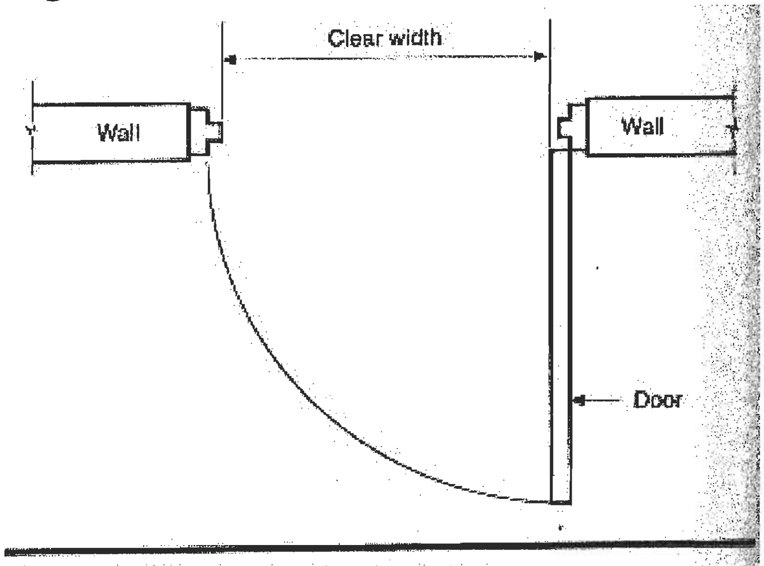

Figure A-5-2.1.2.1 Clear door width.

2.9 Egress Width

The calculations used to determine the egress width, especially stair width, needed to provide a given capacity and flow time will be described. *Flow* is the number of persons passing a point in a unit of time. *Flow Time* is the total time needed for a crowd to move past a point in the egress system. *Capacity* is the number of persons a movement facility can serve in a certain amount of time. *Demand* is the number of persons actually attempting to use the facility.

The calculations will take in to account the actual number of people in the crowd trying to exit, their varying abilities, the direction of crowd movement, stair width, and other details of design such as the ability to reach a handrail (NFPA 101A).

Stairs:

Stairs serve a multitude of functions whether inside or outside a building. These functions include normal occupant movement along them, emergency exiting in case of a fire, and rescue and fire-control operations conducted by fire fighters. Because stairs are used so widely on a day-to-day basis now, they are the scenes of many an accident; thus much attention is given to them.

Stairs most often occur within an exit. To be considered an exit, interior stairs must be separated from the other spaces on the floor. Outside stairs need to be separated from the interior of the building by fire rated construction to be considered an exit (NFPA 101).

An example of an unacceptable arrangement is shown in Figure 5 as follows:

There is a remoteness formula referred to as the *one-half diagonal* rule. This rule is stated as, "Where two exits or exit access doors are required, they shall be placed at a distance from one another equal to and at least one half the length of the maximum overall diagonal dimension of the building or area to be served, measured in a straight line between the nearest edge of the exit doors or exit access doors." Where exit enclosures are provided as the required exits and are interconnected by a corridor, exit separation shall be permitted to be measured along the line of travel within the corridor.

Where more than two exits or exit access doors are required, at least two of the required exits or exit access doors shall be arranged to comply with the above. The other exits or exit access doors shall be located so that if one becomes blocked, the others shall be available. An examples of this arrangement is shown in Figure 6.

Figure 6. Protection of exit access corridors.

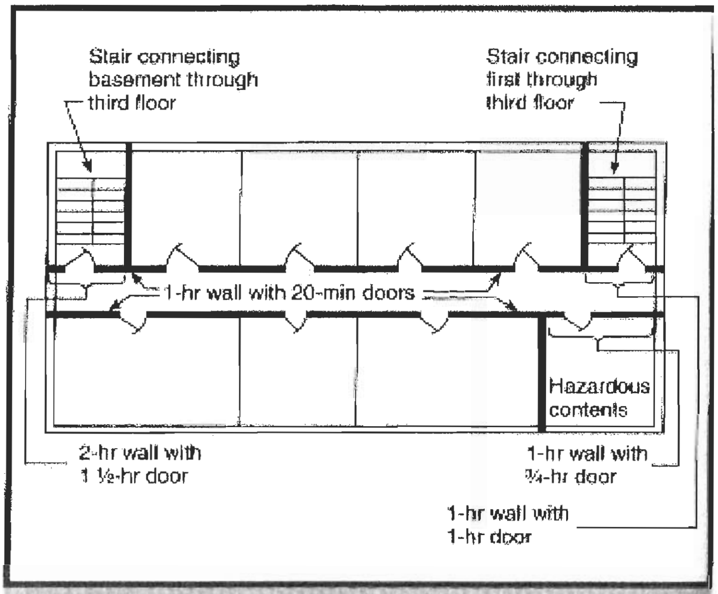

Figure 5-4. Protection of exit access corridors. This plan shows an example of the protection of exit access corridors required by 5-1.3.1. Note the difference in required protection for the corridor wall segments serving also as enclosure protection from the hazardous contents area (see Section 6-4) and as part of the enclosure of an exit (see 5-1.3.2).

2.11 Illumination of Means of Egress

When a fire occurs in a building, the degree of visibility in passageways, stairs, and corridors may mean the difference between an orderly exit and chaos often resulting in life and death situations. There has been a history of some noteworthy fires in which the failure of normal or emergency lighting was a major factor and resulted in many deaths. Some of these fires include: The Iroquois Theater, Chicago, 1903—602 deaths, The Coconut Grove Night Club, Boston, 1942—492 deaths, and the Summerland, Isle of Man, 1973—50 deaths. As you can see, proper illumination is an integral part of the exit procedure. The illumination of means of egress provided here are to comply with every occupancy. The exit access shall include only designated stairs, aisles, corridors, ramps, escalators, and passageways leading to an exit. The exit discharge shall include only designated stairs, aisles, corridors, ramps, escalators, walkways, and exit passageways leading to a public way. Illumination need only be provided outside a building in enough to lead the occupants to either a public way or a distance away from the building that is considered safe.

Illumination should continue throughout the entire exiting process. It is required that there be at least a 1 ft-candle (10 lux) of illumination at floor level in all three elements of a means of egress: the exit access, the exit, and the exit discharge. Lights that are placed in walls approximately 1 foot above the floor work well because they are not likely to be obscured by smoke. Lighting should be arranged that the failure of any single light does not leave the area in total darkness. All lights, circuits, or auxiliary power must be arranged to ensure continuity of egress lighting. This can be succeeded in a number of ways: overlapping light patterns, duplicate light bulbs in fixtures, or overlapping dual circuits.

Sources of illumination should be reliable. It is not wise to depend on battery operated systems or other types of portable lamps or lanterns and they should not be used as a primary source of illumination. Battery-operated electric lights can be used as a source of emergency lighting though.

2.12 Emergency Lighting

Emergency lighting facilities for means of egress should be placed appropriately where called for depending on the type of occupancy. Specific occupancy emergency lighting requirements will follow in a later section. In general, emergency lighting should be placed in every building where required, at doors equipped with delayed egress locks, and the stair shaft and vestibule of smoke-proof enclosures. A standby generator that is installed for the smoke-proof mechanical ventilation equipment can be used for the stair and vestibule power supply.

When maintenance of the emergency lighting facilities, depends on changing from one power source to another, there should be not be an substantial interruption of lighting during any time. There should not be more than a 10-second delay when emergency lighting is provided by a prime mover-operated electric generator. Generators driven by prime movers on site must be capable of automatically starting and picking up the lighting load within 10 seconds. If the generator is unable to complete this task, a

Figure 7. Schematic of bypass isolation transfer switch.

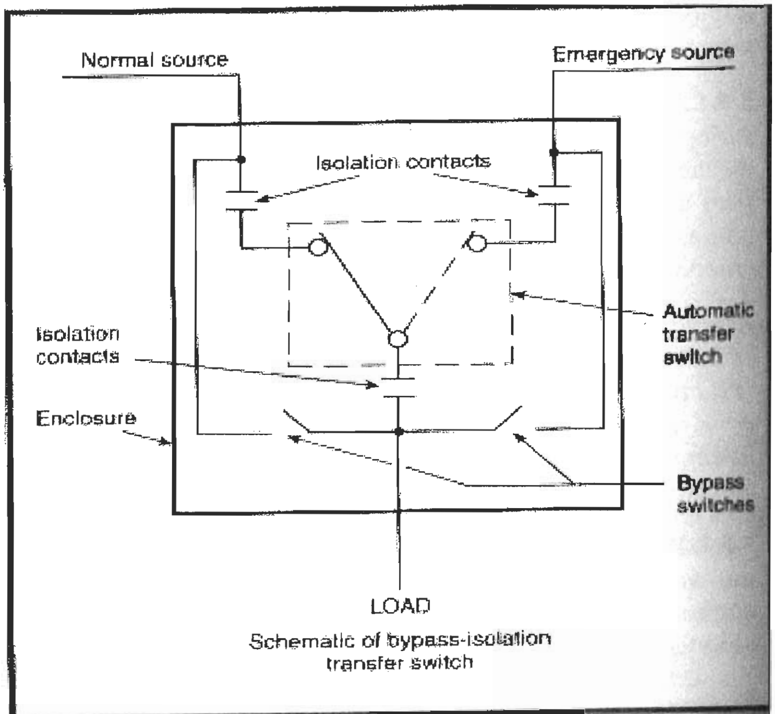

Figure 5-80. Schematic of bypass-isolation transfer switch.

Figure 8. Arrangement of normal and alternate emergency sources.

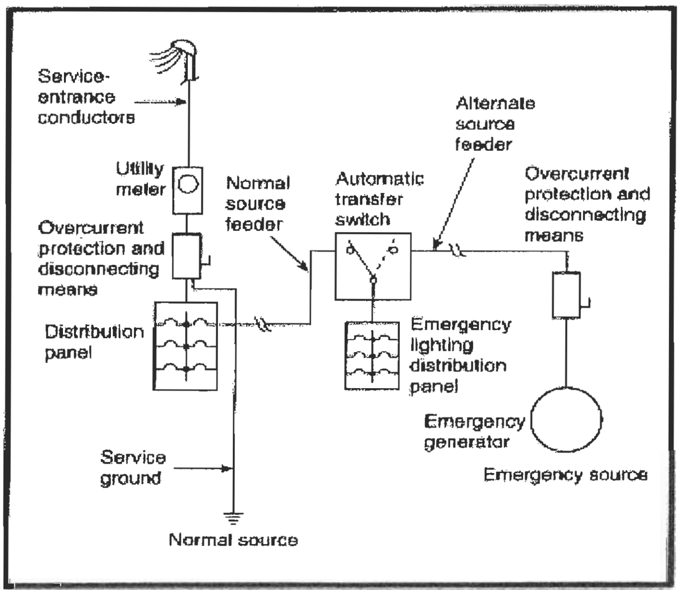

Figure 5-81. Arrangement of normal and alternate sources where emergency power is supplied from an on-site generator.

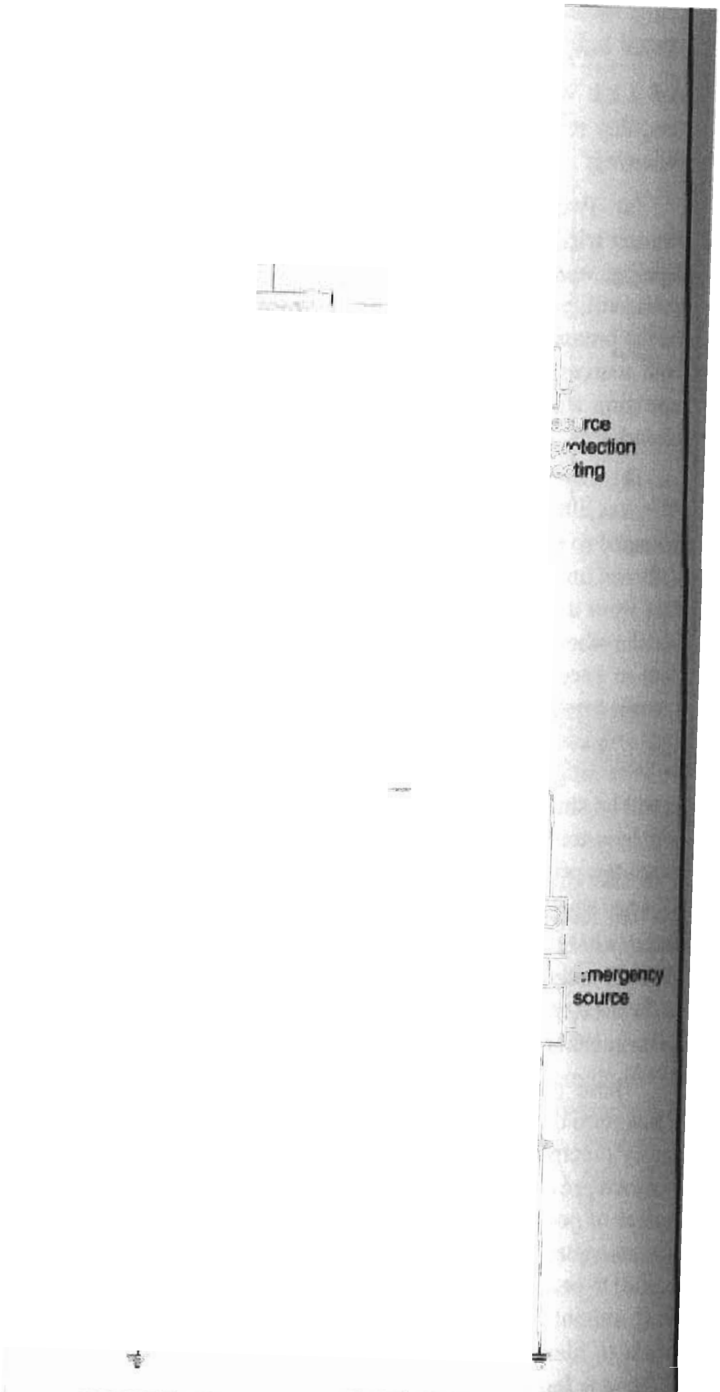

Figure 5-82. Two methods of obtaining an emergency source by connection ahead of the service disconnecting means. [See Section 700-12(e) of NFPA 70, National Electrical Code.] This does not meet the requirements for emergency lighting in the Life Safety Code.

Figure 10. More examples of emergency source connections.

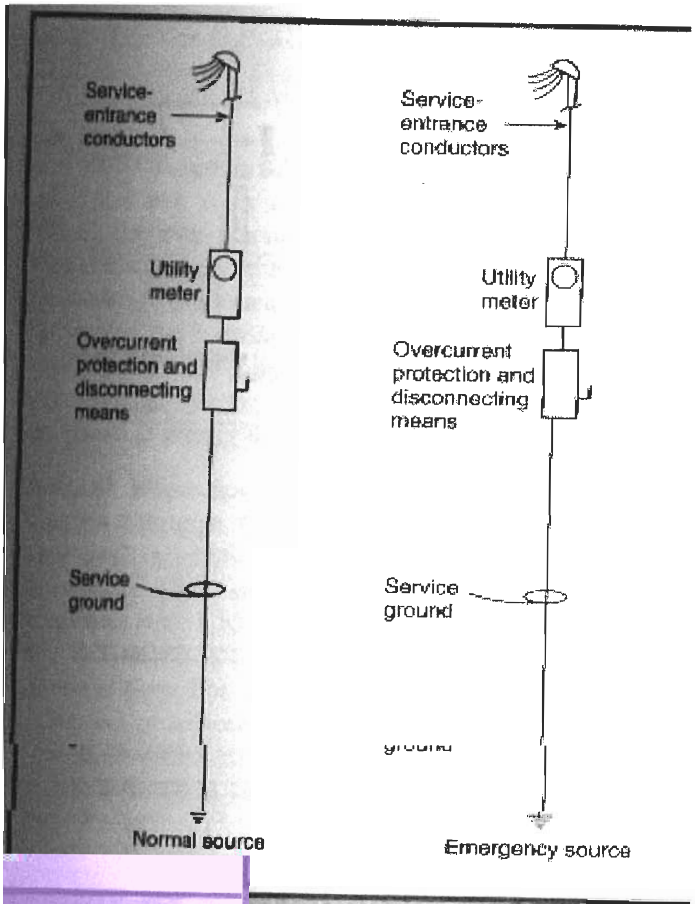

Figure 5-63. Two separate services to the same building as permitted by Section 700-12(d) of NFPA 70, National Electrical Code. This is not recognized by the Life Safety Code for emergency lighting.

2.13 Testing and Maintenance of Equipment

All emergency generators and emergency lighting equipment should be tested. A functional test should be conducted on every required battery-powered emergency lighting system at 30 day intervals for a minimum of 30 seconds and annually for a duration of an hour and a half. The equipment must be fully functional for the entire duration of the test. Written records of tests and visual inspections should be kept by the owner for the inspection of the authority having jurisdiction.

2.14 Identification of the Means of Egress

Exits should be designated by an approved sign readily visible form any direction of exit access. Any occupancies requiring specific identification will be taken up in a later section. What will follow are the general requirements for all occupancies.

Sign placement should be such that no point in the exit access corridor is more than 100 ft (30m) from the nearest sign. This distance requirement is only applicable to new exit access corridors and does not apply to signs in exit access corridors in existing buildings.

Where there are floor proximity exit signs, the bottom of the sign should be placed no less than 6 in., no more than 8 in above the floor. This is important because signs located near the ceiling may become obstructed by the presence of smoke. These floor proximity signs are used in addition to the regular exit signs placed over doors. These supplemental signs may be approved electroluminescent, self-luminous, or self-illuminated types. Take note that these floor proximity signs are not intended to take the place of the regular exit signs but are used in addition to them to increase the level of safety in exiting a fire.

All required signs should be located and be of such size, distinctive color, and design as to be immediately visible to exiting occupants. They should be of contrast to any decorations, interior finish, or other signs already in place. Any decorations, furnishings, or equipment that impairs the visibility of an exit sign is not permitted. There should also be no other brightly illuminated signs that one might mistake for an exit or compete with the exits' attention.

In the case of exit doors, the sign should be placed on the door or adjacent to the door with the nearest edge of the sign within 4 in. of the door frame.

· Color of Signs

The color of exit signs has been traditionally red, but green is now often used as well. There are no specific requirements for color based on the fact that either red or green will be used in most places, and that there may be some situations where some color other than red or green may actually provide better visibility.

· Size of Signs

Externally illuminated signs should have the word EXIT or other appropriate wording in plainly legible letters not less than 6 inches high with the principal strokes of letters not less than ¾ in wide. The letters of the word, EXIT, should be of no less than 2 in, except the letter 'I', and the minimum spacing between letters should be no less than 3/8 in. Signs larger than this should be proportionally altered.

Internally illuminated signs should have the word EXIT or other appropriate wording in letters legible from a distance of at least 100 ft under all normal and emergency lighting conditions.

· **Illumination of Signs**

The following terms of illumination are defined as given by NFPA 101.

Externally Illuminated- The light source is contained outside of the device or legend that is to be illuminated. The light source is typically a dedicated incandescent or fluorescent source.

Internally Illuminated- The light source is contained inside the device or legend that is illuminated. The light source is typically incandescent, fluorescent, electroluminescent, light-emitting diodes, or self-luminous.

Self-Luminous- Illuminated by self-contained power sources (i.e., tritium) and operates independently of external power sources. Batteries do not qualify as a self-contained power source. The light source is typically contained inside the device.

Electroluminescent- A light-emitting capacitor. Alternating current excites phosphor atoms where placed between the electrically conductive surfaces and produces light. This light source is typically contained inside the device.

Photoluminescent materials are not permitted for use in exit signs or exit markers in floor proximity egress path marking systems. There are many problems associated with the decay and duration of signs made of photoluminescent material and therefore lack credibility.

