FPE596 Culminating Course Progress Report for the NA893 Community Support Center, Yokosuka Naval Base, Japan

FPE596 Final Report
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Keywords:

Life Safety Code
Fire Protection Analysis
Prescriptive-Based Design
Performance-Based Design
Fire Dynamics Simulator (FDS)
Japanese Building Standard Law
Japanese Fire Services Act

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EXECUTUVE SUMMARY

This is the culminating project report for the Fire Project Engineering Master's of Science at California Polytechnic at San Luis Obispo. This project will consider a project for the US military in Japan, JFY893 Community Support Facility, Yokosuka Naval Base. The subject facility consists of a library, education center, family services, and other community services. The Library shall serve as the Main Base Library, keep and store books and provide library services for active duty population, dependents and retirees. The Education Center provides services for advancing of the academic, technical, and vocational education of military personnel of all grades and ranks in order to enhance their potential to the military services.
The Family Service shall provide information and referral services, education and training services, and counseling service for active duty population with services usable to dependents and retirees.

This paper will be separated into three different components. First, the subject facility will be introduced so that its function is understood to the reader. The background of the project will go into specific floor and room detail and also provide occupant load information per room and floor. It will also be noted that Japanese criteria as well as US criteria and Department of Defense criteria will be used for the design of this project.

The prescriptive and performance-based analysis of the subject facility will be performed. The prescriptive-based analysis will be based on the core Fire Protection Engineering Courses. The performance-based analysis will be based on three design fires. The building has passed all prescriptive and performance-based analysis and is deemed to be safe from a fire safety perspective.

The occupancy classification and means of egress will be discussed as per FPE521 Egress Analysis and Design. The first floor has been classified as a ordinary hazard 2 due to the main library. The upper floors have been categorized as a light hazard. Based on the occupant load, there are three stairwells and the facility exits and doorways have been sized accordingly.

The electrical and communications system will be considered as per FPE522 Fire Detection and Alarm Systems. Although very similar, the Japanese criteria on alarm spacing is slightly stricter and thus resulting in a larger number of alarms and detectors in the facility. Furthermore, the Department of Defense criteria regarding Mass Notification Systems is also applied to further reinforced intelligibility requirements of the facility.

The mechanical engineering systems will be covered via the FPE523 Fire Suppression System class. One significant difference in the fire suppression system is that the Japanese Building Standard Law requires a fire pump, emergency generator, and water cistern even though there is sufficient supply. Furthermore, the fire sprinkler demand is dictated by the stricter US Department of Defense criteria, UFC 3-600-01.

Thus, the fire suppression system is safer than the NFPA prescribed rules since they are exceeded.

The fire safety strategy of the fire resistance in the building will be discussed through the FPE 524 Structural Fire Protection course coverage. Based on the International Building Code, the required construction classification will be Class II. The materials used to construct the columns, beams, floor assemblies, roof assembly, exterior walls, interior walls, door openings, joints, penetrations, and partitions will be distinguished. Since Japan is in a seismic region and due to the new seismic laws, the structural requirements have increased. Furthermore, due to the new anti-terrorism and force protection laws by the Department of Defense, the building would need to be able to withstand a 40-ton car bomb since it is a primary gathering facility. Due to all these structural requirements, this building will be able to withstand significant threats from fire, external threats such as explosions, and natural events such as earthquakes.

The next section of the project paper is the performance-based analysis. The performance-based analysis will be analyzed in several sections. The performance-based analysis will be based on three fire scenarios. Then, the Required Safe Egress Time (RSET) will need to be considered. An analysis of the time taken by occupants to safely escape from the effects of fire will be done in a quantitative and methodical way. Next, the Available Safe Egress Time (ASET) will need to be evaluated.

Three design fires which will be located on the main library floor will be considered in this paper. A fire in the main book stacks of the library will be considered and the fire will be modeled by the traveling fire method due to the long span of the book shelves in a large open room. The second fire will be the book stacks in the periodical room which is significantly spaced closely together in a small enclosed space. The third fire will be designed after a workstation fire in the multi-media room.

The Required Safe Egress Time (RSET) is a summation of the time to notification from the sounding of an alarm, the reaction time of the occupants of the facility, the pre-evacuation activity time, and the actual travel time to egress the facility. Based on calculations and some assumptions, the required safe egress time is conservatively calculated at 8 minutes and 8 seconds to evacuate close to 1,500 occupants from the four-story building.

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The Available Safe Egress Time (ASET) is the time the effects of fire reach the tenability limits prescribed in the acceptance criteria will be determined. There are several factors which will need to be considered. The subject facility's structural integrity and its ability to survive the fire will need to be evaluated. The ability of the occupants to egress the facility when subjected to intense heat and smoke will also need to be considered as well. Computer modeling such as Fire Dynamics Simulator (FDS) will be used. Due to the higher prescriptive standards, the ASET exceeded the RSET in when evaluated against all these factors.