The average luminance of the letters and background is measured in footlamberts. The contrast ratio is determined form these measurements by the following:

$$\text{Contrast} = L_g\text{-}L_e / L_{g,}$$

L_g is the greater luminance and L_e is the lesser luminance. Either the variable L_g or Le may represent the letters; the remaining will represent the background. The average luminance of the letters and background can be calculated by measuring the luminance at the positions indicated by the following figure at the numbered spots.

In measuring the luminance of exit signs, there are some exceptions. The first being approved existing signs, and the second being self-luminous or electroluminescent signs that provide evenly illuminated letters. The letters should have a minimum luminance of 0.06 footlamberts (0.21 cd/sq. m) as measured by a color-corrected photometer. The luminance of these signs is measured by determining the luminance of circular areas no greater than 3/8 in. in diameter at the positions indicated in Figure 11 shown as follows:

Figure 11. Measurement of exit sign luminance.

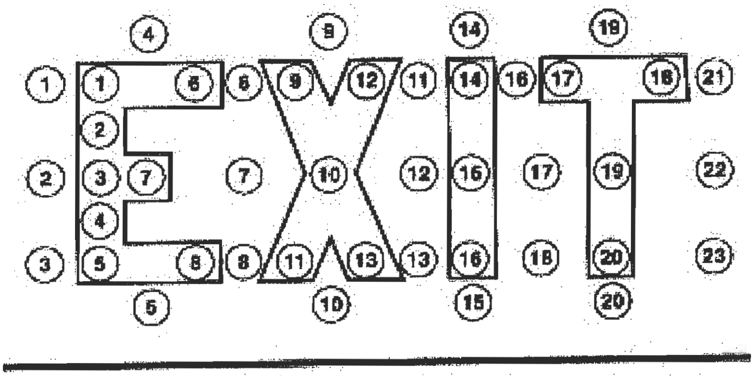

Figure A-5-10.3.3 Measurement of exit sign luminance.

All signs are required to stay continuously illuminated except they may be permitted to flash on and off upon activation of the fire alarm system. The flashing repetition rate should be approximately one cycle per second, and the duration of the off-time should not exceed one quarter second per cycle. Flashing signs when activated with an alarm system prove to be of assistance in getting a persons attention and are therefore useful.

· **Specific Requirements**

A directional sign reading EXIT should be placed in all locations where the direction of travel to the nearest exit is not obvious. In regards to directional indicators, they should be located outside the EXIT legend, and should be no less than 3/8 of an inch from any letter. They are permitted to be part of the sign or to exist separately. The directional indicator should be of a chevron type and should be able to be identified from a distance of no more than 40ft at 30 ft-candle and 1 ft-candle average illumination on the floor representing normal and emergency lighting levels respectively. The indicator should be placed at the end of the sign for the direction indicated. An example of this are shown in Figure 12 as follows:

Figure 12. Example locations of exit signs.

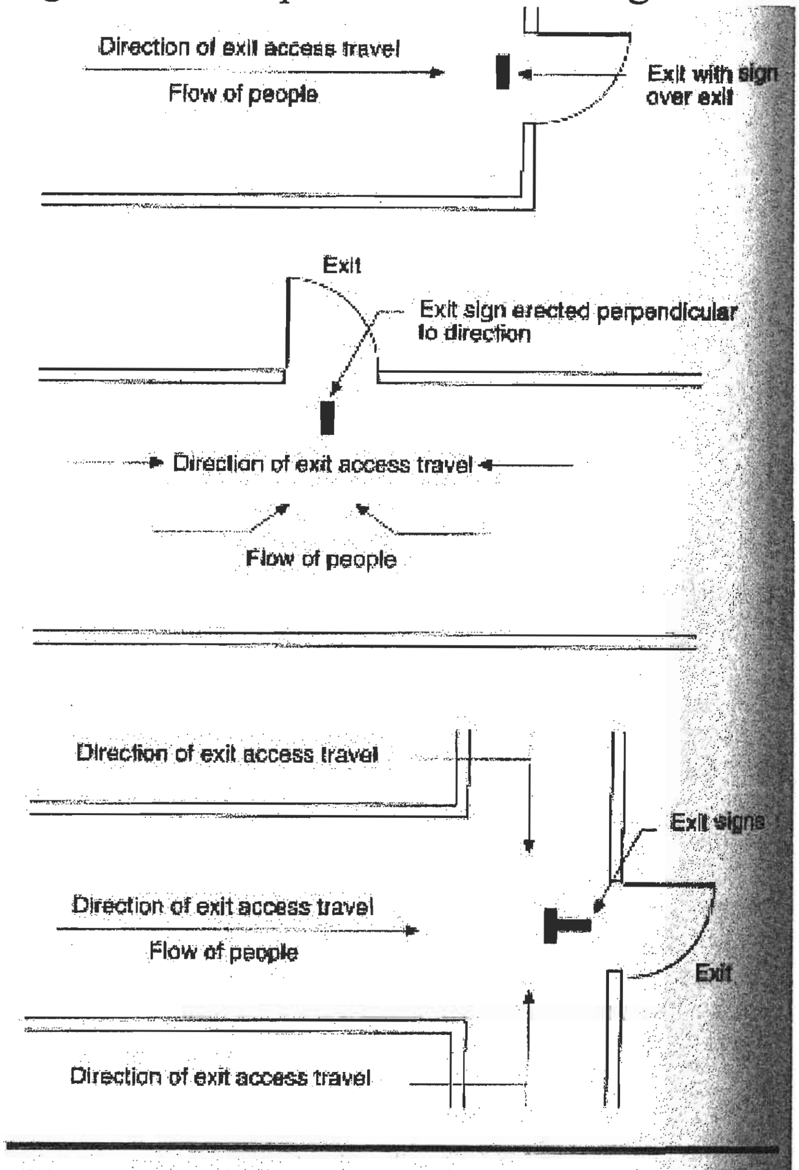

Figure A-5-10.1.2 Location of exit signs.

· **Special Signs**

Any door, passage, or stairway that is neither an exit or way of exit access and that is arranged or located so as to be mistaken for an exit, must have a sign clearly stating so. The exit should be identified by a sign reading, NO EXIT. The word, NO, is to be in letters 2 in. high with stroke width of 3/8 in. and the word EXIT in letters 1 in. high. The word EXIT should be placed below the word NO.

It is very important to comply with this fact in that improperly labeled passageways and stairways that lead to dead end spaces can trap occupants from exit doors and be detrimental to their safety. Supplemental information such as, To Basement, or To Storeroom, would be helpful. An example of a special sign is given as follows:

Figure 13. Measurement of self-luminous exit sign luminance.

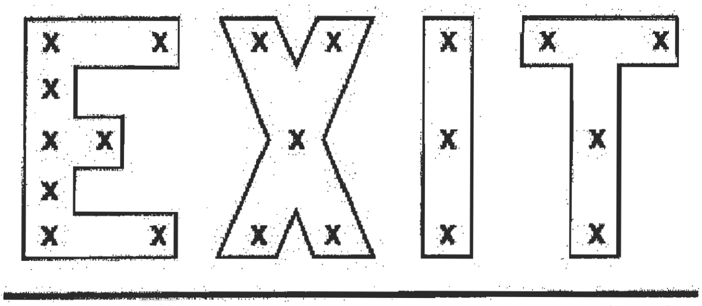

Figure A-5-10.3.3 Exception No. 2 Measurement of self-luminous exit sign luminance.

• **Elevator Signs**

Elevators that are a part of the egress process should be properly labeled with the following signs with a minimum letter height of 5/8 in. in every elevator lobby:

The signs that follow are to be used in place of signs that indicate that elevators should not be used during fires.

"In the event of fire, this elevator will be used by the fire department for evacuation of people."

In order to eliminate possibly unexplainable outlying data, decisions about the test subjects were made. For example, a decision was made not to compare the sample with the disabled people of the population who go out with an assistant. This decision was based on the fact that since these people would most likely remain with their assistant, the assistant would be able to find the exit for them. People with a seeing-severity score greater than 10.0, meaning they were blind, were also not tested (Boyce 81).

The samples were compared to their respective population using different factors to physically influence their ability to locate and read the exit signs. Analysis of the data yielded that the distance at which participants could locate and read each of the exit signs decreased as seeing severity increased. As shown in Table 1 and Table 2, the mean distances at which subjects without a seeing disability read non-illuminated, illuminated, and LED exit signs were greater than the respective mean distances at which subjects with seeing disabilities read each sign. The differences in the distance at which subjects with and without seeing disabilities read the non-illuminated exit sign was found to be significant with a

Table 1
Distance (m) at which subjects can locate exit signs by the presence or absence of seeing disability

Type of Sign and Subject Group	Mean (m)	Median (m)	Standard Deviation (m)
Non-illuminated exit sign:			
all disabled (105 people)	14.3	15.0	2.3
with seeing disability (25 people)	13.9	15.0	2.8
without seeing disability (80 people)	14.5	15.0	2.2
Illuminated exit sign:			
all disabled (118 people)	14.6	15.0	1.5
with seeing disability (25 people)	14.0	15.0	2.6
without seeing disability (93 people)	14.8	15.0	0.9
LED exit sign:			
all disabled (83 people)	14.7	15.0	1.4
with seeing disability (23 people)	14.6	15.0	1.5
without seeing disability (60 people)	14.7	15.0	1.2

(Boyce, 82)

Table 2
Distance (m) at which subjects can read exit signs by the presence or absence of seeing disability

Type of Sign and Subject Group	Mean (m)	Median (m)	Standard Deviation (m)
Non-illuminated exit sign:			
all disabled (105 people)	13.3	15.0	3.1
with seeing disability (25 people)	11.4	15.0	4.0
without seeing disability (80 people)	13.7	15.0	2.7
Illuminated exit sign:			
all disabled (118 people)	14.2	15.0	2.7
with seeing disability (25 people)	12.9	15.0	4.6
without seeing disability (93 people)	14.5	15.0	1.8
LED exit sign:			
all disabled (83 people)	14.6	15.0	1.6
with seeing disability (23 people)	14.0	15.0	2.6
without seeing disability (60 people)	14.7	15.0	1.2

(Boyce, 83)

confidence level of 95%. The differences between the distances at which subjects with and without seeing disabilities located the sign were not found to be significant. The results indicated that the subjects, even those with seeing disabilities, were overall capable of locating and reading exit signs at code-compliant travel distances (Boyce 81-83).

In summary, the LED sign was the most visible and legible by people with a seeing disability, followed by the illuminated sign and the non-illuminated sign. Some factors that were not tested may also have impact. The results did not take into account contrasting colors, noise, activity, and smoke obscuration that may even further hinder a person's inability to locate the appropriate exit sign during an emergency (Boyce 85). This study suggests that any type of exit sign is acceptable, however, the use of the LED sign would be best.

2.17 Fire Exit Drills

In every building or structure large enough that a fire itself would not initiate evacuation, fire alarms and fire exit drills are a necessity. The alarms are used to alert occupants to begin emergency procedures and facilitate the orderly conduct of fire drill exits. Fire drills are to be conducted frequently so occupants can become familiar with the manner in which to exit a building. Drills include suitable procedures to ensure that all people in the building or all people subject to the drill actually participate. Emphasis is placed on orderly, disciplined evacuation rather than speed. Finally, drills are to be held at expected and unexpected times and under differing conditions to simulate the many unusual conditions that may occur during a real fire.

Each occupancy type has different specific rules for conducting fire drills. These drills are to be designed in cooperation with the local authorities. Responsibility for the planning and conducting of the drill is given only to competent people who have the necessary leadership qualifications. In this project, a fire drill was conducted by the project group in conjunction with the local fire department representatives at a school in Guadalupe. Because this project focuses specifically on hospitals and schools, fire exit drill procedures are only mentioned for these occupancies.

2.17.1 Fire Exit Drill Procedures for Existing Health Care Occupancies

- The administration of every health care occupancy shall have in effect and available written copies of a plan stating the procedures to follow in case of a fire, as well as plans for the evacuation to areas of refuge and for evacuation from the building if necessary. This written fire safety plan shall provide for
  - the use of alarms
  - transmission of alarm to the fire department
  - response to alarms
  - isolation of fire
  - evacuation of area
  - preparation of building for evacuation, and
  - extinguishing of a fire.

- All employees shall be periodically instructed and kept informed with respect to their duties under the plan. A copy of this plan is to be kept at the telephone operator's position or at the security center.
- All facility personnel shall be instructed in the use of and response to fire alarms. Also they shall be instructed in the use of the code phrase to ensure transmission of an alarm under the following conditions:
  - When the individual who discovers a fire must immediately go assist an endangered person.
  - During a malfunction of the building fire alarm system.
- Personnel hearing the code announced must first activate the building fire alarm using the nearest manual alarm station and then immediately execute their duties as outlined in the fire safety plan.
- Fire exit drills include the sounding of the fire alarm signal and simulation of emergency conditions. Drills are to be conducted quarterly on each shift so that all staff members become familiar with the procedures. When drills are conducted between 9:00pm and 6:00am, a coded announcement shall be permitted to be used instead of the fire alarm. During fire drills, the movement of infirm or bedridden patients to safe areas or outside of the building is not required.
- All employees are to be instructed in life safety procedures and devices.
- The proper protection of patients requires the prompt and effective response of heath care personnel. The basic requirements of this task include:
  - removal of all occupants directly involved with the fire emergency
  - transmission of an appropriate fire alarm signal

- confinement of the fire's effects by closing doors to isolate the fire area, and
- execution of evacuation duties as detailed in the facility's fire safety plan.

2.17.2 Fire Exit Drill Procedures for Existing Educational Occupancies

- Fire drills are conducted every month the facility is in session, except in climates where weather is severe. In that case, at least four fire drills must be conducted before the drills are deferred. In addition, a drill must be conducted within the first 30 days of operation.
- The drills must be executed at different hours the school is occupied by students. Such times would include:
  - during recess or gym periods
  - during assemblies
  - during passing between classes.
- If a fire drill is called when students are moving up and down stairs, they shall be instructed to form in a file and proceed towards the nearest exit.
- Every fire exit drill is an exercise in the school's management in which the complete control of the class is achieved. A heavy emphasis is placed on a brisk, quiet, and orderly exiting process in which running is forbidden. If there are students incapable of holding their place or moving at a reasonable speed, more capable pupils will assist that person.
- Monitors shall be appointed among more mature pupils to assist in the execution of fire drills. Their job includes the holding of doors in the line of march or to close

doors to prevent the spread of fire. There should be two substitutes appointed to provide appropriate performance in case monitors are absent.

- Teachers are responsible for searching toilet and other rooms after they have joined their classes to the preceding lines.
- Because drills simulate actual fire conditions, students will never be allowed to obtain clothing after the alarm has sounded.
- Every class is to proceed to a predetermined point outside the building and remain there while a check is made to see that all are accounted for, leaving only when a recall signal is given to return to the building or when dismissed. These points are to be sufficiently far away from the building and from each other as to avoid danger from any fire, confusion, or interference with the fire department.
- Whenever it is necessary to cross roadways, signs reading "Stop! School Fire Drill," or an equivalent is to be carried by monitors so that traffic will stop for the students.
- Fire exit drills will never include any fire extinguishing procedures.

2.18 Special Requirements and Exceptions to Occupancies

Each occupancy has slightly different rules in order to enhance the amount of fire safety for that particular occupancy. Because this project will focus on educational and health care occupancies, only these exceptions will be discussed as follows:

2.18.1 Requirements and Exceptions for Educational Occupancies

· Preschool, kindergarten, and first grade classrooms must be located on the level of discharge. Second grade classrooms must not be more than one floor above or below the level of discharge. This requirement is important in that small children may be trampled over by larger children in the act of evacuating the building. Smaller children are also not as developed in their motor skills and may therefore require assistance or rescue.

· Slide escapes, escalators, fire escape stairs, and revolving doors are not permitted as required means of egress in an educational facility.

· All normally occupied rooms should have an exit door leading directly to an exit access corridor or exit. Exceptions to this are:

- rooms that have doors opening directly to an exit access balcony or the outside rooms that are normally occupied that have only one intervening room in which the travel distance through is limited to 75 ft, personal effects such as coats and other belongings are kept in metal lockers (or the room is sprinklered), and either the intervening room is supplied with fire detectors connected to the buildings alarm system or the entire building has an automatic sprinkler system.

· In discharging from exits, all should be arranged by the general requirements specified previously. The exception to this is that every classroom used for educational purposes or that occupies students below the floor of exit discharge, should have access to at least one exit that leads directly to the exterior level of discharge without entering the floor above.

· Illumination should be in accordance with the general requirements.

· Emergency lighting should be provided as specified previously with the exception of administrative areas, general classrooms, and mechanical rooms and storage areas. In marking the means of egress, the signs should follow the guidelines above with the exception of small elementary schools where the locations of exits are obvious and familiar to all.

· Every room or space greater than 250 sq. ft used for a classroom or other educational purposes must have at least one window for emergency rescue and ventilation purposes. The window must be able to be opened without the use of tools and should be no less than 20in (width) by 24 in (height) in dimensions. The bottom of the opening of the window should not be more than 44 in above the floor and any latching device on the window not more than 54 in above the floor. The windows should be accessible to the fire department and open into an area having access to the public way. There are three exceptions to this:

- buildings protected throughout by an approved automatic sprinkler system
- if the room has a door leading directly to the outside
- in rooms located higher than three stories above grade, the area of the window may be modified to the dimensions necessary for ventilation.

· These windows are an important part in providing a supplementary means of emergency escape. Firefighters may need to use rescue ladders and the windows may provide additional air to breath in a smoke-filled room.

2.18.2 Requirements and Exceptions for Health Care Occupancies

· All aisles, passageways, corridors, exit discharges, exit locations, and accesses should be in accordance with the general requirements above. Exceptions to this will be explained in the following.

- All doors in new health care occupancies are specified as clear, unobstructed width and not leaf width.
- Ramps are undesirable in hospitals and nursing homes. They have a great potential for accidents in both everyday normal and emergency traffic. They are the only practical way though of moving patients in beds from one floor to another permitting the slope of the ramp is not too great. A better plan is to provide a horizontal egress to another section of the building.
- Exit access corridors in new general hospitals and nursing homes are required to be no less than 8 ft in clear, unobstructed width. This is due to the fact that many patients may be moved on litters or in wheelchairs.
- Exceptions to arrangement of means of egress are if there is an exit door opening directly to the outside, patient rooms are permitted to have an intervening room if it is used as an exit access for more than eight patient sleeping beds, special

nursing suites may have an intervening room that allows for constant and direct supervision by nursing personnel, and rooms other than patients' sleeping rooms are allowed to have one or more adjacent rooms.

· Illumination of means of egress and emergency lighting should be in accordance with the general specifications above. Buildings equipped with or in which the use of life support systems is required by the patients, the equipment should comply with NFPA 99-Standard for Health Care Facilities.

· NFPA 99 specifies that emergency generating equipment should be inspected weekly for a time of no less than thirty minutes a month under load.

· Marking of means of egress should be in accordance with the general requirements with an exception to self-luminous exit signs as permitted.

2.19 Theoretical Calculation for Exit Times and its Significance

There are many theoretical calculations used to predict the required time for all of the occupants of a building. The formula used for this project came from the book "Curso Avanzado de Prevención de Incendios" provided by the organization. This formula was used, because it could be applied to all types of exiting situations including horizontal and vertical distances.

The theoretical time to evacuate a building is given by the following equation:

2.20 Calculation for Fixed Exit Times and its Significance

According to the Manual de Protección Contra Incendios used by the Cuerpo de Bomberos de Costa Rica, there are fixed exit times for the different parts of the egress system. The first fixed time concerns exiting from the hallway into the stairs. The code book states that every person on a floor must be in the stairwell within 90 seconds. The second fixed time concerns moving through the stairs. All of the people cannot take more than five minutes to move from their current location to a temporary safety zone by way of the stairs. Therefore, if two safety zones exist between the first and 15th floor of a building, a person evacuating from the 15th floor has 10 minutes to get to the bottom, because they can reach the temporary safety zone. The final fixed time concerns the time to pass through the exit discharge to a location a safe distance away from the building. Every person must reach this point within 90 seconds. Using all of this information, the fixed time can be expressed in the following manner:

T_{fixed} = 180 seconds + (number of safety zones)*(300 seconds)

The fixed time gives the amount of time in which all of the people in the building should reach the point a safe distance from the building. This is different from the theoretical time, because the theoretical time predicts the amount of time all of the people will evacuate given the current conditions of the building. The fixed time acts as a benchmark, or an ideal time in which people are expected to evacuate (Manual de Protección Contra Incendios 6.115).

2.21 Theoretical Calculations for Dynamic Capacity versus Static Capacity and their Significance

The static and dynamic capacities are useful theoretical calculations used to predict the number of people that can be safely allowed in a building. The static capacity is defined in terms of the value of the occupant load for a given occupancy type. The static capacity is equivalent to the product of the occupant load and the size of the area in question, or alternately described:

Static capacity = a/L, where

- L = occupant load obtained from the *Life Safety Code* as follows for each of the occupancies observed in this project:
  - Health care occupancies
    - Not less than 11.1 sq. m per person in health care sleeping departments
    - Not less that 22.3 sq. m of gross floor area per person of inpatient health care treatment departments.
  - Educational occupancies
    - 1.9 net sq. m per person for classrooms.
    - 4.6 net sq. m per person for laboratories, shops, and similar vocational rooms.
- a = the net area of the location.

The dynamic capacity is another method of calculating a theoretical number of people to be allowed in a building. This value is based on the theoretical time of evacuation described in the previous section. The dynamic capacity as defined in the book "Curso Avanzado de Prevención de Incendios" provided by the organization is:

Dynamic capacity = P / F*t, where

- P = the number of occupants.
- F = a constant for the fluctuation of circulation, equivalent to 1.1 people per second per unit of passage.
- t = the total evacuation time

The dynamic capacity will be calculated using the total evacuation time value acquired as described in the previous section.

In order to acquire a single, theoretical limit to the number of people allowable, the minimum of the static and dynamic capacities are taken. This number can be compared to the actual amount of people in the area at one time. If the actual number of people occupying the area is greater than the theoretical value, alternate strategies for increasing fire safety can be used such as sprinklers (Dept. of Risk Engineering).

2.22 Human Behavior during Fire Evacuation

There exists a widely held belief that a human's first response to a fire emergency is panic. Panic is assumed to be the instinctual response to changes in the immediate social or physical environment such as the smell of smoke, smoke itself, the absence of light, someone yelling "fire", or a sudden fire alarm. This action is particularly noted when people are asleep or in a crowded area of a building. Although many believe this to be true, there is little evidence to suggest that human behavior is unpredictable or governed by such stimulus-response rules (Sfintesco 96).

Careful analyses of witness statements following major fire disasters characterize the human response to be largely considerate and affiliative. Panic appears to be an exception to the rule, occurring only when their route of escape appears to be closing rapidly and their time to search for an alternative means of escape appears to be inadequate (Sfintesco 96).

In 1972, Wood carried out an exploration of behavior in fires based on interviews of fire victims. Wood believed that if people are aware that an escape route exists, then they are less likely to leave because they felt less threatened by the fire. Their motivation of escape would therefore only be dominant when other objectives, like extinguishing the fire, cannot be done. Also, the more training an individual has received, the more likely that person is likely to fight the fire instead of leaving. Finally, if the person perceives the fire as an extremely serious threat, the person is most likely to leave (Sfintesco 96-97).

The affiliative model summarizes the strong tendency to move toward familiar people, such as family and friends, and familiar places, such as a familiar entrance route.

Another consequence noted in this model is that separated individuals responded quickly to ambiguous cues, whereas intact family groups did not begin to evacuate until there was a clear sign of the fire threat (Sfintestco 96-97).

2.23 Proper Fire Safety Inspection Procedures

A fire safety inspector plays an important role in enforcing the fire laws. Inspectors must be knowledgeable in code requirements and inspection procedures. They also must have astute judgement, a keen eye for observing, and strong communication skills. Fire safety inspectors should follow the guidelines for inspection preparation, determining unsafe situations while working on-site, and communicating these problems to the management of the property.

There are many good measures to take when preparing for an inspection. First, the inspector should become aware of the reasons why the inspection is being made, and also what to observe during the inspection. The necessary equipment, such as flashlights, cameras, notebooks, and proper clothing must be acquired. Bringing reference materials such as fire code books may also be useful, but should not be carried on the job, because an excessive number of books gives the impression of not being skilled in fire inspection. The inspector should also make time to increase familiarity with fire code provisions for the region. Finally, past inspection reports should be read so that checks can be made to see if old problems were corrected, and so the inspector can become acquainted with the layout of the building (Robertson 154-156).

should or should not be pointed out depending on the level of familiarity of the personnel. In all cases, patience in explaining must be used so that the recommendations and requirements for change are completely understood. Before leaving, if a person other than the owner or property manager accompanied the inspector, an exit interview with a responsible management representative should be made so that the management can be advised of all the problems noted during the visit. All of the mandatory changes as well as suggestions should be clearly defined on paper so that there is no possible future discrepancies between the inspector and the property manager (Robertson 163-166).

While inspecting egresses in Costa Rica, the fire inspector guidelines will be practiced so that the inspection not only progresses smoothly, but also correctly. It is very possible that potential fire hazards or causes of fire may lie in these egress areas rendering them unusable during a fire emergency. By identifying possible problems and reporting them, it is possible to increase the chance people will successfully exit the occupancy during a fire.

2.24 How the Checklist Will Be Placed into Law

The following information was gathered from an interview with Esteban Ramos, assistant to the chief engineer of the Cuerpo de Bomberos de Costa Rica.

In order for the recommendations of our project to be placed into law, many procedures must be followed. First, the proposed law is created. Second, technical representatives from the INS, or National Institute of Insurances, work solely on the so specified law with representatives from the government in order to resolve any discrepancies.

After these discussions take place, the INS then sends the document to one of the following three ministries of the republic: health, environment and energy, or economy depending on the law to be implemented. They discuss the new law, and if there are no objections, the law is published in the official newspaper, La Gaceta, in where the public has the chance to read the proposed law and voice their opinions if there are discrepancies. If there are problems, the ministry meets an additional time and a revised law is either published again or taken out of consideration. After two months, if there are no objections, the law is officially implemented and signed into law by the President. The specific body who compiled the said proposal then becomes in charge of working with the law and ensuring its enforcement.

The checklist and specific requirements for healthcare and educational facilities will be submitted to the INS for proposal into law. Technical representatives from the bomberos will review the proposal and discuss it with the INS. After the discussions have taken place, the so proposed will be discussed with the ministry of health. If no objections are present, the proposed document will be placed in La Gaceta. If after two months there are no additional objections, the proposed document will be signed into law.

2.25 Supplemental Information

Supplemental information on doors, locks, latches, panic hardware, stairs, ramps, occupant load, measurement of means of egress, egress capacity, number and arrangement of means of egress, measurement of travel distances to exits, discharge from exits, and interior finishes can be found in Appendix F.

systematically inspecting each building. The present condition of each buildings egress system was noted. Any corrections that needed to be made to the building were carefully considered and recorded in the "comments" section of the checklist.

In addition to conducting an inspection on various parts of an egress system at the school in Guadalupe, a fire drill was conducted to acquire raw data on evacuation times. Prior to the fire drill, the students and faculty were notified of the purpose of the drill. The fire drill was conducted following the NFPA guidelines stated in Section 2.17.2 of this report.

The governmental and social issues concerning the implementation of additional egress requirements was not overlooked. To get an accurate picture, the research was done on scene in Costa Rica. It was discovered that adequate literature on this subject could not be obtained, therefore an interview was conducted with Esteban Ramos, assistant to the chief engineer of the Cuerpo de Bomberos de Costa Rica. All of the information related to the implementation of the checklist into law was presented in Section 2.22 of this report.

· Checklist

A checklist, presented in English in Appendix B and in Spanish in Appendix C, for use with both hospitals and schools, was created in Microsoft Excel for Windows 95/98. The checklist is divided into three parts. The first part requires the input of different values under the "value" section in order to calculate theoretical evacuation times and building capacities. The second part is a list of "yes and no" questions to check if different requirements of the major parts of egress systems were met. If the question does not pertain to the occupancy type being inspected, the question is designated as "not applicable". Next to each question, a "comments" section is presented to note specific problems with that part of the egress system. The third part uses Excel's built-in mathematical commands to automatically produce theoretical values for exit times, and static and dynamic capacities.

All of the theoretical values were calculated automatically using Excel. The formulas used were the same ones described in the Literature Review section of this report in parts 2.19, 2.20 and 2.21, with the exception of the dynamic capacity calculation. A new dynamic capacity calculation was developed in conjunction with the liaison and tested using the data values obtained from the test inspection on the 5th floor of the INS building. The equation is as follows:

Dynamic capacity = C*(Tfixed – d1 / vh – d2 / vv – d3 / vh) / (1/w1 + 1/w2 + 1/w3), where:

- C = coefficient of circulation, equal to 1.8 people per meter per second
- Tfixed = the fixed time value calculated as described in Section 2.20 of this report.
- d1 = the total horizontal distance to the stairway
- d2 = the vertical distance from the current floor to ground level
- d3 = the horizontal distance of the exit discharge to a place a safe distance away from the building
- vh = the vertical velocity in normal situations
- vv = the horizontal velocity in normal situations

- w1 = the lesser of the corridor width and the width of the door leading to the stairs
- w2 = the width of the stairs
- w3 = the width of the door leading to the exit discharge

At the bottom of the checklist, another set of yes/no questions was presented. These questions were checked to see if the measured evacuation time was less than or equal to the theoretical evacuation times in normal and panic situations. This was done to check if the measured time was less than the fixed time, and if the measured number of people in the zone was less than or equal to the minimum of the static and dynamic capacity.

Two documents, one for hospitals and one for schools were also created to explain the different rules that each element in the second part of the checklist must follow. If one of the requirements were not met, the item received a check under "no". The documents are used in conjunction with the checklist to efficiently inspect both schools and hospitals.

· Sampling

Our sample group consisted of two healthcare buildings and one educational building. There is a great deal of bias in our sample because the buildings inspected were chosen by the organization and therefore were not randomly selected.

A few short interviews with key figures were conducted in the fire department and governmental positions. Questions were asked to determine:

- Codes Costa Rica uses now

- People who enforce those codes
- Code differences between Costa Rica and the USA
- Present tools for implementing new codes
- Blueprint approval procedures
- Cultural reasons known as to why there might be hindrances to enhancing their present level of egress safety.

· Inspection

Each type of building was inspected to determine its specific egress needs. While walking through the facility an inspection was co· wiho degjth h skl· t t d t

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- Testing/Maintenance - testing and maintenance procedures of equipment are determined
- Identification - inspection of exit signs: their color, size, illumination, specific requirements, any special signs, and testing and maintenance will be examined.
- Fire protection devices - existence of tested and working fire alarms, fire alarm signaling devices, and smoke detectors.

Chapter IV. Analysis of the Collected Data

4.0 Introduction

This section presents an analysis of all the data collected and observed as described in the Methodology section of this report. Each element of the checklist and the comments were inspected in order to develop the analysis. All of the data, including additional comments, were entered into the Excel checklist, which is presented in English in Appendix B and in Spanish in Appendix C.

Each of the buildings was divided into different zones, because either the occupancy loads differed between zones, or the inspection took place on multiple floors. Each hospital was split into two zones. The first zone was the patient waiting area and the second zone was the patient sleeping area. The school was divided into three zones, one for each floor in the building.

The analysis section consists of three different sections. First, hospitals and schools were analyzed. The analysis of each was done separately because the occupancy types were different and independent of each other. In this analysis a few specific problems with each egress system are discussed in detail, in particular, those problems that could be most realistically fixed and implemented and could play the biggest role in improving fire safety in buildings. Next, a graphical analysis on each building is presented in order to view the effects of changing different variables in the theoretical equations. By studying these graphs, relationships between the physical aspects of buildings and evacuation times and capacities can be seen. Buildings were analyzed separately in order to observe if the effects were only specific to a certain occupancy type or building size. Finally, an analysis of the social aspects of this project is presented.

4.1 Results of the Inspections

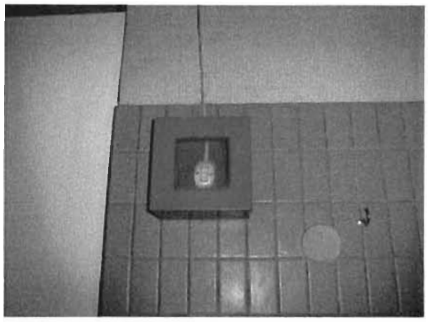
The results presented in this section were observed on site at each location. The results were based on the data from the "yes/no" section of the checklist. The actual observations and comments for each element of the egress system for each building can be seen in English in Appendix B and in Spanish in Appendix C.

4.1.1 Hospitals

After inspecting the hospitals in Nicoya and Liberia, common problems in the lack of egress safety were seen. Some of the major issues observed were: lack of an adequate alarm system and smoke detectors, signs giving incorrect exiting instructions, obstructed exit discharges, and improper placement of hazardous materials.

The hospitals had neither an adequate fire alarm system nor smoke detectors. In Nicoya, the alarm system consisted of a single pull station located in an extremely busy area, covered by not readily breakable glass and placed approximately eight feet above the floor. A picture of this pull station is shown in Figure 14.

Figure 14. Fire alarm pull station at Nicoya hospital.



The activation system is much like a light switch covered by glass with no breaking device present. This is the only way to activate the alarm in the building.

The alarm system was also inadequate because it was used not only to warn of fire but also of earthquakes. The hospital in Nicoya also did not have smoke detectors. In Liberia, neither an alarm system nor smoke detectors were present.

Each hospital contained a set of laboratories, a pharmacy, an X-Ray area, and a general information area all in a single room. Since these areas will consistently have large numbers of people present, there will be constant traffic of people in these areas. In the opinion of the group, the presence of an effective alarm system and smoke detectors are the most important factors of a complete exit system. The alarm gives the first signal that there is a problem and notifies that the premises should be evacuated or that refuge should be taken in a safe area. If a person cannot know that there is danger, the completeness of the evacuation system is of no relevance because the person does not know there is danger. Once an alarm system is activated though, people can begin the evacuation process. Part of this evacuation process involves taking the correct path to exit the building safely.

In order to exit the building safely, exit signs should be placed so that a person completely unfamiliar with the building can easily and readily evacuate the building. The exit signs in both hospitals did not effectively tell people the location of an exit. The signs were not illuminated and were either placed at inappropriate locations, or directed to areas that were not exits. Figures 15 and 16 show the exit signs from each hospital.

Figure 15. Typical exit sign in Nicoya hospital.

This exit sign was located in the most central corridor of the building. The sign is not illuminated, and does not have any pictures depicting exiting. Most important, neither arrow directly leads a person to a safe place away from the building.

Figure 16. Typical exit sign in Liberia hospital.

This exit sign has both pictures and words. However, this sign does not say what in direction the exit is located, nor was placed near an exit. Also, very few of these were present in the building, which could cause confusion during an evacuation.

The purpose of exit signs is to make clear the direction a person should take so as to exit the building in an orderly fashion. When people do not know where to go in an emergency, they can become confused and possibly create a chaotic situation. Chaotic situations where people are afraid and already in a state of panic can create injuries when trying to evacuate. The existence of clearly readable exit signs allows people to know exactly where to go in order to safely exit the building, thus lessening the chance that people will panic from fear of not being able to exit.

Once the direction of exit is in clear view a person can begin to exit the building. A clear path along the corridors inside the building, the actual exit, and the path outside the building leading to the area of safety must be completely free of obstacles so as not to complicate the evacuation process. An unobstructed path is necessary for proper order and efficiency in evacuating the building. In both Nicoya and Liberia the paths were a major problem. Construction materials, stretchers, wheel chairs, trashcans, benches, hazardous materials, and numerous other miscellaneous obstacles were all present and obstructing the path of discharge from each building, especially in Liberia. Figures 17 and 18 show the obstruction of pathways in the hospitals.

Figure 17. Exit discharge at Nicoya hospital.

This exit discharge has debris all around the only pathway in this area that leads a safe distance away from the building.

Figure 18. Exit discharge at Liberia hospital.

The exit discharge is blocked by trash barrels. Moreover, the exit is padlocked on the opposite side, thus creating a dangerous situation during an evacuation.

The last issue that we feel is of major importance is the improper placement of the hazardous materials. In both hospitals, the placement and storage of combustible materials, oxygen and nitric oxide for example, was unacceptable and endangered the patients and hospital personnel. The location of these materials was unacceptable, because they were placed outside in direct sunlight, and in some cases blocking exit discharges. Figures 19, 20, and 21 show these unacceptable locations in each hospital.

Figure 19. Storage of combustible materials at Nicoya hospital.

The blue tanks contain nitric oxide. As shown, the tanks were placed outside in direct sunlight, thus increasing the chance they will explode.

Figure 20. Combustible materials in exit discharge at Liberia hospital.

These combustible materials not only obstruct the discharge, but could also explode making the discharge unusable during an emergency.

Figure 21. Combustible materials in corridor at Liberia hospital.

These tanks obstruct the hallway located in the children's sleeping area of the hospital.

Materials such as nitric oxide, which are frequently encountered in healthcare facilities, have the potential for explosion, and thus represent a great fire hazard. In terms of egresses, if the materials blocking the means of egress ignite, the egress becomes unusable. In such a situation, the people would be forced to turn around and find an alternate means of exiting. Therefore, materials that are likely to produce poisonous fumes or gases and those that will burn with extreme rapidity need to be properly classified and compartmentalized away from the means of egress according to their nature.

4.1.2 School

Four problems were observed at the San Jorge school in Guadalupe. These problems were: the lack of an adequate alarm system and smoke detectors, the lack of exit signs giving proper directions to the closest exit, the disorder during evacuation, and the narrow stair and door widths.

No alarm system or smoke detectors were present at the school. Again, as in each hospital, an alarm system and smoke detectors are needed to immediately notify the occupants of a fire emergency. We cannot stress the importance of this factor enough. It is of prime importance in a total exit system. There were also no exit signs present. The reasons for having proper signs have already been discussed in the previous section on hospitals.

A fire drill was conducted, in addition to the inspection, to acquire raw data on evacuation times. The drill itself was chaotic because the children ran and screamed in a disorderly manner. Figure 22, which shows the some children not moving towards the exit but rather in the opposite direction, depicts the chaos of the situation.

Figure 22. Children exiting in a disorderly fashion during a fire drill at Guadalupe school.

The children are running and carrying their bags and papers, which is not allowed during a fire drill.

Finally, the widths of the doors, the stairwell, and the stairs themselves were too small. The width of the stairs was too small, because not enough children could easily and safely move efficiently down the stairs, as shown in Figure 23. The width of the door was clearly too small, because a backup at the door was created as the children attempted to evacuate from the building during the fire drill, as shown in Figure 24.

Figure 23. Narrow stair width at Guadalupe school.

Not many children can fit on the stairwell at once, because the stairs are too narrow.

Figure 24. Blocked, narrow doorway at Guadalupe school.

The children are having a difficult time exiting the building, because the doorway is too narrow.

4.2 Analyses Using the Theoretical Calculations

Using the information from Appendices B and C, the theoretical exit times and the static and dynamic capacity were calculated. With this information, the level of fire safety in terms of an effective evacuation was determined.