The final section will conclude with an evaluation of the facility from a prescriptive and performance-based analysis of the subject facility. Further, recommendations on changes that could have been made to make the facility safer will be presented. Although there were many challenges of planning and designing a US military facility in a foreign country, the reliance on the strictest rule resulted in a safer facility.

PROJECT INTRODUCTION

BACKGROUND

First, it should be noted that this facility is not located in the continental United States. Rather, this facility is located on a US Naval facility in Japan. The naval base is called Yokosuka Naval Base and is located 80 kilometers due south of Tokyo as shown in Figure 1. Yokosuka Naval Base is the regional subordinate command in the Far East in the Pacific Region.

Figure 1: Map of Japan and Location of Yokosuka Naval Base

Fleet Activities, Yokosuka comprises 568 acres and is located 43 miles south of Tokyo at the entrance of Tokyo Bay and approximately 18 miles south of Yokohama. Yokosuka is on the Miura peninsula in the Kanto Plain region of the Pacific Coast in Central Honshu, Japan. Yokosuka Naval Base is the largest overseas U.S. Naval installation in the world and is considered to be one of the most strategically important bases in the U.S. military. Its primary mission is to serve and support the 7th Fleet of the US Navy.

The subject facility is located in the community center and is surrounded by housing, the high school, the chapel, the commissary, and other community activities such as community shopping and the theater, as shown in Figure 2. It is the perfect location for the community support facility since it is located in the middle of the community which uses it.

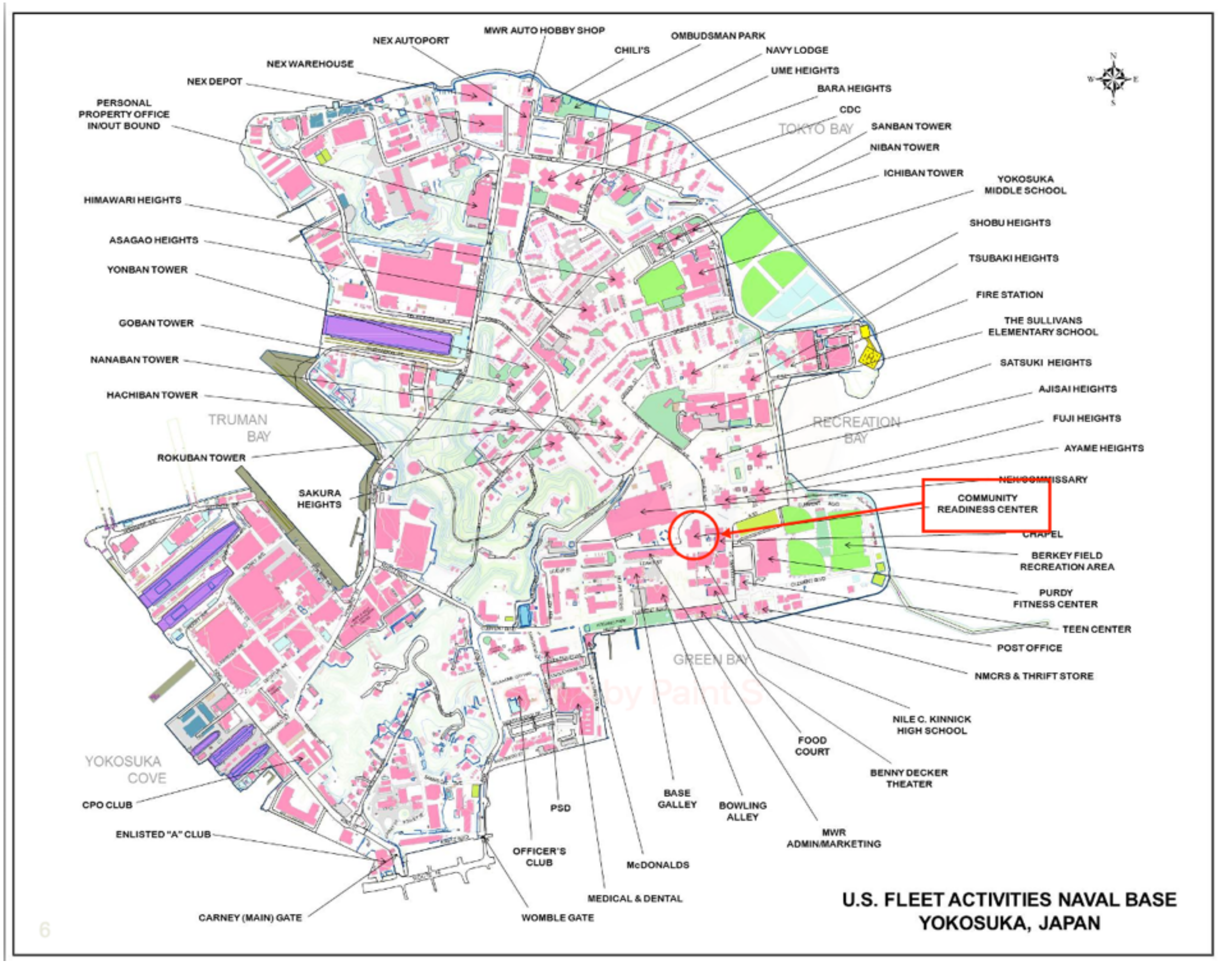


Figure 2: Map of Yokosuka Naval Base and Location of subject facility

Figure 3 is a more detailed site plan of the proposed facility.