4.2.1 Hospital in Nicoya

The information shown in Tables 3 and 4, the theoretical exit times, static and dynamic capacities, and the measured values acquired from the hospital in Nicoya, suggests that people would have a difficult time successfully exiting the building.

Table 3. Theoretical time comparisons for Nicoya's hospital.

	Theoretical Evacuation Time under Normal Circumstances (sec)	Theoretical Evacuation Time under Panic Circumstances (sec)	Fixed Time (sec)
Zone 1: patient waiting area	227.05	450.38	180
Zone 2: patient sleeping area	403.38	831.71	180

Table 6. Theoretical capacity comparisons for Liberia's hospital.

	Actual number of people	Static Capacity (people)	Dynamic Capacity (people)
Zone 1: patient waiting area	100	184	111
Zone 2: patient sleeping area	500	728	5

It can be predicted that people would have a difficult time successfully exiting the sleeping area, because the theoretical evacuation times are many times larger than the fixed times. Again, because people do not know how to readily find the exits and evacuate safely due to the lack of an emergency plan and training, it is very likely that panic conditions would be met if an emergency occurred, thus increasing the evacuation time. The large times occur for two reasons. First, the door and corridor widths were very small due to the debris blocking the doors and corridors. Second, the maximum distance to the nearest exit and the greatest distance for a discharge that leads a safe distance away from the building were both very long. Even if the people are aware of how to exit the area properly, according to the information in Table 5, the patients and staff located in the sleeping area still could not evacuate quickly.

Because exit times and travel distances were long, and door and corridor widths were small, the dynamic capacity for the sleeping area was very small, as shown in Table 6. The theoretical capacity is the minimum of the dynamic and static capacity; in both cases the dynamic capacity is the theoretical capacity. The dynamic capacity for the sleeping area was much smaller than the actual number of people in the sleeping area, which shows the same error in the equation as in Nicoya. More than five people can be present in the building, but a number as large as 500 will produce major evacuation problems according to the theoretical calculations.

In contrast, the patient waiting area has a good chance of having a successful evacuation. If an emergency plan is created, then according to the theoretical value in Table 5, the people could evacuate in less time than the fixed time. The dynamic capacity shown in Table 6 for this area is also larger than the actual number of people in the waiting area, which again shows that the area can be evacuated successfully.

4.2.3 School in Guadalupe

As shown in Tables 7 and 8, the theoretical exit times, static and dynamic capacities, and the measured values acquired from the hospital in Liberia, suggest that people would have a difficult time successfully exiting the building from the second and third floors of the school.

Table 7. Theoretical time comparisons for Guadalupe's school.

	Measured Evacuation Time (sec)	Theoretical Evacuation Time under Normal Circumstances (sec)	Theoretical Evacuation Time under Panic Circumstances (sec)	Fixed Time (sec)
Zone 1: first floor	281.44	107.14	280.81	180
Zone 2: second floor	281.44	341	503	180
Zone 3: third floor	281.44	221.8	371.8	180

Table 8. Theoretical capacity comparisons for Guadalupe's school.

	Actual number of people	Static Capacity (people)	Dynamic Capacity (people)
Zone 1: first floor	20	231	92
Zone 2: second floor	155	273	57
Zone 3: third floor	82	137	57

The dynamic capacities for the second and third floor were smaller than the actual values as shown in Table 7, because the widths of the exit doors and stairs were small. The dynamic capacities and actual number of people in the school did not differ to the same extent as did the dynamic capacities and actual number of people for the hospitals. Specifically, the third floor actual number of people was close to the dynamic capacity, which means that, although the number is larger, the difference is small enough that the occupants on the third floor could evacuate relatively safely. Again, the dynamic capacity should only be used as an approximation.

The school presents particularly interesting data, because actual, measured evacuation times can be compared to the theoretical times as shown in Table 8. The actual theoretical evacuation time for the whole building is equivalent to the maximum theoretical evacuation time amongst the different zones of the building. In this case, the normal theoretical evacuation time for the school was the time from the second floor, 341 seconds. The students from all three floors evacuated in 281.44 seconds, which is less than the theoretical time, but greater than the fixed time. The measured time for the school is therefore acceptable, because the measured time was less than the theoretical time. The measured time, however, is not ideal, because the measured time is not less than the fixed time.

The theoretical time approximates the evacuation time of a zone based on the current physical aspects of the building. Because the theoretical time is only an approximation, it is possible for the measured time to be less than the theoretical time, as in the case for the school.

The third floor theoretical times and first floor theoretical time were larger than the total measured time. This does not have significant meaning, because an evacuation of the whole building was performed, not an evacuation floor by floor. For example, if only the first floor was to be evacuated, the occupants could evacuate much faster than the measured time of 281.44 seconds, because only a small number of occupants are present on that floor.

4.2.4 Graphical Analysis

The theoretical exit time calculation as defined in Section 2.19 of this report and the dynamic capacity calculation as defined in Section 3 of this report were mathematically analyzed using the data observed. Because the theoretical time and dynamic capacity equations were the same for each type of building, this graphical analysis was only performed using the data shown in Table 9 from the waiting area of Liberia's hospital. By allowing different values to vary, one at a time, general trends for the increase and decrease of the theoretical time and dynamic capacity were seen. All of the values in the equation except one were held constant to see how the dynamic capacity and normal theoretical time value changed. Only the normal theoretical time value was tested, because the same equations are used with different velocity constants, thus still producing the same type of curve or line.

Figures 25 through 31 graphically depict the trends in value change for the dynamic capacity and the normal theoretical exit time when the different values in Table 9 are allowed to vary one at a time. The maximum horizontal travel distance, the minimum door width, the and maximum discharge travel distance were modified one at a time to see how the dynamic capacity changed. The maximum horizontal travel distance, the minimum door width, the maximum discharge travel distance, and the number of people in the zone were modified one at a time to see how the normal theoretical exit time changed.

For each graph, 25 different data points were examined. Points were chosen on an incremental basis above and below each measured value. For example, if the minimum door width in is 1.11m as shown in Table 9, some of the data points would be: 1.20m, 1.15m, 1.05m, 1.00m, 0.95m, and 0.90m.

Table 9. Liberia Hospital Waiting Zone Measurement Data.

Measurements	*Value*	
Number of stories in building	1	stories
Number of sublevels	0	sublevels
Number of people per floor	100	people
Width of floor	13	m
Length of floor	19.72	m
Occupancy Load	1.4	m^2 / per.
Maximum horizontal travel distance to nearest exit	13	m
Minimum exit door width	1.11	m
Width of corridor	2.32	m
Minimum stairway width	0	m
Vertical distance to bottom floor using stairs	0	m
Minimum width of the doors leading to the exterior	1.11	m
Horizontal travel distance of the path of discharge	28.44	m
Number of safety zones	0	zones

First, the dynamic capacity was tested. Figures 25, 26, and 27 show the results of allowing the maximum horizontal travel distance, the minimum exit door width, and the maximum discharge travel distance to vary.

Figure 25. Maximum Horizontal Distance vs. Dynamic Capacity.

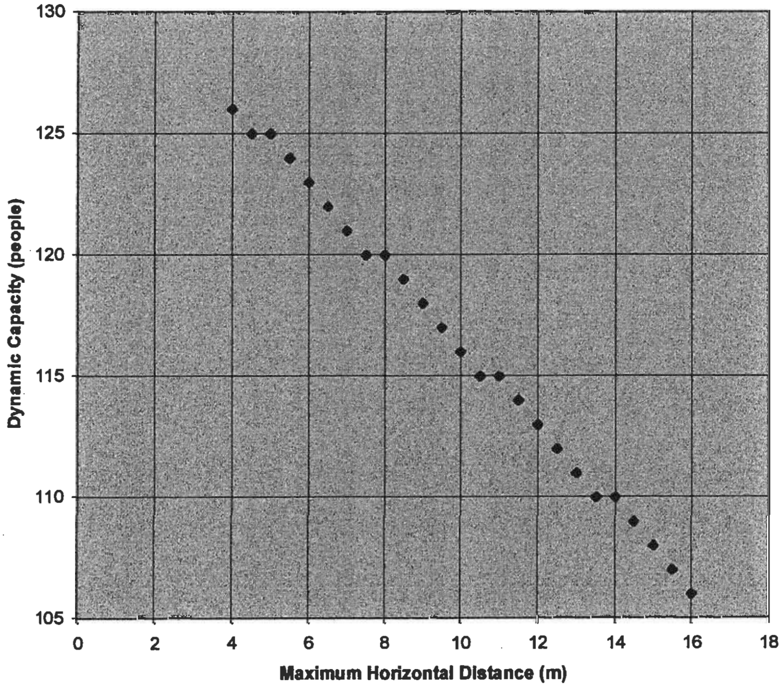


Figure 26. Minimum Exit Door Width vs. Dynamic Capacity.

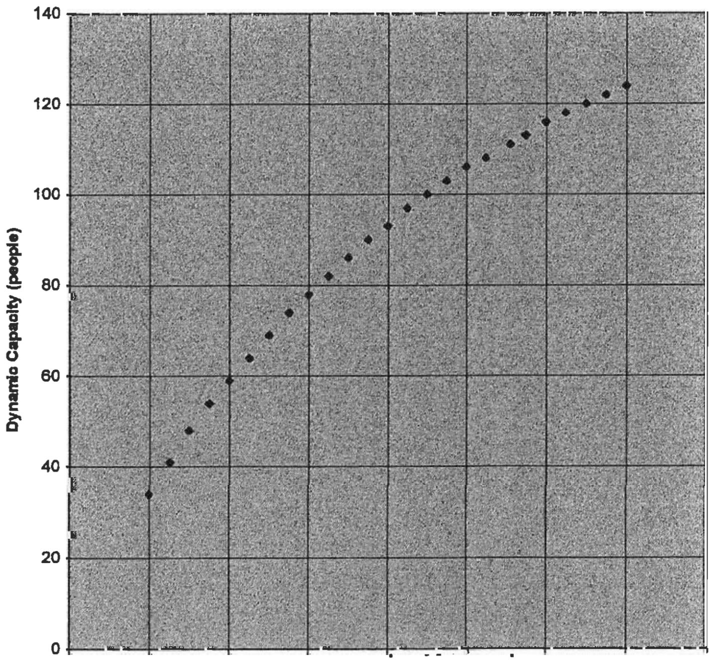
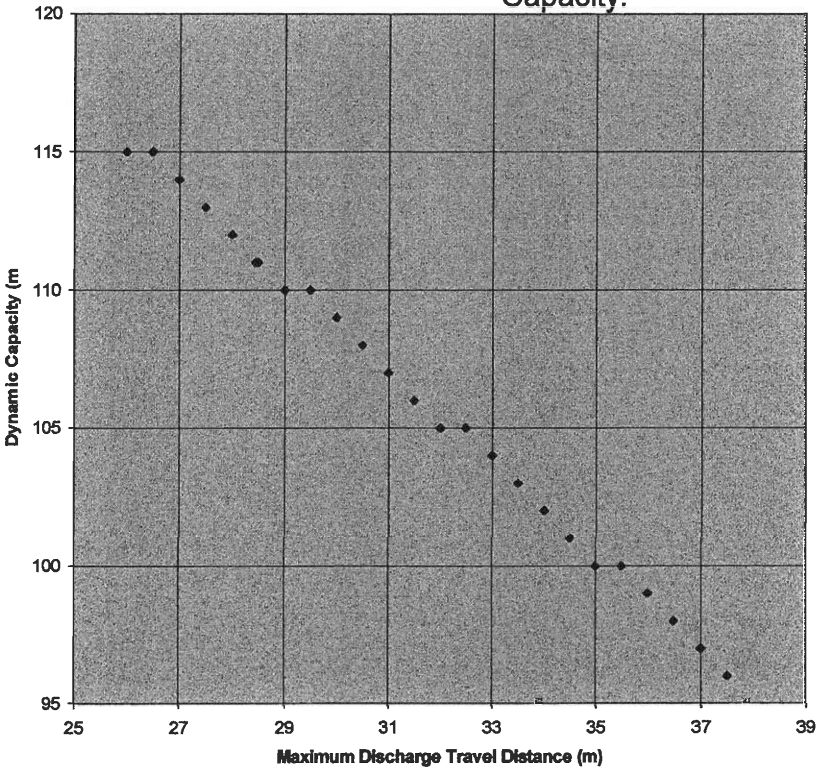


Figure 27. Maximum Discharge Travel Distance vs. Dynamic Capacity.



Increasing any travel distances decreases the dynamic capacity linearly. Increasing the door widths increases the dynamic capacity at the start, but as the widths got larger, the amount of change is not as great.

Next, the normal theoretical evacuation time was tested. Figures 28 through 31 show the results of allowing the maximum horizontal travel distance, the minimum exit door width, the maximum discharge travel distance, and the number of people in the zone to vary.

Figure 28. Maximum Horizontal Distance vs. Normal Theoretical Exit Time.

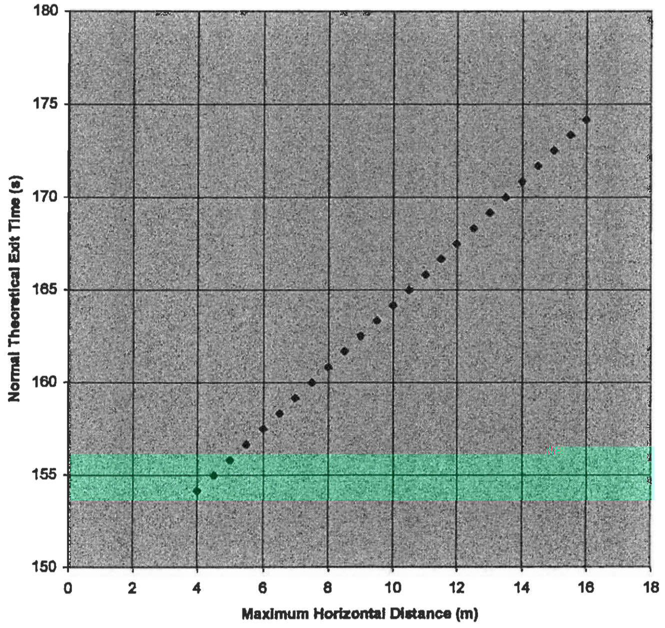
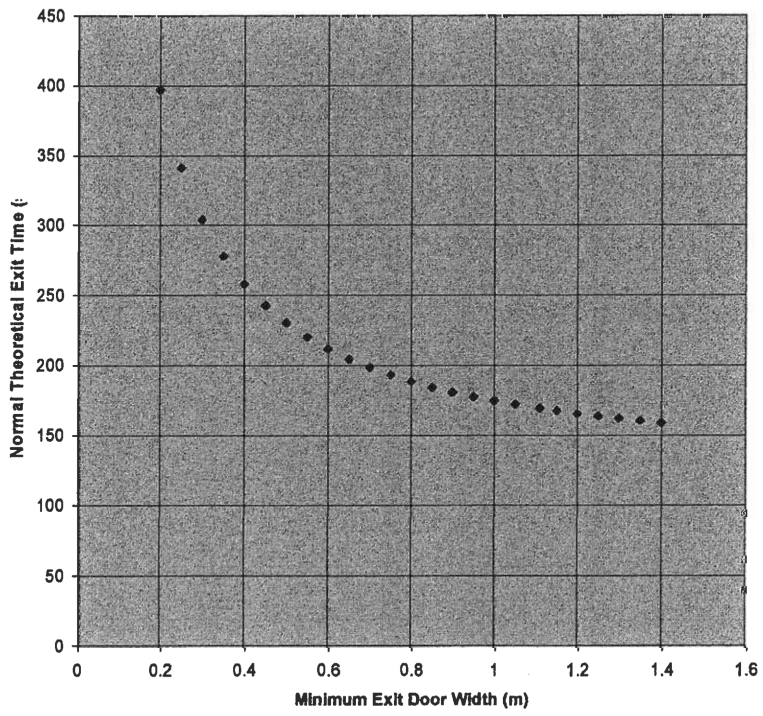


Figure 29. Minimum Exit Door Width vs. Normal Theoretical Exit Time.



Increasing any type of travel distance increases the normal theoretical exit time linearly. Increasing the door widths decreases the normal theoretical exit time at the start, but as the widths got larger, the amount of change is not as great. Increasing the number of people present in the area decreases the time linearly.

The minimum corridor width was not examined, because the value does not affect the equation unless the minimum exit door width is greater than the minimum corridor width. Also, the minimum exterior door width was not examined, because when modified, the minimum exterior door width would affect both equations in the same way as the minimum exit door width.

Improving only one value at a time did not remarkably change either the time or the dynamic capacity for the better. Therefore, in order to decrease the theoretical exit time and increase the dynamic capacity greatly, more than one value would have to be modified.

4.2.5 Analysis of the Theoretical Calculations

The calculations for theoretical times are used to acquire an estimate for evacuation times given the current physical features of the building for both normal and panic conditions. The panic condition times are always higher than the normal times, because it is assumed that there will be more confusion amongst people, thus taking them a longer time to evacuate safely. When any horizontal or vertical travel distance is increased, the theoretical time to evacuate is increased. When any door widths are shrunk, the theoretical time to evacuate is again increased. These conclusions correspond to what would be expected in real life.

The theoretical calculation presented in Section 2.21 of this report for static capacity used solely the area of the building and the occupancy load as defined in NFPA101. Therefore, because the occupancy load is considered a constant, the only way to increase the static capacity would be to increase the length or width of the building. The static capacity generally gives a large value for the theoretical capacity, because it does not account for wall thickness inside of the buildings. The static capacity is only concerned with the outer boundaries of the building.

As shown in Table 4 and Table 6, the theoretical calculation for dynamic capacity is not completely accurate. Extremely low values or negative numbers suggest highly that the travel distances are too long and/or the door and corridor widths are too small, not that the capacity for the building is as small as the theoretical result. The reason the theoretical dynamic capacity can be so tiny is because the fixed time, calculated as described in Section 2.20 of this report, has a low value. Therefore, with further testing, the fixed time equation may change thus making the dynamic capacity equation more accurate. The dynamic capacity equation does follow with the accepted notion that increased travel distances and decreased door and corridor widths decrease the dynamic capacity.

4.3 Impact

Training of staff and personnel in evacuation procedures is an integral part of a total exit system. Staff that is knowledgeable in proper procedure during emergencies helps to promote order, thus decreasing the chance of a chaotic situation. When people know where they are supposed to be and are directed by a leadership figure, evacuation proceeds in a more orderly way.

According to Roy Cedeño from the Department of Education for the Prevention of Fires, "it is not in the culture of Costa Rica to be concerned with the prevention of fire." Therefore, developing the idea of being concerned about fire safety involves changing a belief of the people in this culture. One way to do accomplish the change is to educate children. Currently, children in Costa Rica occasionally go to the local fire department to learn about fire safety. Through the education of children, information can be relayed to the parents in conversations provoked by questions like "what did you learn in school today?"

Our project group actively participated in the education process by conducting a fire drill in the school. This fire drill allowed the students, faculty, and administration to see directly how well they can evacuate.

In order to increase preparation and education, an active effort must be made to show that evacuating procedures and fire safety in terms of egress systems are important topics. Increasing the awareness of the people will help increase the preparation and education necessary to prevent the loss of life due to the inability to evacuate.

Chapter V. Conclusions and Recommendations

The checklist and its accompanying parts are to be used as a general checklist for inspecting buildings. The checklist was designed with documentation so that anyone, specifically the local firemen, will be able to perform inspections on hospitals and schools when we leave Costa Rica. Therefore, additional inspections on other schools and hospitals can be performed to acquire more data on the level of safety in these buildings. Data collected will further support the current data obtained to show that the level of fire safety in these buildings can be improved. By continuing inspections, more evidence can be found to further justify reasons to take action and increase the level of fire safety in these buildings.