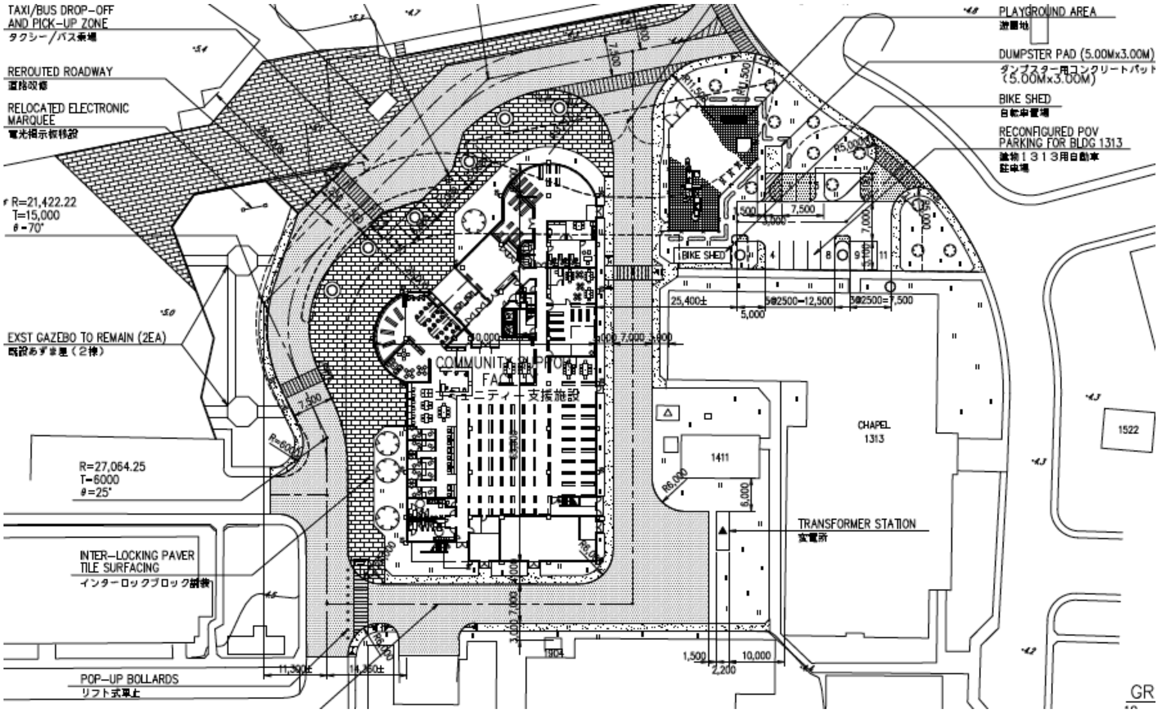


Figure 3: Site Plan of NA893 Community Support Facility

The subject facility is situated in the community core of the Yokosuka Naval Base and is located in the heart of the community. Since the design of this facility was completed after the terrorist attack on September 11, there were many Anti-Terrorism/Force Protection rules that were created and could not be waived. Some of these details could be seen in the site plan. Although there are roads around the entire facility, the new Anti-Terrorism/Force Protection rules cannot allow vehicles to come within 50 feet of an occupied facilities unless there is a controlled perimeter. There is a public road which runs from the north to west of the facility, but there is a 50 feet clearance from the subject facility to the road. However, the road to the south and east of the subject facility are closed off with bollards which the fire department has access to. The southern and eastern road is classified as a fire road and is to be accessed by emergency vehicles and other vehicles that have clearance to do so.

The fire road is a requirement by the local fire department. This is an example of many of the challenges in designing a US military facility in Japan since there are many competing criteria that sometime conflict with each other.

Figure 4 is an actual photo of the community support facility during construction. As can be seen from the photo, the community support facility did keep its original design intent from the design drawings and renderings.

Figure 4: Photograph of subject facility during construction

CHALLENGES

There were many difficult challenges during the development of the Facilities Requirement Document and Design of the facility as well as the development of this culminating report for the FPE596 class. One of the more interesting issues is that this facility needed to adhere not only to US rules but Japanese rules. Furthermore, the US regulations kept changing due to issues such as the terrorist attack on September 11 which caused a significant change on how federal facilities were to be designed. Finally, the development of this FPE596 report itself was challenging since the design had been completed over a decade ago and access to many of its files are difficult to obtain.

As referred to previously, this project was programmed in the year 2000 but there was an act of terror on September 21, 2001 which would significantly change how Federal facilities were to be built. Since the terrorist attack on 2001, the US government created Anti-Terrorism/Force Protection rules that would make federal facilities safer from terrorist attacks. These rules would come in the form of facility setbacks, ventilation changes, new communications requirements, and many other issues to include Structural (progressive collapse), Fire Protection Engineering, and all key disciplines.

This facility was funded, designed, and constructed using Japanese taxpayer funds. Therefore, all Japanese rules and regulations were to apply to this facility. In short, the subject facility had to comply with both US and Japanese law and criteria. When there were differences between the US and Japanese rules, the stricter of the two would need to be taken to satisfy both. Therefore, all the US and Japanese rules and regulations needed to be met and exceeded. Thus, these facilities built under the Japanese Facilities Improvement Program of the Ministry of Defense of Japanese are safer than US built facilities since they had to meet the laws governing both US and Japan. It should be noted that a lot of time was taken to identify the difference and determine the minimum criteria that needed to be met for both US and Japanese rules and regulations

The Building Standard Law (BSL) is the main law that regulates buildings and their equipment. The BSL was established in 1950, and has been amended many times to meet new technologies and to cope with new hazards. As major disasters happened or new technologies were introduced, the government has amended or added new articles that described new requirements and technical specifications. Before 2000, performance based design was done under the equivalency concept. It depended on a provision in the BSL that described the Minister approval for new technologies beyond current expectations. However lawyers criticized the process of approval that was closed to the public because of the applicant's patent, etc, and that the performance criteria depended on the enforcement side. As alternative materials and equipment were already contemplated by each provision, it was also difficult to prove equivalencies that involved multiple provisions that did not include specific objectives and performance criteria

One final difficulty in the creation of this report was the lack of access to information of this subject facility. Since this is a military facility, the Department of Defense is not very keen on releasing information which can give away the strength of its forces. The loading of the community support facility can infer the overall strength of the Yokosuka Naval Base and the 7th Fleet since its facilities are developed based on Basic Functional Requirements. For a facility such as a community support facility, the size is very dependent on the forces that are deployed to the region. The Basic Functional Requirements also feed the occupancy and loading requirements of the building. Therefore, from HVAC calculations and Fire Sprinkler demand of a facility, the overall deployment numbers of Yokosuka Naval Base and the 7th Fleet can be inferred through back calculation. Therefore, the Department of Defense does not want to provide specific details on its facilities.

Due to this issue, much of the construction drawings and specifications were not easily accessible. Due to time constraints in gaining access to this information, much of this study report will be made using guesses on common design and construction methodology in Japan. It is the hope of this student that this would be acceptable for this culminating student report.

Figure 5: Rendering of a the NA893 Community Support Facility

PURPOSE OF THE FACILITY

The proposed building sited at U.S. Fleet Activities Yokosuka and will be utilized for community support activities. The main objective is to consolidate into single facility the community support activities for military personnel and their dependents assigned at Fleet Activities, Yokosuka. Accessibility requirements for physically handicapped persons shall be provided for entire facility. A rendering of the facility is provided in Figure 5 above.

The Library shall serve as the Main Base Library, keep and store books and provide library services for active duty population, dependents and retirees.

The Education Center provides services for advancing of the academic, technical, and vocational education of military personnel of all grades and ranks in order to enhance their potential to the military services.

This center provides information, education and training services, and counseling service for active duty population with services usable to dependents and retirees of all grades and ranks in order to enhance their potential to the military services.

The Family Service shall provide information and referral services, education and training services, and counseling service for active duty population with services usable to dependents and retirees.

The floor plans can be found in the Appendix of this report. The following pages also show color coded floor plans that show the occupancy classifications of the project.