After inspecting two hospitals and one school with the checklist created based on NFPA 101 and NFPA101a, our group developed a set of recommendations which we feel are realistic and have a good chance of getting implemented in the very near future. When making recommendations where money may be a concern, we must recommend those aspects that we feel can be realistically implemented with reasonable cost that can quickly give the most improvement. The five areas in which improvements could take place right away are as follows: sprinklers, alarm/smoke detectors, signs, clear obstacles, and hazards. Fixing or making improvements in all these areas will increase the efficiency of the evacuation process.

- Sprinklers: Sprinklers help protect people while they are waiting to exit. They will especially be of tremendous use in hospitals because of the "defend in place" strategy. A good sprinkler system will help enormously and will have relatively low cost since no alteration of the existing structure is necessary.

- Alarms/Smoke detectors: Detectors are of major importance. They are the first to signal danger. We recommend purchasing a proficient system. Depending on the make and model, the number and placement of pull stations and or detectors will vary. The alarms, when activated, should be connected to the local fire station. This will automatically notify the firefighters when there is an emergency and thus help in immediate response time and help prevent injury. In addition, the smoke detectors should be connected to the general fire alarm system so that immediate warning of a fire can be given if the fire occurs in a location where there are generally few people.

- Signs: Signs direct people to a safe place. It is necessary to purchase signs with arrows clearly showing the direction of the exit. Maps should also be placed throughout the hospital saying, "you are here. This is the way to the nearest exit". These kinds of indicators are very helpful when a person is in an unfamiliar setting.

- Obstacles: Remove obstacles from the egress system. Clearing all the obstacles away will not only help in creating a clear path of evacuation, but will also help in the everyday efficiency of the hospital. People will be able to maneuver with more ease and effectiveness.

- Hazards: Remove combustible hazards from the egress system. Removing these hazards prevents the possibility of rendering an exit useless during a fire. Also, the presence of hazards in the egress increases the chance that people will get affected by an explosion, because people will most likely be passing through these areas in order to escape from the building. Hazards should be stored in a separate temperature controlled room.

In the future, we recommend fixing the structural problems, which can be expensive. An implementation plan can be comprised to fix these problems in order of their urgency so that when funds become available, there can be swift movement in beginning the remodeling. We also recommend that action be taken to create plans on what to do in case of a fire emergency. Once these plans are created, they should be taught to the staff in both hospitals and schools and practiced so that everyone can be prepared for fire emergencies. Schools should also conduct more frequent fire drills so that the students also know how to evacuate from the building properly.

Our suggestions for improvements are only short term actions in response to the problems we observed. These short term actions, however, can lead to some in-depth research in others areas. Some areas we feel will benefit from future research are as follows: a fire logistics project, enhanced grades K-6 fire safety education programs, in service's, and implementation of laws. By studying fire logistics, specifically fire alarms, smoke detectors, and sprinkler systems, we can enhance both fire safety and egress systems which deserve attention. An education program for kindergarten through sixth grade would greatly enhance the community's awareness of fire safety issues. In-service training programs would also be helpful in preparing staff and personnel to react to different kinds of emergencies such as evacuation procedures and biohazards. Finally the implementation of laws mandating regular inspection of buildings and laws requiring that a set of building plans be approved in terms of fire safety before construction begins would greatly assist in improving fire protection as the country continues to develop.

As already mentioned, one way to increase the level of fire safety is enforce fire safety. The Cuerpo de Bomberos de Costa Rica is planning on integrating the checklist and its documentation into law as the first fire inspection procedural guide for schools and hospitals. As described in Section 2.24, they have the power and the capability to implement the checklist. Therefore, inspections and then repairs on the egress systems in buildings may become mandatory.

Enhancing fire protection not only will decrease the amount of money lost due to fire, but will also decrease the chance that people will be injured or killed from fire or smoke. By improving the different parts of the egress system and by continuing to study different aspects of fire prevention, we believe that the overall amount of fire safety throughout the entire country can increase greatly.

Appendix A. Company Information

The INS, or National Insurances Institute was created on October 30, 1924 by Minister of the House Tomas Soley Guell under President Ricardo Jimenez Oreamuno. This office set out to establish basic guidelines for handling accidents on the job, in the street, or at home. Today, the INS contains 11 agencies, 3 offices, and 21 dispatch locations throughout Costa Rica including Nicoya, Cartago, Limón, and Quepos.

The INS continues to strive to demonstrate their capacity to provide a strong infrastructure for social security. One of the ways they are achieving this is through a modernization process in all of structures to increase its ability to provide for the public. The modernization will improve administrative, technical, and human aspects through making the services available more easily and rapidly for the public (INS Guia Servicios 4-5).

The Costa Rican Fire Department, also known as El Cuerpo de Bomberos de Costa Rica, or bomberos for short, is one of the bodies of the INS. Before the Costa Rican Fire Department came into existence, the country was extremely vulnerable to all of the dangers a fire could induce. However, on July 27, 1865, after receiving a fire pump from the United States, the executive branch of the government approved the regulation of the first fire department in San José. In 1914, after receiving negative comments from a council member, the chiefs and 14 firefighters resigned. In 1917, the fire department eventually merged with the police department because of the lack of firefighters. In years to come, however, their skills would soon be needed.

medical emergencies, and other such emergencies that occur either regionally or nationally. With these functions, the bomberos are able to assess and investigate the risks of fire, make plans, have brigades for control and combat against fire (INS Guia Servicios 29).

Appendix B. On-Site Inspection Checklist Data in English

On the following pages, the actual data from the hospitals and school is presented using the English version of the checklist.

Fire Inspection Checklist

Building name: Hospital de la Annexión en Nicoya
Floor / zone: 1: patient waiting area
Occupancy classification: Heath care - assembly
Name of inspector: Tanya Theriault and Michael Sao Pedro
Date of inspection: 3-Jun-99

	Value	
0. MEASUREMENTS		
Number of stories in building	1	stories
Number of sublevels	0	sublevels
Number of people per floor	270	people
Width of floor	23.4	m
Length of floor	54	m
Occupancy Load	1.4	m^2 / per.
Maximum horizontal travel distance to nearest exit	39	m
Minimum exit door width	2.6	m
Width of corridor	2	m
Minimum stairway width	0	m
Vertical distance to bottom floor using stairs	0	m
Minimum width of the doors leading to the exterior	2.6	m
Horizontal travel distance of the path of discharge	28	m
Number of safety zones	0	zones
Measured total evacuation time		s

ILLUMINATION & CLARITY

[redacted]

Handrails provided and adequate			X	
Discharge arrangement adequate & clear			X	
7. EXIT DISCHARGES				
Lead to public ways		X		***Discharges do not necessarily lead a safe distance from the building. Re-entrance may also be needed***
Free of storage and debris		X		***Wheelbarrows and debris obstructed the exit a safe distance away from the building.***
Adequate lighting	X			
8. ALARM SYSTEM				
Alarm system present		X		***An alarm system was present, but is used also for earthquake evacuation procedures.***
Alarm system functional			X	***We were not allowed to test the alarm system.***
Alarm bells appropriately placed	X			
Alarm pull stations present and adequate		X		***There was only one pull station that was too high to be readily activated.***
Smoke detectors present		X		***There were no smoke detectors.***
Alarm systems activate correctly			X	***We were not allowed to test the alarm system.***
9. SAFETY ZONES				
Safety zones present		X		***Safety zones were not present.***
Adequate protection given			X	***Because there were no safety zones, this factor cannot be determined.***
10. SIGNS				
Show correct directions for locating exit	X			

[illegible]oretical Time – normal discharge distance	[illegible]	seconds
Theoretical Time – panic horizontal distance	[illegible]	seconds
Theoretical Time – panic vertical distance	0	seconds
Theoretical Time – panic discharge distance	127.[illegible]	seconds
Total Theoretical Evac. Time under normal circumstances	227.[illegible]	seconds
Total Theoretical E[illegible]nic circumstances	[illegible]	seconds
Total Fixed Time	180	seconds
Static Capacity	800	people

rooms

	Measured	Theoretic	Yes	No
Is the measured evacuation time less than or equal to the theoretical exit time under normal circumstances?	0	227.05		
Is the measured evacuation time less than or equal to the theoretical exit time under panic circumstances?	0	450.38		
Is the measured evacuation time less than or equal to the fixed time?	0	180		
Is the measured capacity less than or equal to the theoretical capacity?	270	140		X

Fire Inspection Checklist

Building name: Hospital de la Annexión en Nicoya
Floor / zone: 2: patient sleeping areas
Occupancy classification: Heath care
Name of inspector: Tanya Theriault and Michael Sao Pedro
Date of inspection: 3-Jun-99

	Value	
0. MEASUREMENTS		
Number of stories in building	1	stories
Number of sublevels	0	sublevels
Number of people per floor	200	people
Width of floor	72	m
Length of floor	45	m
Occupancy Load	11.1	m^2 / per.
Maximum horizontal travel distance to nearest exit	47	m
Minimum exit door width	1.2	m
Width of corridor	2	m
Minimum stairway width	0	m
Vertical distance to bottom floor using stairs	0	m
Minimum width of the doors leading to the exterior	1.15	m
Horizontal travel distance of the path of discharge	81.5	m
Number of safety zones	0	zones
Measured total evacuation time		s

Date of last alarm system inspection	none	

	Yes	No	Does not Apply	Comments
1. DOORS IN MEANS OF EGRESS				
Rules followed for locks on doors for rooms where people sleep	***X***			
Rules followed for locks on doors that are used in the means of egress	***X***			
2. EXIT DOORS				
Adequate number and location	***X***			
Adequate size	***X***			
Correct door hardware & swing	***X***			***The doors are not required to have a specific direction of swing, but must swing.***
Door, frame, and hardware serviceable	***X***			
Readily visible	***X***			
Opens easily	***X***			
Unobstructed	***X***			
Provides protection from fire		***X***		***The doors were made of thin wood.***
Provides protection from smoke		***X***		***The doors did not close completely to block out smoke.***
3. CORRIDORS				
Adequate width	***X***			
Unobstructed	***X***			

[redacted]

A. EXIT ILLUMINATION & CLARITY

Handrails provided and adequate			*X*	
Discharge arrangement adequate & clear			*X*	
7. EXIT DISCHARGES				
Lead to public ways		*X*		***Discharges do not necessarily lead a safe distance from the building. Re-entrance may also be needed***
Free of storage and debris		*X*		***Wheelbarrows and debris obstructed the exit a safe distance away from the building.***
Adequate lighting	*X*			
8. ALARM SYSTEM				
Alarm system present		*X*		***An alarm system was present, but is used also for earthquake evacuation procedures.***
Alarm system functional			*X*	***We were not allowed to test the alarm system.***
Alarm bells appropriately placed		*X*		***There were no alarm bells in some populated locations.***
Alarm pull stations present and adequate		*X*		***There was only one pull station that was too high to be readily activated.***
Smoke detectors present		*X*		***There were no smoke detectors.***
Alarm systems activate correctly			*X*	***We were not allowed to test the alarm system.***
9. SAFETY ZONES				
Safety zones present		*X*		***Safety zones were not present.***
Adequate protection given			*X*	***Because there were no safety zones, this factor cannot be determined.***
10. SIGNS				
Show correct directions for locating exit	*X*			

L OTHERS		
COMPARISON MEASURES		
Theoretical Time -- normal horizontal distance	170.22095	seconds
Theoretical Time -- normal vertical distance	0	seconds
Theoretical Time -- normal discharge distance	282.40188	seconds
Theoretical Time -- panic horizontal distance	327.63095	seconds
Theoretical Time -- panic vertical distance	0	seconds
Theoretical Time -- panic discharge distance	531.11690	seconds
Total Theoretical Exit Time under normal circumstances	400.89	seconds
Total Theoretical Exit Time under panic circumstances	551.71	seconds
Totals Fixed Time	180	seconds
Static Capacity	282	people
circumstances)	-37	people

	Measured	Theoretic	Yes	No
Is the measured evacuation time less than or equal to the theoretical exit time under normal circumstances?	0	403.38		
Is the measured evacuation time less than or equal to the theoretical exit time under panic circumstances?	0	831.71		
Is the measured evacuation time less than or equal to the fixed time?	0	180		
Is the measured capacity less than or equal to the theoretical capacity?	200	-37		*X*

Fire Inspection Checklist

Building name: Hospital Dr. Enrique Baltodano Briceño - Liberia
Floor / zone: 1: patient waiting area
Occupancy classification: Health care - assembly
Name of inspector: Tanya Theriault and Michael Sao Pedro
Date of inspection: 10-Jun-99

	Value	
0. MEASUREMENTS		
Number of stories in building	1	stories
Number of sublevels	0	sublevels
Number of people per floor	100	people
Width of floor	13	m
Length of floor	19.72	m
Occupancy Load	1.4	m^2 / per.
Maximum horizontal travel distance to nearest exit	13	m
Minimum exit door width	1.11	m
Width of corridor	2.32	m
Minimum stairway width	0	m
Vertical distance to bottom floor using stairs	0	m
Minimum width of the doors leading to the exterior	1.11	m
Horizontal travel distance of the path of discharge	28.44	m
Number of safety zones	0	zones
Measured total evacuation time		s

[redacted]

Staff Response

Adequate integrity of walls and doors	X			
No dead ends	X			
Smoke barriers present		X		*There were no smoke barriers.*
4. EXIT ILLUMINATION & CLARITY				
Adequate lighting level in all exits	X			
Signs illuminated		X		*There were no illuminated signs.*
Easily identifiable as an exit		X		*Some exits were not clearly marked, especially for discharges.*
Separate electrical circuit		X		*All lights are on the same electrical system.*
Emergency power system maintained and tested		X		*Emergency lights failed an operation test.*
5. FIRE DOORS				
Rating appropriate for location			X	*There were no fire doors.*
Door frame and hardware serviceable			X	
Closing and latching devices operational			X	
6. STAIRWAYS				
Adequate width			X	*Because the hospital was only at ground level, there were no stairs.*
Adequate integrity of walls & doors			X	
Venting arrangements adequate & serviceable			X	
Stair construction adequate			X	

[redacted]

TY ZONES

not be determined.

[redacted]

	Measured	Theoretic	Yes	No
Is the measured evacuation time less than or equal to the theoretical exit time under normal circumstances?	0	169.17		
Is the measured evacuation time less than or equal to the theoretical exit time under panic circumstances?	0	307.3		
Is the measured evacuation time less than or equal to the fixed time?	0	180		
Is the measured capacity less than or equal to the theoretical capacity?	100	111	*X*	

Fire Inspection Checklist

Building name: Hospital Dr. Enrique Baltodano Briceño - Liberia
Floor / zone: 2: patient sleeping areas
Occupancy classification: Health care
Name of inspector: Tanya Theriault and Michael Sao Pedro
Date of inspection: 10-Jun-99

	Value	
0. MEASUREMENTS		
Number of stories in building	1	stories
Number of sublevels	0	sublevels
Number of people per floor	500	people
Width of floor	108.84	m
Length of floor	74.21	m
Occupancy Load	11.1	m^2 / per.
Maximum horizontal travel distance to nearest exit	32.92	m
Minimum exit door width	0.76	m
Width of corridor	2.8	m
Minimum stairway width	0	m
Vertical distance to bottom floor using stairs	0	m
Minimum width of the doors leading to the exterior	0.69	m
Horizontal travel distance of the path of discharge	71.2	m
Number of safety zones	0	zones
Measured total evacuation time		s

Date of last alarm system inspection	None	

	Yes	No	Does not Apply	Comments
1. DOORS IN MEANS OF EGRESS				
Rules followed for locks on doors for rooms where people sleep	X			
Rules followed for locks on doors that are used in the means of egress		X		***Gates that were in the means of egress were locked with padlocks.***
2. EXIT DOORS				
Adequate number and location	X			
Adequate size	X			
Correct door hardware & swing	X			
Door, frame, and hardware serviceable	X			
Readily visible	X			
Opens easily	X			
Unobstructed		X		***The doors were blocked by multiple types of debris.***
Provides protection from fire		X		***The doors were made of wood.***
Provides protection from smoke		X		***The doors did not close tightly.***
3. CORRIDORS				
Adequate width	X			
Unobstructed		X		***There were benches, debris, and wheelchairs blocking corridors.***

[redacted]

[redacted]

Instructions regarding evacuation procedures		X		***There were no instructions regarding evacuation procedures.***
All signs clearly visible	X			
Provide both pictorial and verbal explanation	X			
Can be read from a given distance	X			
11. OTHER				
Area under protection from hazardous materials		X		***There were combustible materials near rooms and exits.***
Travel distances not exceeded		X		***The maximum travel distance allowed is 30m.***
Outside window or door present	X			

12. SPECIAL COMPARISON MEASURES		
Theoretical Time – normal horizontal distance	420.36374	seconds
Theoretical Time – normal vertical distance	0	seconds
Theoretical Time – normal discharge distance	521.24316	seconds
Theoretical Time – panic horizontal distance	530.09708	seconds
Theoretical Time – panic vertical distance	0	seconds
Theoretical Time – panic discharge distance	758.57649	seconds
Total Theoretical Exit Time under normal circumstances	941.61	seconds
Total Theoretical Exit Time under panic circumstances	1288.67	seconds
Total Fixed Time	180	seconds
Static Capacity	728	people
Dynamic Capacity (using normal circumstances)	5	people
Theoretical Capacity	5	people

	Measured	Theoretic	Yes	No
Is the measured evacuation time less than or equal to the theoretical exit time under normal circumstances?	0	941.61		
Is the measured evacuation time less than or equal to the theoretical exit time under panic circumstances?	0	1288.67		
Is the measured evacuation time less than or equal to the fixed time?	0	180		
Is the measured capacity less than or equal to the theoretical capacity?	500	5		*X*

Fire Inspection Checklist

Building name: Escuela San Jorge
Floor / zone: 1
Occupancy classification: educational
Name of inspector: Tanya Theriault and Michael Sao Pedro
Date of inspection: 29-Jun-99

	Value	
0. MEASUREMENTS		
Number of stories in building	1	stories
Number of sublevels	0	sublevels
Number of people per floor	20	people
Width of floor	9.91	m
Length of floor	44.14	m
Occupancy Load	1.9	m^2 / per.
Maximum horizontal travel distance to nearest exit	28	m
Minimum exit door width	0.8	m
Width of corridor	1.78	m
Minimum stairway width	0	m
Vertical distance to bottom floor using stairs	0	m
Minimum width of the doors leading to the exterior	1.73	m
Horizontal travel distance of the path of discharge	24.1	m
Number of safety zones	0	zones
Measured total evacuation time	281.44	s

Date of last alarm system inspection		

	Yes	No	Does not Apply	Comments
1. DOORS IN MEANS OF EGRESS				
Rules followed for locks on doors for rooms where people sleep			*X*	***Does not apply to schools.***
Rules followed for locks on doors that are used in the means of egress	*X*			
2. EXIT DOORS				
Adequate number and location	*X*			
Adequate size		*X*		***The required width is .81m. The door width in this case was .8m.***
Correct door hardware & swing		*X*		***The kindergarten room door was locked from the inside.***
Door, frame, and hardware serviceable	*X*			
Readily visible		*X*		***There were no signs indicating the location of an exit.***
Opens easily	*X*			
Unobstructed	*X*			
Provides protection from fire		*X*		***The doors were made of easily combustible wood.***
Provides protection from smoke	*X*			
3. CORRIDORS				
Adequate width		*X*		***The minimum width is 1.8m. The corridor width in this case was 1.78m.***
Unobstructed	*X*			

Adequate integrity of walls and doors		X		***The walls inside the building were made of wood.***
No dead ends	X			
Smoke barriers present		X		***Smoke barriers were not present.***
4. EXIT ILLUMINATION & CLARITY				
Adequate lighting level in all exits	X			
Signs illuminated			X	***There were no exit signs.***
Easily identifiable as an exit		X		***There were no signs that showed the direction of exit.***
Separate electrical circuit			X	***Because there was no emergency power system, this could not be determined.***
Emergency power system maintained and tested			X	***Because there was no emergency power system, this could not be determined.***
5. FIRE DOORS				
Rating appropriate for location			X	***There were no fire doors present.***
Door frame and hardware serviceable			X	
Closing and latching devices operational			X	
6. STAIRWAYS				
Adequate width			X	***The first floor did not have any stairways.***
Adequate integrity of walls & doors			X	
Venting arrangements adequate & serviceable			X	
Stair construction adequate			X	

Handrails provided and adequate			X	
Discharge arrangement adequate & clear			X	
7. EXIT DISCHARGES				
Lead to public ways	X			
Free of storage and debris	X			
Adequate lighting	X			
8. ALARM SYSTEM				
Alarm system present		X		***There was no fire alarm system, only bells to signal the passing between classes.***
Alarm system functional			X	***Because there was no fire alarm system, this could not be determined.***
Alarm bells appropriately placed			X	
Alarm pull stations present and adequate			X	
Smoke detectors present		X		***There were no smoke detectors.***
Alarm systems activate correctly			X	
9. SAFETY ZONES				
Safety zones present			X	***Safety zones are not required for schools.***
Adequate protection given			X	
10. SIGNS				
Show correct directions for locating exit			X	***There were no exit signs in the school.***

heoretical T... – normal horizontal distance		
Theoretical ...e – normal vertical distance		
heoretical Time – normal discharge distance	[illegible]	seconds
Theoretical Time – panic horizontal distance	[illegible]	seconds
Theoretical Time – panic vertical distance	0	seconds
Theoretical Time – panic discharge distance	[illegible]	seconds
Total Theoretical Exit Time under normal circumstances	107.14	seconds
Total Theoretical Exit ...es under panic circumstances	[illegible]	seconds
Total Fixed Time	180	seconds
Static Capacity	[illegible]	people
...under normal circumstances		

	Measured	Theoretic	Yes	No
Is the measured evacuation time less than or equal to the theoretical exit time under normal circumstances?	281.44	107.14		*X*
Is the measured evacuation time less than or equal to the theoretical exit time under panic circumstances?	281.44	280.81		*X*
Is the measured evacuation time less than or equal to the fixed time?	281.44	180		*X*
Is the measured capacity less than or equal to the theoretical capacity?	20	92	*X*	

Date of last alarm system inspection		

	Yes	*No*	*Does not Apply*	Comments
1. DOORS IN MEANS OF EGRESS				
Rules followed for locks on doors for rooms where people sleep			***X***	***Does not apply to schools.***
Rules followed for locks on doors that are used in the means of egress	***X***			
2. EXIT DOORS				
Adequate number and location	***X***			
Adequate size		***X***		***The required width is .81m. The door width in this case was .8m.***
Correct door hardware & swing	***X***			
Door, frame, and hardware serviceable	***X***			
Readily visible		***X***		***There were no signs indicating the location of an exit.***
Opens easily	***X***			
Unobstructed	***X***			
Provides protection from fire		***X***		***The doors were made of easily combustible wood.***
Provides protection from smoke	***X***			
3. CORRIDORS				
Adequate width		***X***		***The minimum width is 1.8m. The corridor width in this case was 1.00m. Also, classroom paths were too small.***
Unobstructed	***X***			

Adequate integrity of walls and doors		X		*The walls inside the building were made of wood.*
No dead ends	X			
Smoke barriers present		X		*Smoke barriers were not present.*
4. EXIT ILLUMINATION & CLARITY				
Adequate lighting level in all exits	X			
Signs illuminated			X	*There were no exit signs.*
Easily identifiable as an exit		X		*There were no signs that showed the direction of exit.*
Separate electrical circuit			X	*Because there was no emergency power system, this could not be determined.*
Emergency power system maintained and tested			X	*Because there was no emergency power system, this could not be determined.*
5. FIRE DOORS				
Rating appropriate for location			X	*There were no fire doors present.*
Door frame and hardware serviceable			X	
Closing and latching devices operational			X	
6. STAIRWAYS				
Adequate width		X		*The stairway width was .89m. The required width is a minimum of 1.12m.*
Adequate integrity of walls & doors		X		*The walls were made of wood and were painted.*
Venting arrangements adequate & serviceable			X	*Venting arrangements were not present.*
Stair construction adequate		X		*The handrails were shaky, and the stair heights were uneven.*

[redacted]

[illegible]	[illegible]	
Theoretical Time – normal discharge distance	[illegible]	seconds
Theoretical Time – plane horizontal distance	[illegible]	seconds
Theoretical Time – plane vertical distance	130.06730	seconds
Theoretical Time – plane discharge distance	193.27[illegible]	seconds
Total Theoretical Exit Time under normal circumstances	281	seconds
[illegible] circumstances	507	seconds
Total Plane Time	180	seconds
Static Capacity	27	
[illegible]	[illegible]	

	Measured	Theoretic	Yes	No
Is the measured evacuation time less than or equal to the theoretical exit time under normal circumstances?	281.44	341	X	
Is the measured evacuation time less than or equal to the theoretical exit time under panic circumstances?	281.44	503	X	
Is the measured evacuation time less than or equal to the fixed time?	281.44	180		X
Is the measured capacity less than or equal to the theoretical capacity?	155	57		X

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Instructions regarding evacuation procedures			X	
All signs clearly visible			X	
Provide both pictorial and verbal explanation			X	
Can be read from a given distance			X	
11. OTHER				
Area under protection from hazardous materials	X			
Travel distances not exceeded	X			
Outside window or door present		X		***There were no windows in the rooms located in the middle of the third floor.***

12. SPECIAL COMPARISON MEASURES		
Theoretical Time -- normal horizontal distance	79.444444	seconds
Theoretical Time -- normal vertical distance	75.852684	seconds
Theoretical Time -- normal discharge distance	66.499358	seconds
Theoretical Time -- panic horizontal distance	124.44444	seconds
Theoretical Time -- panic vertical distance	100.51935	seconds
Theoretical Time -- panic discharge distance	146.83269	seconds
Total Theoretical Exit Time under normal circumstances	221.8	seconds
Total Theoretical Exit Time under panic circumstances	371.8	seconds
Total Fixed Time	180	seconds
Static Capacity	137	people
Dynamic Capacity (using normal circumstances)	57	people
Theoretical Capacity	57	people

	Measured	Theoretic	Yes	No
Is the measured evacuation time less than or equal to the theoretical exit time under normal circumstances?	281.44	221.8		X
Is the measured evacuation time less than or equal to the theoretical exit time under panic circumstances?	281.44	371.8	X	
Is the measured evacuation time less than or equal to the fixed time?	281.44	180		X
Is the measured capacity less than or equal to the theoretical capacity?	82	57		X

Appendix C. On-Site Inspection Checklist Data in Spanish

En las páginas siguientes, se presenta toda la información obtenida de las inspecciones de los hospitales y la escuela usando el checklist en español.

4. La iluminación y la claridad de las puertas de salida				
Debe haber suficientes luces en todas las salidas	*X*			
Señales iluminadas		*X*		***No había señales iluminadas.***
La salida debe ser fácilmente identificable	*X*			
Circuito eléctrico separado		*X*		***Todos las luces eran activadas por el mismo sistema que no era separado.***
El sistema eléctrico de emergencia debe mantenerse y probarse		*X*		***El sistema de emergencia era peligroso.***
5. Puertas que dan protección contra el fuego				
Calificación apropiada para la ubicación			*X*	***No había puertas que dieran protección contra el fuego.***
Se puede reparar el marco y los componentes			*X*	
Los mecanismos de cierre y artefactos que cierran con picaporte deben estar en optimas condiciones de operación			*X*	
6. Las escaleras				
Anchura adecuada			*X*	***No había escalera porque no tenía pisos, solamente la planta baja.***
Integridad adecuada de paredes y puertas			*X*	
Mecanismos de ventilación adecuados y con buen mantenimiento			*X*	
Construcción adecuada de la escalera			*X*	
Pasamanos adecuados			*X*	
Ruta al lugar de seguridad adecuada y limpia			*X*	
7. Descarga de salidas				
Descargas que dirijen a lugares públicos		*X*		***No necesariamente dirijían a un lugar bastante fuera del edificio. Era posible que se necesitara que se ingresara nuevamente al edificio para poder evacuar.***
No debe haber ni almacenamiento ni escombros		*X*		***Había basura que bloqueaba la descarga.***
Iluminación adecuada	*X*			

[redacted]

[redacted]

[illegible]

e la [illegible] … [illegible] de cálc[illegible]

n as [illegible] … [illegible] circunstancias d[illegible] … periódic[illegible]

[illegible] y s[illegible]

del para

para [illegible]

[illegible] | [illegible] | [illegible]

Inspección de la seguridad de los edificios contra el fuego

Nombre del edificio: Hospital de la Anexión en Nicoya
El piso / la zona: 2: donde duermen los pacientes
Tipo de ocupación: hospital - asamblea
Nombre del inspector: Tanya Theriault y Michael Sao Pedro
Fecha de la inspección: 3-Jun-99

	número	
0. Medidas y variables		
Número de pisos en la construcción	1	pisos
Número de sótanos	0	sótanos
Número de personas en el piso	200	personas
Ancho del piso	72	m
Largo del piso	45	m
Carga de ocupación	11.1	m^2 / per.
Distancia horizontal máxima para evacuar por la salida más cercana	47	m
Anchura mínima de la puerta de salida	1.2	m
Anchura de pasillo	2	m
Anchura mínima de la escalera	0	m
Distancia vertical de escalera desde piso hasta la planta baja	0	m
Anchura mínima de la puerta al exterior	1.15	m
Distancia horizontal máxima para ir al lugar seguro al aire libre	81.5	m
Número de zonas de seguridad	0	zonas
Tiempo total medido de la evacuación		segundos

[illegible]

[redacted]

[redacted]

8. Sistema de alarma				
Existe un sistema de alarma		***X***		***Existía un sistema de alarma, pero también se usaba para señalizar terremotos.***
Funcionabilidad			***X***	***No podíamos hacer una prueba.***
El equipo de sonido de la alarma debe estar apropiadamente colocado		***X***		
Las estaciones adecuadas para sonar la alarma		***X***		***Había solamente una estación que no se podía usar fácilmente.***
Existencia de detectores de humo		***X***		***No había detectores de humo.***
Los sistemas del alarma deben activarse correctamente			***X***	***No podíamos hacer una prueba.***
9. Las zonas de seguridad				
Deben existir las zonas de seguridad		***X***		***No había zonas de seguridad***
Protección adecuada			***X***	***No se pudo determinar, porque no había zonas de seguridad.***
10. Las señales				
Existen instrucciones correctas para buscar una salida	***X***			
Existen instrucciones sobre procedimientos de evacuación		***X***		***No había instrucciones sobre procedimientos de evacuación.***
Se puede verlas fácilmente	***X***			
Tienen dibujos y descripciones verbales		***X***		***Las descripciones eran solamente verbales.***
Se puede leerlas desde una distancia adecuada	***X***			
11. Otros				
El área tiene protección contra materias peligrosas		***X***		***Había materias peligrosas en el sol cerca de los cuartos de mecánico.***
Las distancias de salir por los pasillos no deben estar excedidas		***X***		***Excedió el máximo de 30m.***
Debe existir una puerta o ventana al exterior	***X***			

12. Medidas para comparar	**Teórico**	

Tiempo teórico para la distancia horizontal en condiciones normales	170.9259	segundos
Tiempo teórico para la distancia vertical en condiciones normales	0	segundos
Tiempo teórico para ir al lugar seguro al aire libre en condiciones normales	232.4517	segundos
Tiempo teórico para la distancia horizontal en circunstancias de pánico	327.5926	segundos
Tiempo teórico para la distancia vertical en circunstancias de pánico	0	segundos
Tiempo teórico para ir al lugar seguro en circunstancias de pánico	504.1184	segundos
Tiempo teórico total para evacuar en condiciones normales	403.38	segundos
Tiempo teórico total para evacuar en circunstancias de pánico	831.71	segundos
Tiempo fijo	180	segundos
La capacidad estática	292	personas
La capacidad dinámica (usando condiciones normales)	-37	personas
La capacidad teórica	-37	personas

	Medido	**Teórico**	***Sí***	***No***
¿Es el tiempo medido para evacuar menor o igual que el tiempo teórico en condiciones normales?	0	403.38		
¿Es el tiempo medido para evacuar menor o igual que el tiempo teórico en circunstancias de pánico?	0	831.71		
¿Es el tiempo medido para evacuar menor o igual que el tiempo fijo?	0	180		
¿Es la medida del número de personas menor o igual que la capacidad teórica?	200	-37		***X***

Inspección de la seguridad de los edificios contra el fuego

Nombre del edificio: Hospital Dr. Enrique Baltodano Briceño - Liberia
El piso / la zona: 1: la sala de espera
Tipo de ocupación: hospital - asamblea
Nombre del inspector: Tanya Theriault y Michael Sao Pedro
Fecha de la inspección: 10-Jun-99

	número	
0. Medidas y variables		
Número de pisos en la construcción	1	pisos
Número de sótanos	0	sótanos
Número de personas en el piso	100	personas
Ancho del piso	13	m
Largo del piso	19.72	m
Carga de ocupación	1.4	m^2 / per.
Distancia horizontal máxima para evacuar por la salida más cercana	13	m
Anchura mínima de la puerta de salida	1.11	m
Anchura de pasillo	2.32	m
Anchura mínima de la escalera	0	m
Distancia vertical de escalera desde piso hasta la planta baja	0	m
Anchura mínima de la puerta al exterior	1.11	m
Distancia horizontal máxima para ir al lugar seguro al aire libre	28.44	m
Número de zonas de seguridad	0	zonas
Tiempo total medido de la evacuación		segundos
Fecha de la última inspección del sistema de alarma	ninguno	

	Sí	*No*	*No aplicable*	**Comentarios**
1. Las puertas en medios de salida				
Reglas a seguir para las cerraduras en habitaciones donde las personas duermen			*X*	***No había cuartos donde duerman los pacientes en la sala de espera.***
Reglas a seguir para las cerraduras en puertas que se usan en los medios de salida			*X*	
2. Puertas de salida				
Número y ubicación adecuados	*X*			
Tamaño adecuado	*X*			
Los componentes correctos de la puerta y el giro	*X*			
Se puede reparar la puerta, el marco, y los componentes	*X*			
Visibles	*X*			
Se abren fácilmente	*X*			
Nada bloquea la salida	*X*			
Da la protección adecuada contra el fuego		*X*		***Las puertas eran hechas de madera.***
Da la protección adecuada contra el humo		*X*		***Las puertas no cerraban completamente.***
3. Los pasillos				
Anchura adecuada	*X*			
Nada bloquea la salida	*X*			
La integridad adecuada de paredes y puertas	*X*			
Ningún pasillo sin salida	*X*			
Existencia de barreras contra humo		*X*		***No había barreras contra humo.***
4. La iluminación y la claridad de las puertas de salida				

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

ara la distancia vertical en condiciones normales	0	segundos
co para ir al lugar seguro al aire libre en condiciones normales	97.45005	segundos
Ti teórico la distancia horizontal en circunstancias de pánico	115.0501	segundos
distancia vertical en circunstancias de pánico	0	segundos
ir al lugar seguro en circunstancias de pánico	192.2501	segundos
N sa		
para evacuar en condiciones normales	169.17	segundos
a evacuar en circunstancias de pánico	307.3	segundos
84 co Tiempo fijo	180	segundos
La capacidad estática	184	personas
capacidad eó námica (usando condiciones normales)	111	personas
m La capacidad teórica	111	personas

	Medido	Teórico	Sí	No
S raido para evacuar menor o igual que el mpo teórico en condiciones normales?	0	169.17		
es d d po sa ido para evacuar menor o igual que el po teórico en circunstancias de pánico?	0	307.3		
es T ido para evacuar menor o igual que el tiempo fijo?	0	180		
9 a mero de personas menor o igual que la capacidad teórica?	100	111	*X*	

Inspección de la seguridad de los edificios contra el fuego

Nombre del edificio: Hospital Dr. Enrique Baltodano Briceño - Liberia
El piso / la zona: 2: donde duermen los pacientes
Tipo de ocupación: Hospital Dr. Enrique Baltodano Briceño - Liberia
Nombre del inspector: Tanya Theriault y Michael Sao Pedro
Fecha de la inspección: 10-Jun-99

	número	
0. Medidas y variables		
Número de pisos en la construcción	1	pisos
Número de sótanos	0	sótanos
Número de personas en el piso	500	personas
Ancho del piso	108.84	m
Largo del piso	74.21	m
Carga de ocupación	11.1	m^2 / per.
Distancia horizontal máxima para evacuar por la salida más cercana	32.92	m
Anchura mínima de la puerta de salida	0.76	m
Anchura de pasillo	2.8	m
Anchura mínima de la escalera	0	m
Distancia vertical de escalera desde piso hasta la planta baja	0	m
Anchura mínima de la puerta al exterior	0.69	m
Distancia horizontal máxima para ir al lugar seguro al aire libre	71.2	m
Número de zonas de seguridad	0	zonas
Tiempo total medido de la evacuación		segundos

[illegible]

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[redacted]

[redacted] [redacted] [redacted]

[redacted]

Tiempo teórico para la distancia horizontal en condiciones normales	420.3637	segundos
Tiempo teórico para la distancia vertical en condiciones normales	0	segundos
Tiempo teórico para ir al lugar seguro al aire libre en condiciones normales	521.2432	segundos
Tiempo teórico para la distancia horizontal en circunstancias de pánico	530.0971	segundos
Tiempo teórico para la distancia vertical en circunstancias de pánico	0	segundos
Tiempo teórico para ir al lugar seguro en circunstancias de pánico	758.5765	segundos
Tiempo teórico total para evacuar en condiciones normales	941.61	segundos
Tiempo teórico total para evacuar en circunstancias de pánico	1288.67	segundos
Tiempo fijo	180	segundos
La capacidad estática	728	personas
La capacidad dinámica (usando condiciones normales)	5	personas
La capacidad teórica	5	personas

	Medido	**Teórico**	***Sí***	***No***
¿Es el tiempo medido para evacuar menor o igual que el tiempo teórico en condiciones normales?	0	941.61		
¿Es el tiempo medido para evacuar menor o igual que el tiempo teórico en circunstancias de pánico?	0	1288.67		
¿Es el tiempo medido para evacuar menor o igual que el tiempo fijo?	0	180		
¿Es la medida del número de personas menor o igual que la capacidad teórica?	500	5		***X***

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[illegible]

[redacted]

[redacted] [illegible]

[redacted]

8. Sistema de alarma				
Existe un sistema de alarma		*X*		***No había un sistema de alarma.***
Funcionabilidad			*X*	***No se podía determinar, porque no había un sistema de alarma.***
El equipo de sonido de la alarma debe estar apropiadamente colocado			*X*	
Las estaciones adecuadas para sonar la alarma			*X*	
Existencia de detectores de humo		*X*		***No había detectores de humo.***
Los sistemas del alarma deben activarse correctamente			*X*	
9. Las zonas de seguridad				
Deben existir las zonas de seguridad			*X*	***No se requiere las zonas de seguridad en las escuelas.***
Protección adecuada			*X*	
10. Las señales				
Existen instrucciones correctas para buscar una salida			*X*	***No había señales que demostrara la salida.***
Existen instrucciones sobre procedimientos de evacuación			*X*	
Se puede verlas fácilmente			*X*	
Tienen dibujos y descripciones verbales			*X*	
Se puede leerlas desde una distancia adecuada			*X*	
11. Otros				
El área tiene protección contra materias peligrosas	*X*			
Las distancias de salir por los pasillos no deben estar excedidas		*X*		***El primer grado estaba colocado un piso más que la planta baja. La distancia horizontal excedió el máximo de 23m.***
Debe existir una puerta o ventana al exterior		*X*		***No había ventanas al exterior en las aulas en el centro del piso.***