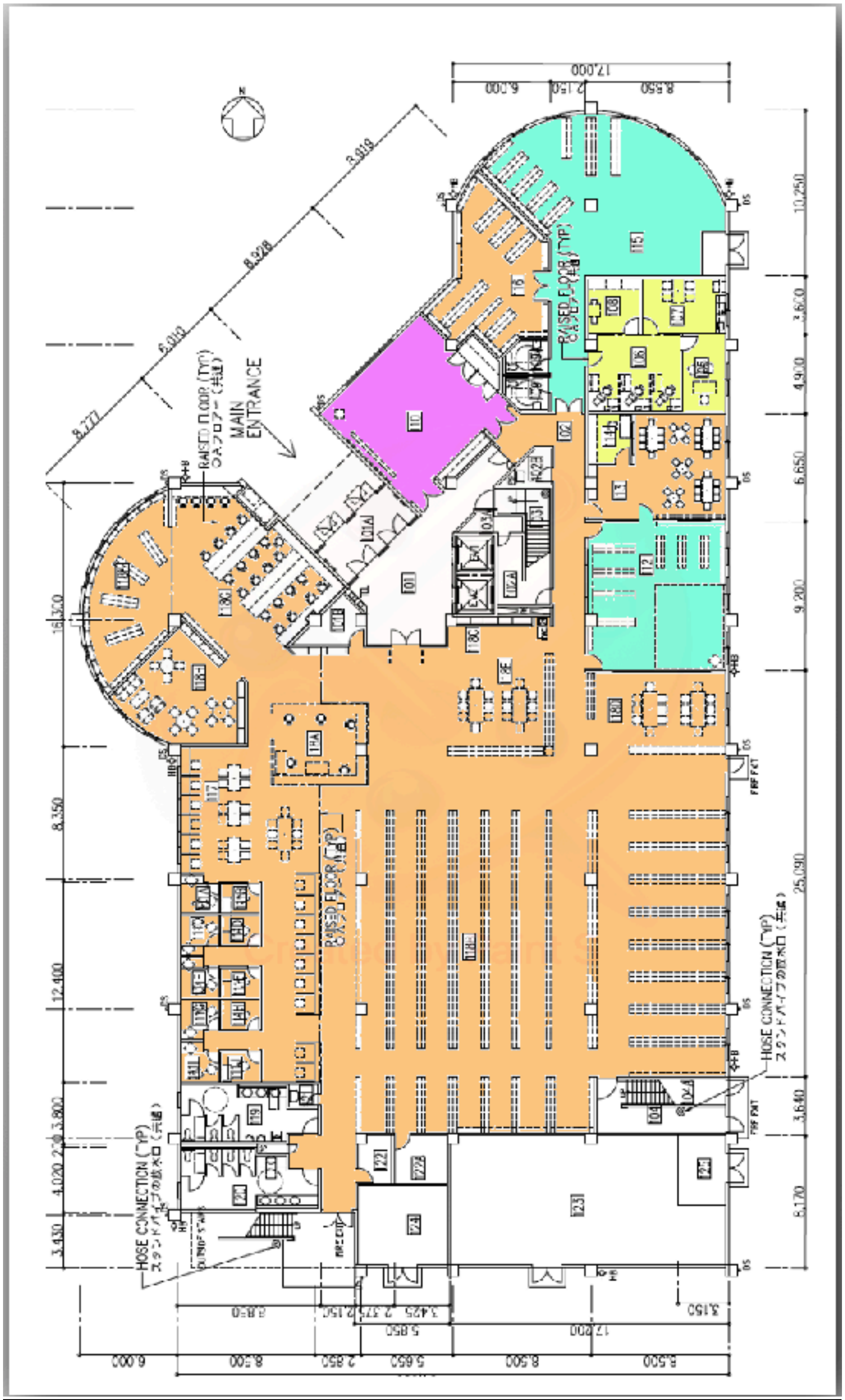


Figure 6: First Floor Plan with Color Coded Occupancy

Table 1: First Floor Occupancy Classification and Square Footage

First Floor	Area (SF)
Office	623
Library	11605
Study/Reading	1460
Assembly	981
Storage	1830

Figure 6 is the floor plan of the first floor with color coded occupancies. Table 1 shows the area of each occupancy type. The following is a summary of first floor room functions: Library (First Floor Level): The Library shall serve as the Main Base Library, keep and store books and provide library services for active duty population, dependents and retirees.

Room 105 Office (Director): Office space for Library Director. Office shall be provided with a desk, chairs, LAN.

Room 106 Office (Assistant Director/Administrative Clerk): Office space for Asst. Director and Administration Clerk. Office shall be provided with a desk, chairs, LAN.

Room 107 Breakroom (Staff): Break room for Library Staff. Room shall be provided with kitchenette, microwave oven, refrigerator, tables & chairs.

Room 108 Office (Data Management): Room for photo-copying, various administrative work and storage of files. Room shall be provided with a copy machine, FAX machine, work table, movable steel shelving.

Room 110 Multipurpose Room: Room for special programs & various types of meetings. Room shall be provided with a conference table, chairs, white boards, bulletin boards, OH projection screen.

Room 111 Media Room: Private cubicles for Audio & Video viewing/listening. Cubicles shall be provided with TV, video & audio player, acoustical treatment and view window on doors.

Room 112 Children's Reading Room: Room where children (0 to 12yrs old) will access books, reading, & storytelling. Room shall be provided with a view window, carpeted platform, book shelving, children sized tables & chairs.

Room 113 Study Room (Children Group): Room for children's group study. Room shall be provided with a view window, book shelving, children sized tables & chairs.

Room 114 Office (Children's Group): Office for staff supervising the Children's Reading and Study Room. Room shall be provided with a view window, desk & chair.

Room 115 Office (Technical Service): Room for staff to order, receive, process, and prepare library books & materials. Room shall be provided with desk, chair, storage shelving units, LAN, bulletin board & white board.

Room 116 Periodical/Compact Storage: Room where back issues of periodicals and miscellaneous items are stored. Room shall be provided with storage shelving units.

Room 117 Study Area (Private Booths): Area for individual "study booths". Area shall be provided with tables, chairs & individual modular booths.

Room 118A Circulation Desk: Area where the staff controls/oversees the Library areas and operations, check in/out of library books & materials. Area shall be provided with built-in counter/desks, chairs, LAN and copy machine.

Room 118B Book Stack Area: Area where library books and materials are stacked. Area shall be provided with standard, vertical adjustable shelving.