12. Medidas para comparar	**Teórico**	

Inspección de la seguridad de los edificios contra el fuego

Nombre del edificio: Escuela San Jorge
El piso / la zona: 3
Tipo de ocupación: educativo
Nombre del inspector: Tanya Theriault y Michael Sao Pedro
Fecha de la inspección: 29-Jun-99

	número	
0. Medidas y variables		
Número de pisos en la construcción	3	pisos
Número de sótanos	0	sótanos
Número de personas en el piso	82	personas
Ancho del piso	11.3	m
Largo del piso	22.9	m
Carga de ocupación	1.9	m^2 / per.
Distancia horizontal máxima para evacuar por la salida más cercana	13.5	m
Anchura mínima de la puerta de salida	0.8	m
Anchura de pasillo	1.37	m
Anchura mínima de la escalera	0.89	m
Distancia vertical de escalera desde piso hasta la planta baja	7.4	m
Anchura mínima de la puerta al exterior	1.73	m
Distancia horizontal máxima para ir al lugar seguro al aire libre	24.1	m
Número de zonas de seguridad	0	zonas
Tiempo total medido de la evacuación	281.44	segundos

Fecha de la última inspección del sistema de alarma		

	Sí	No	No aplicable	Comentarios
1. Las puertas en medios de salida				
Reglas a seguir para las cerraduras en habitaciones donde las personas duermen			X	***No es aplicable para escuelas.***
Reglas a seguir para las cerraduras en puertas que se usan en los medios de salida	X			
2. Puertas de salida				
Número y ubicación adecuados	X			
Tamaño adecuado		X		***El ancho requirido es 0,81m. En este caso era 0,8m.***
Los componentes correctos de la puerta y el giro	X			
Se puede reparar la puerta, el marco, y los componentes	X			
Visibles		X		***No había señales de salida.***
Se abren fácilmente	X			
Nada bloquea la salida	X			
Da la protección adecuada contra el fuego		X		***Las puertas eran hechas de madera combustible.***
Da la protección adecuada contra el humo	X			
3. Los pasillos				
Anchura adecuada		X		***El ancho mínimo es 1,8m. El del pasillo era 1,37m.***
Nada bloquea la salida	X			
La integridad adecuada de paredes y puertas		X		***Las paredes en el edifico eran hechas de madera.***
Ningún pasillo sin salida	X			
Existencia de barreras contra humo		X		***No había barreras contra el humo.***

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Appendix D. Checklist Item Descriptions in English

Instructions on how to use the checklist for existing hospitals

I. Introduction

- Each element in the checklist must comply with each of the information points listed under each heading. Some of these rules have noted exceptions or additional rules.
- Any time "no" is checked in, attempt to make a comment stating where and why that part did not pass.
- Occupancy load for health care
    - 11.1 sq. m per person in health care sleeping departments
    - 22.3 sq. m of gross floor area per person of inpatient health care treatment departments.
    - 1.4 sq. m per person for waiting areas.

II. Doors in Means of Egress

1. Rules followed for locks on doors for rooms where people sleep
    - Locks cannot be placed on patient sleeping rooms unless:
        - The door is only locked from the corridor side and can be opened by the staff.
        - The clinical needs of the patients require specialized security measures for their safety, provided the keys are carried by staff at all times.
2. Rules followed for locking on doors that are used in the means of egress
    - Doors not in a required means of egress shall be permitted to be subject to locking.
    - Doors within a required means of egress cannot have a latch or lock that requires the use of a tool or key from the egress side unless:
        - The clinical needs of the patients require specialized security measures for their safety, provided staff can readily unlock such doors at all times.
        - Delayed egress locks shall be permitted, provided not more than one such device is located in any egress path.
        - Access-controlled egress doors shall be permitted.
        - Reliable means of unlocking them such as a remote-control unlocking devices, or by having the staff carry all keys to unlock doors at all times is permitted providing only one locking device will be permitted on each door.

III. Exit Doors

1. Adequate number and location
    - Exits should be located at opposite ends of the building, and in cases where the floor is extremely large, in between edges of the building
    - There should be no dead ends, or locations where there is no possible exit from a point in the building.
    - At least 2 exits should be available from every floor

2. Adequate size
   - minimum of 81cm clear for every exit door

3. Correct door hardware and swing
   - Exit doors are <u>not</u> required to have a specific direction of swing.
   - Doors are to be constructed such that they swing

4. Door, frame, and hardware serviceable
   - Can the door easily be fixed if it becomes broken
   - Hinges can easily be fixed

5. Readily visible
   - All means of egress should be marked with an approved sign readily visible from any direction of exit access.
   - The signs should be easily distinguishable by color and should contrast any other furniture or designs.

6. Opens easily
   - The way of opening the door is easily and readily known

7. Unobstructed
   - There are no foreign materials blocking the exit way.

8. Provides protection from fire
   - Door is not flammable
   - Door is made of material that can resist heat

9. Provides adequate protection from smoke
   - The door closes tightly to prevent smoke from entering

IV. Corridors

1. Adequate width
   - 122 cm for areas where patients sleep.
   - 112 cm for any other area.

2. Unobstructed
   - There are no foreign materials blocking the exit way.

3. Adequate integrity of walls and doors
   - Exit corridors are not made of material that is easily flammable.

4. No dead ends

- Every corridor has some means of exit at the end. A person should not have the ability to be lead to a place where no exits are located and thus must turn back the way they came.

5. Smoke barriers present
   - Smoke barriers where required by specific occupancies should be continuous from outside wall to wall, floor to floor, smoke barrier to smoke barrier, or a combination of these. Continuity should be made throughout all concealed and interstitial spaces.

V. Exit Illumination and Clarity

1. Adequate lighting level in all exits
   - Illumination should continue throughout the entire exiting process.
   - It is required that there be at least a 1 ft-candela (10 lux) of illumination at floor level in all three elements of a means of egress: the exit corridor, the exit staircase, and the exit discharge.
   - Lighting should be arranged that the failure of any single light does not leave the area in total darkness. All lights, circuits, or auxiliary power must be arranged to ensure continuity of egress lighting.
   - Sources of illumination should be reliable. It is not wise to depend on battery operated systems or other types of portable lamps or lanterns, which also should not be used as a primary source of illumination. Battery-operated electric lights can be used as a source of emergency lighting though.
2. Signs illuminated
   - Are the signs illuminated
3. Easily identifiable as an exit
   - Exits should be designated by an approved sign readily visible form any direction of exit access.
   - Sign placement should be such that no point in the exit access corridor is more than 30m from the nearest sign, unless:
     - In existing buildings.
   - All signs are required to stay continuously illuminated except they may be permitted to flash on and off upon activation of the fire alarm system.
   - A directional sign reading EXIT should be placed in all locations where the direction of travel to the nearest exit is not obvious.
4. Separate electrical circuit
   - Emergency power should be connected by a different set of circuits in the case of a circuit failure

5. Emergency power system maintained and tested
   - A functional test should be conducted on every required battery-powered emergency lighting system at 30 day intervals for a minimum of 30 seconds and annually for a duration of an hour and a half. The equipment must be fully functional for the entire duration of the test.

VI. Fire Doors

1. Rating appropriate for location
   - Ratings must be in accordance with NFPA 80-fire doors and fire windows
   - Walls have a resistance rating of 30min
   - Doors have a resistance rating of 20min

2. Door frame and hardware serviceable
   - Can the door easily be fixed if it becomes broken
   - Hinges can easily be fixed

3. Closing and latching devices operational

VII. Stairways

1. Adequate width
   - Minimum width clear of all obstructions, except projections not more than 8.9cm at or below handrail height on each side is 112cm.
2. Adequate integrity of walls & doors
   - Resistance ratings of walls and doors should be in accordance with Fire Resistance ratings. Interior finish shall be of correct classification

3. Venting arrangements adequate & serviceable
   - Ventilating systems shall be of working order to initiate the smoke alarm

4. Stair construction adequate
   - All stairs serving as required means of egress shall be of permanent, noncombustible fixed construction.
   - Stairs and intermediate landings shall continue with no decrease in width along the direction of egress travel.
   - Stair treads and landings shall be solid, uniformly slip resistant, and free of projections that could trip stair users. If not vertical, risers shall be permitted to slope under the tread at an angle of no more than 30 degrees from the vertical, however the permitted projection of the nosing shall not be more than 3.8cm.
   - Means of egress that are more than 76cm above the floor shall be provided with guards to prevent falls over the open side.

5. Handrails provided and adequate
   - Required guards and handrails shall continue for the full length of each flight of stairs.
   - At turns of stairs, inside handrails shall be continuous between flights at landings unless:
     - On existing stairs, handrails shall not be required to be continuous between flights of stairs at landings.
   - Handrails are within 76cm of all portions of the required egress width of stairs. The required egress width shall be along the natural path of travel. Exceptions:

a. On existing stairs, handrails shall be provided within 112cm of all portions of the required egress width of stairs
b. If part of a curb separating a sidewalk from a vehicular way, a single step or a ramp shall not be required to have a handrail.
c. Existing stairs, existing ramps, stairs within dwelling units and within guest rooms, and ramps within dwelling units and guest rooms shall have a handrail on at least one side.

6. Discharge arrangement adequate & clear
   - Make sure the discharge area is free of any obstacles that could impede exiting

VIII. Exit Discharges

1. Lead to public ways
   - The exit discharge leads a person a safe distance away from the building.
2. Free of storage and debris
   - There is no garbage or other material that blocks the exit discharge.
3. Adequate lighting
   - Illumination need only be provided outside a building in enough to lead the occupants to either a public way or a distance away from the building that is considered safe.

IX. Alarm System

1. Alarm system present
   - Does the building have some form of alarm signal that produces some form of warning, either through a distinctive noise or message.

2. Alarm system functional
   - Does the alarm system work

3. Alarm bells appropriately placed
   - Can the alarms be readily heard

4. Alarm pull stations present and adequate
   - Pull stations are required and location of them has some exceptions:
     - Fire alarm pull stations in patient sleeping area are not required at exits if they are located at all nurses' control stations or other continuously attended staff locations, provided the pull stations are visible and continuously accessible.
     - Pull station present in the natural exit access path near each required exit from an area
     - Additional fire alarm stations cannot be more than 60m apart from each other on the same floor
   - Detection system must also be able to activate the alarm

5. Smoke detectors present
   - Automatic smoke detection system is required in all corridors unless:

- Where each patient sleeping room has a smoke detector on a system, and a smoke detector is provided at smoke barriers and horizontal exits
- Smoke compartments protected throughout by an approved, supervised automatic sprinkler system

6. Alarm systems activate correctly
   - Do the pull stations work
   - Do the smoke detectors work

X. Safety Zones

1. Safety Zones present
   - The rooms must have a higher resistance rating than normal.

2. Adequate protection given
   - Patients that cannot leave their room because of serious conditions must be heavily protected from fire.

XI. Signs

1. Show correct directions for locating an exit
   - Exits are placed above every doorway including the final door leading to the stairs and/or the exit discharge.

2. Instructions regarding evacuation procedures
   - Every room contains the directions to the nearest exit and what to do in case there is a fire or the alarm sounds.

3. All signs clearly visible
   - Instructions in rooms showing where to go in case of a fire readily seen.

4. Both pictoral and verbal explanation
   - Diagram and verbal description given to describe the exiting process

5. Can be read from a given distance
   - Signs shall be able to be read from the given distance of 30m

XII. Other

1. Area under protection from hazardous material
   - Patients not placed near highly combustible materials

2. Travel distances not exceeded
   - The travel distance between any room door required as an exit access and an exit is not greater than 30m
   - The travel distance between any point in a room and an exit is not greater than 45m

- If the building is protected throughout by an approved sprinkler system, both of the requirements above increase by 15m.

3. Outside door or window present
   - All patient sleeping rooms are required to have an outside door or window

Instructions on how to use the checklist for existing schools

I. Introduction
- Each element in the checklist must comply with each of the information points listed under each heading. Some of these rules have noted exceptions or additional rules.
- Any time "no" is checked in, attempt to make a comment stating where and why that part did not pass.
- Occupancy load for educational facilities
  - 1.9 net sq. m per person for classrooms.
  - 4.6 net sq. m per person for laboratories, shops, and similar vocational rooms.

II. Doors in Means of Egress

1. Rules followed for locks on doors for rooms where people sleep
   - Not applicable for schools

2. Rules followed for locking on doors that are used in the means of egress
   - Doors not in a required means of egress shall be permitted to be subject to locking.
   - Doors may be locked only if they can always be opened from the egress side.

III. Exit Doors

1. Adequate number and location
   - Exits should be located at opposite ends of the building, and in cases where the floor is extremely large, in between edges of the building
   - There should be no dead ends, or locations where there is no possible exit from a point in the building.
   - At least 2 exits should be available from every floor

2. Adequate size
   - minimum of 81cm clear for every exit door

3. Correct door hardware and swing
   - Exit doors are <u>not</u> required to have a specific direction of swing.
   - Doors are to be constructed such that they swing

4. Door, frame, and hardware serviceable
   - Can the door easily be fixed if it becomes broken
   - Hinges can easily be fixed

5. Readily visible
   - All means of egress should be marked with an approved sign readily visible from any direction of exit access.

- The signs should be easily distinguishable by color and should contrast any other furniture or designs.

6. Opens easily
   - The way of opening the door is easily and readily known

7. Unobstructed
   - There are no foreign materials blocking the exit way.

8. Provides protection from fire
   - Door is not flammable
   - Door is made of material that can resist heat

9. Provides adequate protection from smoke
   - The door closes tightly to prevent smoke from entering

IV. Corridors

1. Adequate width
   - 1.8m minimum width
   - Drinking fountains or other equipment, fixed or movable, cannot be placed to obstruct this minimum requirement of 1.8m.
   - If there are more than 60 seats in a classroom, every aisle must be at least 91cm if there are seats on one side and at least 107cm if there are seats on both sides.
   - If there are less than or equal to 60 seats in a classroom, aisles will not be less than 76cm.

2. Adequate integrity of walls and doors
   - Exit corridors are not made of material that is easily flammable.

3. No dead ends
   - Every corridor has some means of exit at the end. A person should not have the ability to be lead to a place where no exits are located and thus must turn back the way they came.

4. Smoke barriers present
   - Smoke barriers where required by specific occupancies should be continuous from outside wall to wall, floor to floor, smoke barrier to smoke barrier, or a combination of these. Continuity should be made throughout all concealed and interstitial spaces.

V. Exit Illumination and Clarity

1. Adequate lighting level in all exits
   - Illumination should continue throughout the entire exiting process.

- Minimum width is clear of all obstructions, except projections not more than 8.9cm at or below handrail height on each side is 112cm.

2. Adequate integrity of walls & doors
   - Resistance ratings of walls and doors should be in accordance with Fire Resistance ratings. Interior finish shall be of correct classification

3. Venting arrangements adequate & serviceable
   - Ventilating systems shall be of working order to initiate the smoke alarm

4. Stair construction adequate
   - All stairs serving as required means of egress shall be of permanent, noncombustible fixed construction.
   - Stairs and intermediate landings shall continue with no decrease in width along the direction of egress travel.
   - Stair treads and landings shall be solid, uniformly slip resistant, and free of projections or lips that could trip stair users. If not vertical, risers shall be permitted to slope under the tread at an angle of no more than 30 degrees from the vertical, however the permitted projection of the nosing shall not be more than 3.8cm.
   - Means of egress that are more than 76cm above the floor or grade below shall be provided with guards to prevent falls over the open side.

5. Handrails provided and adequate
   - Required guards and handrails shall continue for the full length of each flight of stairs.
   - At turns of stairs, inside handrails shall be continuous between flights at landings unless:
     - On existing stairs, handrails shall not be required to be continuous between flights of stairs at landings.
   - Handrails are within 76cm of all portions of the required egress width of stairs. The required egress width shall be along the natural path of travel. Exceptions:
     a. On existing stairs, handrails shall be provided within 112cm of all portions of the required egress width of stairs
     b. If part of a curb separating a sidewalk from a vehicular way, a single step or a ramp shall not be required to have a handrail.
     c. Existing stairs, existing ramps, stairs within dwelling units and within guest rooms, and ramps within dwelling units and guest rooms shall have a handrail on at least one side.

6. Discharge arrangement adequate & clear
   - Make sure the discharge area is free of any obstacles that could impede exiting

VIII. Exit Discharges

1. Lead to public ways
   - The exit discharge leads a person a safe distance away from the building.

- Every room used for educational purposes or student occupancy below the floor of exit discharge must have access to at least one exit that leads directly to the exterior at level of discharge without entering the floor above.

2. Free of storage and debris
   - There is no garbage or other material that blocks the exit discharge.
3. Adequate lighting
   - Illumination need only be provided outside a building in enough to lead the occupants to either a public way or a distance away from the building that is considered safe.

IX. Alarm System

1. Alarm system present
   - Does the building have some form of alarm signal that produces some form of warning, either through a distinctive noise or message.

2. Alarm system functional
   - Does the alarm system work

3. Alarm system appropriately placed
   - Can the alarms be readily heard

4. Alarm pull stations present and adequate
   - Pull stations are required and location of them has some exceptions:
   - Pull station present in the natural exit access path near each required exit from an area
   - Additional fire alarm stations cannot be more than 60m apart from each other on the same floor
   - Detection system must also be able to activate the alarm

5. Smoke detectors present
   - Automatic smoke detection system is required in all corridors unless:
     - Where each patient sleeping room has a smoke detector on a system, and a smoke detector is provided at smoke barriers and horizontal exits
     - Smoke compartments protected throughout by an approved, supervised automatic sprinkler system

6. Alarm systems activate correctly
   - Do the pull stations work
   - Do the smoke detectors work

X. Safety Zones

Not applicable for educational occupancies

1. Safety Zones present
2. Adequate protection given

XI. Signs

1. Show correct directions for locating an exit
   - Exit are placed above every doorway including the final door leading to the stairs and/or the exit discharge.

2. Instructions regarding evacuation procedures
   - Every room contains the directions to the nearest exit and what to do in case there is a fire or the alarm sounds.
3. All signs clearly visible
   - Instructions in rooms showing where to go in case of a fire readily seen

4. Both pictoral and verbal explanation
   - Diagram and verbal description given to describe the exiting process

5. Can be read from a given distance
   - The signs can be read from a given distance of 30m

XII. Other

1. Area under protection from hazardous material
   - Occupants not placed near highly combustible materials

2. Travel distances not exceeded
   - Common paths of travel cannot exceed 23m.
   - The travel distance between any point in a room and an exit is not greater than 45m
   - If the building is protected throughout by an approved sprinkler system, both of the requirements above increase by 15m.
   - Kindergarten and 1st grade must be on the same floor as the exit to the outside of the building. 2nd grade is not allowed to be more than one floor above the floor level with the exit to the outside.

3. Outside door or window present
   - Any room or space greater than 23.2 sq m used for classroom or other educational purposes must have at least one outside window for emergency rescue and ventilation, unless:
     - The building has an approved sprinkler system
     - The room or space has a door leading directly to the outside of the building

Appendix E. Checklist Item Descriptions in Spanish

El checklist para hospitales ya existentes.

I. Introducción

- Cada elemento en la lista de verificación tiene que satisfacer cada punto de información listado bajo cada título. Algunas de estas reglas tienen excepciones o reglas adicionales.
- Cuando se escoge "no" para un item, por favor trate de escribir un comentario sobre el lugar y la razón por qué está mal.
- Escoga uno para la carga de ocupación
    - 11.1 m cuadrados por persona donde duermen los pacientes.
    - 22.3 m cuadrados de piso por persona en departamentos de tratamiento de pacientes.
    - 1.4 m cuadrados de piso por persona en lugares donde esperan las personas.