Room 118C Display Area: Area for display of art works, various exhibits and collections. Area shall be provided with display shelving, bulletin boards and kiosk.

Room 118D Reference Area: Area for Reference material access. Area shall be provided with shelving, tables and chairs.

Room 118E Reading Area: Area for reading and studying. Area shall be provided with study tables, chairs and study carrels.

Room 118F Audio/Visual & Special Collections: Area for Audio / Visual Collections are stacked. Area shall be provided with shelving units.

Room 118G Patron Access Computer: Area for public access of computers. Area shall be provided with tables, chairs, computers and (24) terminals.

Room 118H Periodicals: Area for sitting and reading of current magazines and periodicals. Area shall be provided with tables, couches/chairs, shelving and display units.

The spaces that are not color coded are unoccupied spaces such as the entry vestibule, toilets, communication closets, fire pump room, electrical room, mechanical room. and emergency generator room.

Figure 7: Second Floor Plan with Color Coded Occupancy

Table 2: Second Floor Occupancy Classification and Square Footage

Second Floor	Area (SF)
Office	767
Library/Reading	1023
Classroom	6657
Assembly	2067

Figure 7 is the floor plan of the second floor with color coded occupancies. Table 2 shows the area of each occupancy type. Summary of Second Floor Functions:
Education Center (Second Floor Level): The Education Center provides services for advancing of the academic, technical, and vocational education of military personnel of all grades and ranks in order to enhance their potential to the military services.
Room 205 Office (Chaplain): Office space for Chaplain. Office shall be provided with a desk, chairs, LAN

Room 206 Office (Education) & Library: Office area for stock and display of educational books and videos. Office shall be provided with front counter, bulletin board, reading chairs, reading table and bookshelves.

Room 207 Office (Data Management): Room for photo-copying, various admin.work & storage of files. Room shall be provided with a copy machine, FAX machine, work table and steel shelving.

Room 208 Office (Admin): Office area for Education Director, Librarian and Assistants. Office shall be provided with workstations, front counter, bulletin board, sofa, computer stations, filing cabinet, TV bracket /holder for 20"TV a desk, chairs, LAN

Room 209 Childcare Room: Room for child care of 20 children (0 to 4 yrs old), & 3 childcare providers. Area shall be provided with wash cabinet, supply cabinet, diaper changing table, TV bracket /holder for 20"TV, cribs and toddler chairs.

Room 210 Quiet Room: Room for child care of infants. Area shall be provided with cribs, chairs and view window.

Room 211 Office (Education Staff): Office space for Education staff. Office shall be provided with a desk, chairs, LAN.

Room 212 Fellowship Room: Room for different types of Religious services, meetings and seminars. Room shall be provided with white boards, bulletin boards, seating, podium, and platform stage.

Room 212A Storage: Room to store various seminar support items. Room shall be provided with built-in shelving.

Room 212B Sound Room: Room for audio/visual control equipment. Room shall be provided with PA system equipment, chair and view window.

Room 213 Multi-Purpose Room: Room for various education meetings, training classes and seminars. Room shall be provided with a conference table, chairs, white boards, bulletin boards, OH projection screen, ceiling mounted projector system.

Room 214 Kitchenette: Room where refreshments, foods are prepared. Room shall be provided with a kitchenette, refrigerator, microwave oven and a pass thru window.

Room 215 Preparation Room: Room for preparation of items used in the different religious services or seminars. Room shall be provided with closets and counter.

Rooms 216, 217, 219, 220, 221, 222, 223 & 225 Classroom (30 person): Room for training classes and seminars. Room shall be provided with tables, chairs, white boards, bulletin boards, movable partitions, built-in closets and shelves.

Rooms 218 & 224 Classroom (15 person): Room for training classes and seminars. Room shall be provided with tables, chairs, white boards, bulletin boards, built-in closets and shelves.

The spaces that are not color coded are unoccupied spaces such as the toilets, communication closets, and, mechanical room.

Figure 8: Third Floor Plan with Color Coded Occupancy

Table 3: Third Floor Occupancy Classification and Square Footage

Third Floor	Area (SF)
Office	3395
Classroom	6010
Assembly	609

Figure 8 is the floor plan of the third floor with color coded occupancies. Table 3 shows the area of each occupancy type. Summary of Third Floor Functions: Red Cross & Navy-Marine Corps Relief Society (Third Floor Level): This center provides information, education and training services, and counseling service for active duty population with services usable to dependents and retirees of all grades and ranks in order to enhance their potential to the military services.

Room 305 Office (Volunteer Work Area): Open Work area for volunteers, reception, red cross admin, training support & record keeping. Offices shall be provided with a modular type workstation, desks, chairs, LAN.

Rooms 306, 307, 308, 309 Office (SM, FOC, SC, VC): Office spaces for Red Cross staff. Offices shall be provided with a desk, chairs, LAN.

Rooms 310, 311 & 322 Storage: Room for storing training mannequins, training materials and cleaning supplies. Room shall be provided with metal shelving.

Room 312 Reception (Navy Relief): Room for waiting, receiving and screening of clients. Room shall be provided with bulletin board, sofa and chairs.

Room 313 Waiting Area / Office (Clerical): Area for receiving and waiting of clients and an open work area for the clerical staff. Area shall be provided with a front counter, modular office furniture, bulletin board, sofa, desks and chairs.

Rooms 314, 315, 316, 317 & 318 Office (XO, OA3, COV, CW, Counselor): Office spaces for Navy Relief staff. Offices shall be provided with a desk, chairs, LAN.

Room 319 Office (Data Management): Room for photo-copying and storage of files. Room shall be provided with a copy machine, FAX machine, worktable and steel shelving.

Room 321 Office (Work Room): Office space and work room for volunteer staff. Office shall be provided with a work counter, wall cabinet and cubbie holes.

Room 323 Conference / Training Room: Room for staff meetings, training and orientation for new volunteers. Room shall be provided with conference table, chairs, white boards, bulletin boards, OH projection screen and ceiling mounted projector system.

Room 324 Classroom (60 person): Room for training classes and seminars. Room shall be provided with tables, chairs, white boards, bulletin boards, built-in closets and shelves.

Rooms 325, 326, 327, 328, 329 & 331 Classroom (30 person): Room for training classes and seminars. Room shall be provided with tables, chairs, white boards, bulletin boards, built-in closets and shelves.
Room 330 Classroom (15 person): Room for training classes and seminars. Room shall be provided with tables, chairs, white boards, bulletin boards, built-in closets and shelves.

The spaces that are not color coded are unoccupied spaces such as the toilets, communication closets, and, mechanical room.