II. Las puertas en medios de salida

1. Reglas a seguir para las cerraduras en habitaciones donde las personas duermen
    - Las cerraduras no se pueden colocar en habitaciones donde los pacientes duermen a menos que:
        - La puerta sólo se cierre del lado del pasillo y pueda ser abierta por el personal.
        - Cuando las necesidades clínicas de los pacientes requieran de medidas de seguridad especializada por su seguridad, las llaves deberan estar disponibles y llevadas siempre por el personal.

2. Reglas a seguir para las cerraduras en puertas que se usan en los medios de salida
    - Se permite que las puertas que no se usan en medios de salida estén cerradas.
    - Puertas dentro de medios de salida requeridas no pueden tener un picaporte ni cerradura que requiera el uso de una herramienta o una llave del lado de la salida a menos que:
        - Las necesidades clincas de los pacientes requieran de medidas de seguridad especializada por su seguridad, y el personal siempre pueda abrir fácilmente tales puertas.
        - Las salidas con cerradura de retardo se permitirán siempre y cuando no haya más que solo un artefacto localizado en cualquier pasillo de salida.
        - Hayan puertas controladas del acceso en el medio de salida.
        - Hayan puertas con solamente una cerradura que abra por telecontrol.
        - Hayan puertas con solamente una cerradura en cuales todo el personal siempre llevan las llaves.

III. Puertas de salida

1. Número y ubicación adecuadas

- Las salidas están localizadas en lados opuestos de cada piso en el edificio. Cuando el piso sea extremadamente grande, estarán localizadas en el medio de los pasillos grandes del edificio.
- No debe haber pasillo sin salida.
- Necesita al menos 2 salidas disponibles para cada piso.

2. Tamaño adecuado
    - La anchura es al mínimo 81 cm para cada puerta de salida.

3. Los componentes correctos de la puerta y el giro
    - Las puertas tienen que girar, pero no en una dirección específica.

4. Se pueden reparar la puerta, el marco, y los componentes
    - Se puede reparar la puerta fácilmente.
    - Se pueden reparar las bisagras fácilmente.

5. Visibles
    - Todos los medios de salida necesitan una señal aprobada visible desde cualquier dirección del acceso.
    - Las señales son fácilmente distinguibles por el color y contrastan otros muebles o diseños.

6. Se abren fácilmente
    - La manera de abrir la puerta es fácilmente y prontamente conocida.

7. Nada bloquea la salida
    - No hay obstaculos que bloquean la salida.

8. Da la protección adecuada contra el fuego
    - La puerta no debe ser combustible.
    - La puerta debe estar construida con material resistente al fuego.

9. Da la protección adecuada contra el humo.
    - La puerta debe cerrar en forma ajustada para que no entre el humo.

IV. Los pasillos

1. Anchura adecuada
    - La anchura es de al menos 122 cm para lugares donde duermen los pacientes.
    - La anchura es de al menos 112 cm para otros lugares.

2. Nada bloquea la salida
    - No deben haber obstaculos que bloquean la salida.

3. La integridad adecuada de paredes y puertas
    - Los pasillos de la salida deben estar construidos de materiales no combustibles.

5. El sistema eléctrico de emergencia debe mantenerse y probarse
    - Tiene que hacerse una prueba funcional en cada sistema de iluminación de emergencia en intervalos de 30 días por un mínimo de 30 segundos y anualmente por una duración de una hora y media. El equipo debe estar en completo funcionamiento por lo que dure la prueba.

VI. Puertas que dan protección contra el fuego

1. Calificación apropiada para la ubicación
    - Las paredes tienen una resistencia de 30 minutos.
    - Las puertas tienen una resistencia de 20 minutos.

2. Se puede reparar el marco y los componentes
    - Se puede reparar la puerta fácilmente.
    - Las bisagras se pueden fijar fácilmente

3. Los mecanismos de cierre y artefactos que cierran con picaporte deben estar en optimas condiciones de operación.

VII. Las escaleras

1. Anchura adecuada
    - El ancho mínimo, libre de toda obstrucción debe ser 112 cm, sin incluir la distancia de separación del pasamanos a la pared de 8.9 cm.

2. La integridad adecuada de paredes y puertas
    - Las calificaciones de la resistencia de paredes y puertas son de acuerdo con las calificaciones de la Resistencia del Fuego. El material de las escaleras y la clasificación correcta

3. Mecanismos de ventilación adecuados y con buen mantenimiento
    - El modo de activación de los sistemas de ventilación debe ser mediante los detectores de humo.

4. Construcción adecuada de la escalera
    - Todas las escaleras en medios de salida son permanentes. Estas no deberán ser de materiales combustibles.
    - La escalera y los pisos intermedios deben continuar sin la disminución en la anchura en la ruta de evacuación.
    - La huella y el descano de la escalera deberán ser de material sólido, antidezlisante y libre de obstáculos sobre el piso. Si la contrahuella no es vertical, debe permitirse pendientes bajo la huella en un ángulo no mayor a los 30 grados con respecto al vertical, pero la proyección permitida en la parte interna entre la huella y la contrahuella no será mayor a 3,8 cm.

- Los medios de salida que tengan más de 76 cm por encima del piso requieren las installación de barandas de protección.

5. Pasamanos adecuados
   - Las barandas y los pasamanos deben ser continuos por todo el tramo de la escalera.
   - Los pasamanos interiores tienen que continuar entre tramos y vueltas en el piso de la escalera a menos que:
     - la escalera ya exista.
   - Los pasamanos están en un máximo de 76 cm con respecto al ancho de la escalera. La salida sigue en una ruta natural para la persona que evacua.
     - Las excepciones son:
       a. En la escalera existente, los pasamanos están en un máximo de 112 cm en todas las porciones de la anchura de la escalera.
       b. Si hay una parte que separa la acera de una calle y existe una sola escalera o una rampa no necesita un pasamanos.
       c. Si las escaleras o las rampas están en habitaciones, necesita un pasamanos en por lo menos un lado.
       d. Si ya existan las escaleras o las rampas, necesita un pasamanos en por lo menos un lado.

6. Ruta al lugar de seguridad adecuada y limpia
   - No deben haber obstáculos que bloquean la vía.

VIII. Descarga de salidas

1. Descargas que dirijen a lugares públicos
   - La vía debe dirigir a una persona a una distancia bastante segura fuera del edificio.

2. No debe haber ni almacenamiento ni escombros
   - No hay basura ni otra materia que bloquea la vía.

3. Iluminación adecuada
   - Deben haber bastantes luces de modo que las personas puedan seguir la vía a un lugar seguro fuera del edificio.

IX. Sistema de alarma

1. Existe un sistema de alarma
   - El edificio debe tener una alarma que produzca un sonido o mensaje distintivo cuando hay un fuego.

2. Funcionabilidad
   - El sistema debe estar en optimas condiciones.

3. El equipo de sonido de la alarma debe estar apropiadamente colocado

- Se debe oir las alarmas claramente desde cualquier cuarto.

4. Las estaciones adecuadas para sonar la alarma
   - Las estaciones para sonar la alarma son necesarias.
   - La ubicación de ellas tienen algunas reglas:
     - Las estaciones en las salidas de la habitación donde duermen los pacientes no son necesarias si están localizadas en todas las oficinas de enfermeros u otras ubicaciones donde trabaja el personal si las estaciones son visibles y accesibles continuamente.
     - Las estaciones están colocadas en la vía natural de evacuación cerca de cada salida.
     - Otras estaciones del alarma del fuego no pueden estar a más de 60 m una de la otra en el mismo piso.
   - Los detectores de humo pueden activar el alarma.

5. Existencia de detectores de humo
   - Es necesario tener el sistema automático para descubrir humo en todos los pasillos a menos que:
     - cada habitación donde duermen los pacientes tenga un detector de humo, y un detector de humo colocado en barreras contra humo y salidas horizontales.
     - Los compartimientos de humo estén protegidos por un sistema de rociadores automático, supervisado, y aprobado.

6. Los sistemas del alarma deben activarse correctamente
   - Las estaciones de alarma deben estar en optimas condiciones.
   - Los detectores de humo deben estar en optimas condiciones.

X. Las zonas de seguridad

1. Deben existir las zonas de seguridad.
   - Las habitaciones deben tener una calificación contra fuego más alta que la normal.

2. Protección adecuada
   - Los pacientes que no pueden salir de su habitación a causa de condiciones graves tienen que ser protegidos contra el fuego.

XI. Las señales

1. Existen instrucciones correctas para buscar una salida
   - Las señales están arriba de cada puerta de salida incluyendo las puerta que dirige a la escalera y la vía fuera del edificio.

2. Existen instrucciones sobre procedimientos de evacuación
   - Cada habitación tiene instrucciones sobre:
     - el lugar de la salida más cerca
     - qué se debe hacer en caso de fuego

- qué se debe hacer cuando la alarma suena.

3. Se puede verlas fácilmente
   - Hay instrucciones claramente visibles en habitaciones que muestran adonde se debe ir en caso de fuego.

4. Tienen dibujos y descripciones verbales
   - El esquema y la descripción verbal describe el proceso de evacuar.

5. Se puede leerlas desde una distancia adecuada
   - Se puede leerlas desde una distancia de 30 m.

XII. Otros

1. El área tiene protección contra materias peligrosas
   - Los pacientes no deben estar colocados cerca de materias combustibles.

2. Las distancias de salir por los pasillos no deben estar excedidas
   - La distancia desde una puerta de la habitación al pasillo a la puerta de salida no debe exceder 30 m.
   - La distancia desde cualquier lugar en una habitación a la puerta del pasillo no debe exceder más que 45 m.
   - Si el edificio tiene un sistema aprobado de rociadores, los requisitos anteriores pueden ser aumentados en 15 m.

3. Debe existir una puerta o una ventana al exterior
   - Todas las habitaciones donde duermen los pacientes necesitan una puerta o una ventana al exterior.

El checklist para escuelas ya existentes.

I. Introducción

- Cada elemento en la lista de verificación tiene que satisfacer cada punto de información listado bajo cada título. Algunas de estas reglas tienen excepciones o reglas adicionales.
- Cuando se escoge "no" para un item, por favor trate de escribir un comentario sobre el lugar y la razón por qué está mal.
- Escoga uno para la carga de ocupación
    - 1.9 m cuadrados por persona en los cuartos para clases.
    - 4.6 m cuadrados por persona en laboratorios, y otras habitaciones vocacionales

II. Las puertas en medios de salida

1. Reglas a seguir para las cerraduras en habitaciones donde las personas duermen
    - No es aplicable para escuelas

2. Reglas a seguir para cerrar puertas que se usan en los medios de salida
    - Se permite que las puertas que no se usan en medios de salida estén cerradas.
    - Las puertas pueden tener picaporte si siempre se pueden abrir desde al pasillo.

III. Puertas de salida

1. Número y la ubicación adecuadas
    - Las salidas están localizadas en lados opuestos de cada piso en el edificio. Cuando el piso sea extremadamente grande, estarán localizadas en el medio de los pasillos grandes del edificio.
    - No debe haber pasillo sin salida.
    - Necesita al menos 2 salidas disponibles para cada piso.

2. El tamaño adecuado
    - La anchura es al mínimo 81 cm para cada puerta de salida.

3. Los componentes correctos de la puerta y el giro
    - Las puertas tienen que girar, pero no en una dirección específica.

4. Se pueden reparar la puerta, el marco, y los componentes
    - Se puede reparar la puerta fácilmente.
    - Se pueden reparar las bisagras fácilmente.

5. Visibles
    - Todos los medios de salida necesitan una señal aprobada visible desde cualquier dirección del acceso.
    - Las señales deben ser fácilmente distinguibles por el color y contrastan otros muebles o diseños.

V. La iluminación y la claridad de las puertas de salida

1. Debe haber suficientes luces en todas las salidas
   - La iluminación debe ser continua para todo el proceso de evacuación.
   - Se requiere que haya por lo menos 10 luxes de la iluminación en el piso en los 3 elementos del medio de salida: el pasillo, la escalera, y la vía al lugar seguro.
   - La iluminación debe ser organizada de modo que la no activación de una de las luces no deje el área en oscuridad. Las luces, los circuitos, o el poder auxiliar tienen que asegurar la continuidad de la iluminación del medio de salida.
   - El sistema de iluminación tiene que ser seguro. No está bien que dependa de sistemas operativos por batería u otros tipos de lámparas o focos portátiles.
   - No deben usarse sistemas operativos por batería u otros tipos de lámparas o focos portátiles como una fuente primaria de iluminación.
   - Se pueden usar las luces eléctricas operadas por batería como iluminación emergencia.

2. Señales iluminadas
   - Las señales deben ser iluminadas.

3. La salida debe ser fácilmente identificable
   - Las salidas deben tener señales aprobadas visibles desde cualquier dirección.
   - La señal de salida no debe estar a más de 30 m de la salida más cercana, a menos que:
     - el edificio ya exista.
   - Las señales brillen continuamente sin que destellen por activación del sistema del alarma del fuego.
   - Se pongan señales que digan "SALIDA" cuando la dirreción de la más cercana salida no sea obvia.

4. Circuito eléctrico separado
   - La electricidad de emergencia tiene que estar conectada a un circuito diferente del circuito convencional en caso de que éste falle.

5. El sistema eléctrico de emergencia debe mantenerse y probarse
   - Tiene que hacerse una prueba funcional en cada sistema de iluminación de emergencia en intervalos de 30 días por un mínimo de 30 segundos y anualmente por una duración de una hora y media. El equipo debe estar en completo funcionamiento por lo que dure la prueba.

VI. Puertas que dan protección contra el fuego

1. Calificación apropiada para la ubicación
   - Las paredes tienen una resistencia de 30 minutos.
   - Las puertas tienen una resistencia de 20 minutos.

2. Se puede reparar el marco y los componentes
   - Se puede reparar la puerta fácilmente.

b. Si hay una parte que separa la acera de una calle y existe una sola escalera o una rampa no necesita un pasamanos.
c. Si las escaleras o las rampas están en habitaciones, necesita un pasamanos en por lo menos un lado.
d. Si ya existan las escaleras o las rampas, necesita un pasamanos en por lo menos un lado.

6. Ruta al lugar de seguridad adecuada y limpia
   - No deben haber obstáculos que bloquean la vía.

VIII. Descarga de salidas

1. Descargas que dirijen a lugares públicos
   - La vía debe dirigir a una persona a una distancia bastante segura fuera del edificio.

2. No debe haber ni almacenamiento ni escombros
   - No hay basura ni otra materia que bloquea la vía.

3. Iluminación adecuada
   - Deben haber bastantes luces de modo que las personas puedan seguir la vía a un lugar seguro fuera del edificio.

IX. Sistema de alarma

1. Existe un sistema de alarma
   - El edificio debe tener una alarma que produzca un sonido o mensaje distintivo cuando hay un fuego.

2. Funcionabilidad
   - El sistema debe estar en optimas condiciones.

3. El equipo de sonido de la alarma debe estar apropiadamente colocado
   - Se debe oir las alarmas claramente desde cualquier cuarto.

4. Las estaciones adecuadas para sonar la alarma
   - Las estaciones para sonar la alarma son necesarias.
   - La ubicación de ellas tienen algunas reglas:
     - Las estaciones están colocadas en la vía natural de evacuación cerca de cada salida.
     - Otras estaciones del alarma del fuego no pueden estar a más de 60 m una de la otra en el mismo piso.
   - Los detectores de humo pueden activar el alarma.

5. Existencia de detectores de humo
   - Es necesario tener el sistema automático para descubrir humo en todos los pasillos a menos que:

- cada habitación donde duermen los pacientes tenga un detector de humo, y un detector de humo colocado en barreras contra humo y salidas horizontales.
- Los compartimientos de humo estén protegidos por un sistema de rociadores automático, supervisado, y aprobado.

6. Los sistemas del alarma deben activarse correctamente
   - Las estaciones de alarma deben estar en optimas condiciones.
   - Los detectores de humo deben estar en optimas condiciones.

X. Las Zonas de la seguridad
- No es aplicable para escuelas.

XI. Las señales

1. Existen instrucciones correctas para buscar una salida
   - Las señales están arriba de cada puerta de salida incluyendo las puerta que dirige a la escalera y la vía fuera del edificio.

2. Existen instrucciones sobre procedimientos de evacuación
   - Cada aula tiene instrucciones sobre:
     - el lugar de la salida más cerca
     - qué se debe hacer en caso de fuego
     - qué se debe hacer cuando la alarma suena.

3. Se puede ver fácilmente
   - Hay instrucciones claramente visibles en habitaciones que muestran adonde se debe ir en caso de fuego.

4. Tienen dibujos y descripciones verbales
   - El esquema y la descripción verbal describe el proceso de evacuar.

5. Se puede leerlas desde una distancia adecuada
   - Se puede leerlas desde una distancia de 30 m.

XII. Otro

1. El área tiene protección contra materias peligrosas
   - Las personas no deben estar colocados cerca de materias combustibles.

2. Las distancias de salir por los pasillos no deben estar excedidas
   - La distancia recorrida por los pasillos a la salida no debe exceder 23m.
   - La distancia recorrida entre cualquier punto en una aula y una salida no debe ser más que 45m.
   - Si el edificio está protegido con un sistema aprobado de rociadores, los requisitos arriba indicados aumentan en 15m.

- El jardín infantil y primer grado deben estar colocados en el mismo piso que la salida al exterior del edificio. El segundo grado debe ser como máximo un piso encima del nivel de piso con la salida al exterior.

3. Debe existir una puerta o una ventana al exterior
   - Debe exisitr una puerta o una ventana al exterior en cada aula.
   - Cualquiera habitación o espacio de más de 23.2 m cuadrados que se usa para propósitos educativos debe tener por lo menos una ventana al exterior para el rescate en emergencias y ventilación, a menos que:
     - El edificio tenga un sistema aprobado de rociadores.
     - La habitación o el espacio tenga una puerta que dirija directamente al exterior del edificio.

IQP/MQP SCANNING PROJECT

Chapter VII. References

Works cited.

· Boyce, K.E., T.J. Shields, and G.W. H. Silcock. "Toward the Characterization of Building Occupancies for Fire Safety Engineering: Capability of People with Disabilities to Read and Locate Exit Signs." *Fire Technology* Volume 35 #1 (1999): 79 - 86.

· Bush, Loren S. and James McLaughlin. Introduction to Fire Science. Beverly Hills, CA: Glencoe Press, 1970.

· Coté, Ron, P.E. Life Safety Code Handbook 7th Edition. National Fire Protection Association, Inc., 1997.

· Department of Risk Engineering: Costa Rican Fire Department. Curso Avanzado de Prevención de Incendios.

· Duiliu, Sfintesco, et. al. Fire Safety in Tall Buildings. United States: McGraw-Hill, Inc., 1992.

· INS (Instituto Nacional de Seguros). Guía de Servicios. San José, Costa Rica: Departamento de Comunicaciones del INS, 1996.

· INS (Instituto Nacional de Seguros). Manual de Protección Contra Incendios. Spain: NFPA, 1976.

· Robertson, James C. Introduction to Fire Prevention, Third Edition. New York, NY: Macmillan Publishing Company, 1989.

· Tipton, Howard D., et al. America Burning: The Report of the National Commission on Fire Prevention and Control. Washington, D.C.: U.S. Government Printing Office, 1973.

· *no author listed.* "History of NFPA101." *NFPA Journal* Volume 89 #5 (1995): 82.

· *no author listed.* "NFPA's 100th Anniversary." *NFPA Journal* Volume 90 #3 (1996): 160.

· The Technical Correlating Committee on Safety to Life. NFPA 101A Guide on Alternate Approached to Life Safety. National Fire Protection Association, Inc., 1998.

· Benemérito Cuerpo de Bomberos de Costa Rica. National Insurances Institute, Costa Rica Fire Department. <http://www.ins.go.cr/bomberos/>.