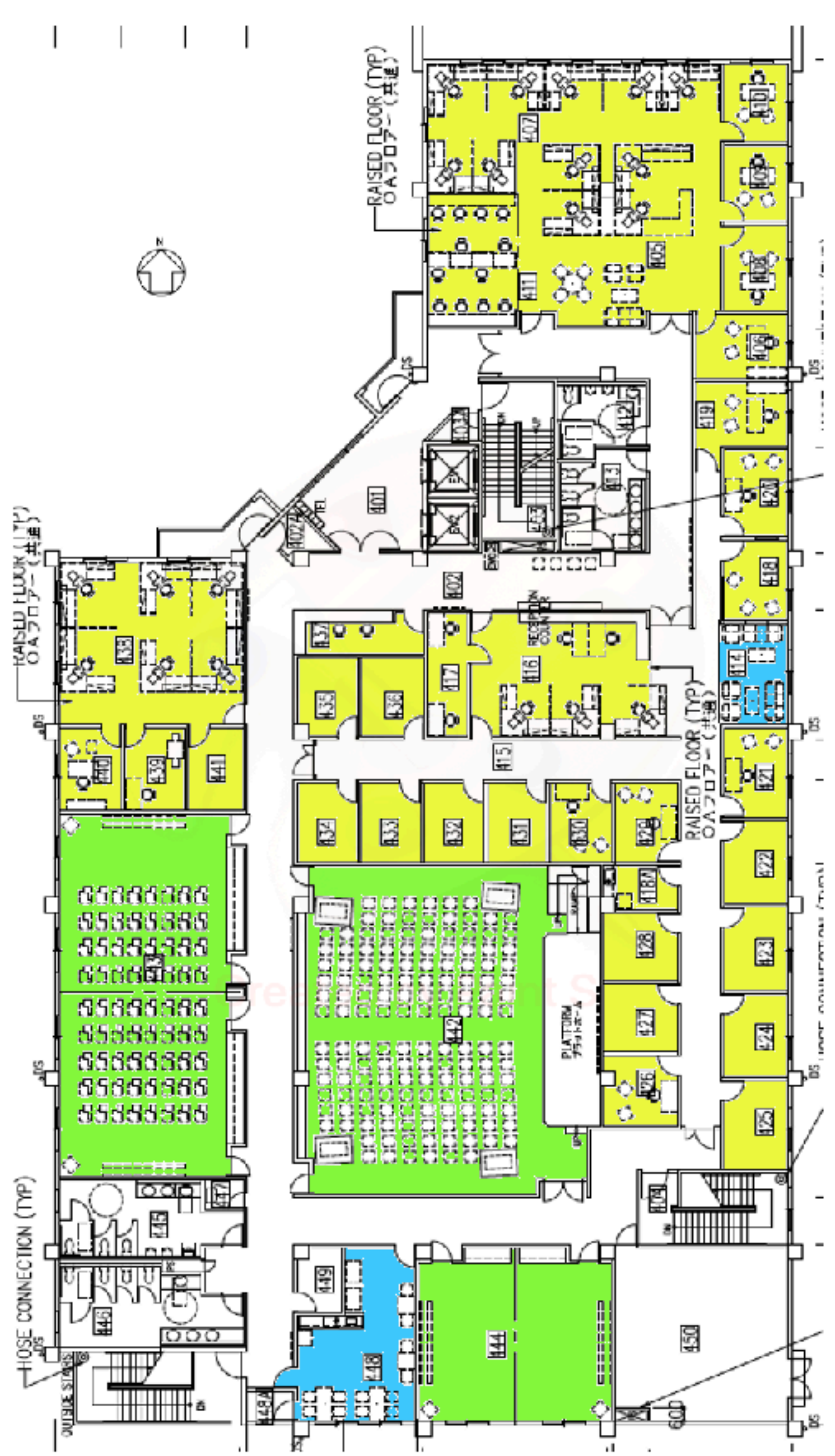


Figure 9: Fourth Floor Plan with Color Coded Occupancy

Table 4: Fourth Floor Occupancy Classification and Square Footage

Fourth Floor	Area (SF)
Office	4609
Classroom	4795
Waiting	571

Figure 9 is the floor plan of the fourth floor with color coded occupancies. Table 4 shows the area of each occupancy type. Summary of Fourth Floor Functions: Family Service Center (Fourth Floor Level): The Family Service shall provide information and referral services, education and training services, and counseling service for active duty population with services usable to dependents and retirees.

Room 405 Waiting Area (Administration): Area for receiving and waiting of customers. Area shall be provided with a sofa and chairs.

Rooms 406, 408, 409 & 410 Office (Director, TAMP MGR, RAP MGR & SSR): Office spaces for Family Services senior staff. Offices shall be provided with a desk, chairs, shelves and LAN.

Room 407 Administration Work Area: Open work area for administration staff. Offices shall be provided with modular type workstations, desks, chairs, LAN.

Room 411 Computer Area: Area for customer accessible computers. Area shall be provided with computer workstations, desks, chairs and LAN.

Room 414 Waiting Area (Clinical Branch): Area for receiving and waiting of patients. Area shall be provided with a sofa and chairs.

Room 416 Reception / Admin Work Area: Area for receiving patients and an open work area for the clerical staff. Area shall be provided with a front counter, modular office furniture, bulletin board, sofa, desks and chairs.

Room 417 Office (Data Management): Room for photo-copying, and storage of files. Room shall be provided with a copy machine, FAX machine, worktable and steel shelving.

Room 418 Children's Playroom: Room for children play area and child observation. Room shall be provided with shelves and a one-way mirror.

Room 419 Office (Clinical / FAP Division Head): Office space for Division Head. Office shall be provided with a desk, chairs, LAN

Rooms 420～424 Office (LSW, SW, I & T, SSS) Clinical Branch: Office spaces for clinical consultations. Offices shall be provided with a desk, chairs, shelves and LAN.

Rooms 425～431 Office (LSW, SIW, SSA) FAP/SAB Branch: Office spaces for clinical consultations. Offices shall be provided with a desk, chairs, shelves and LAN.

Rooms 432～436 Office (LSW, SSA, NPS Nurse) FAP/CAB Branch: Office spaces for clinical consultations. Offices shall be provided with a desk, chairs, shelves and LAN.

Room 437 Reception / Waiting Area (I & R Division): Area for receiving and waiting of customers. Area shall be provided with a sofa and chairs.

Room 438 Office (Admin): Open work area for administration staff. Offices shall be provided with modular type workstations, desks, chairs, shelves and LAN.

Room 439 Office (Data Management): Room for photo-copying, and storage of files. Room shall be provided with a copy machine, FAX machine, worktable and steel shelving.

Room 440 Office (SSA) I & R Division: Office spaces for senior staff. Offices shall be provided with a desk, chairs, shelves and LAN.

Room 442 Classroom AOB/ICR (100 person): Room for training classes and seminars. Room shall be provided with tables, chairs, white boards, bulletin boards, built-in closets and shelves.

The spaces that are not color coded are unoccupied spaces such as the toilets, communication closets, and, mechanical room.

PRESCRIPTIVE BASED DESIGN

The prescriptive and performance-based analysis of the subject facility will be performed. The prescriptive-based analysis will be based on the core Fire Protection Engineering Courses. The occupancy classification and means of egress will be discussed as per FPE521 Egress Analysis and Design. The electrical and communications system will be considered as per FPE522 Fire Detection and Alarm Systems. The mechanical engineering systems will be covered via the FPE523 Fire Suppression System class. The fire safety strategy of the fire resistance in the building will be discussed through the FPE 524 Structural Fire Protection course coverage.

MEANS OF EGRESS

Identification Location of Exits on Floor Plan

There are three means of egress on the first floor. The main entrance at the north-western face of the facility will be the main means of egress for those on the first floor. There is an exit on the eastern side of the first floor. There is also an exit on the southern face of the first floor.

There are three means of egress per floor above the first floor. There is an exit located in the northern part of the building, which is located behind the elevator well and leads out to the main foyer in the first floor. Another exit is located at the south-western corner of the building which is an exterior stairwell that is not enclosed. The south-eastern exit is an enclosed stairwell, which leads out to the backside of the building.

Figures 9 through 12 display the floorplans with the means of egress from either stairway and main exits on the first floor.

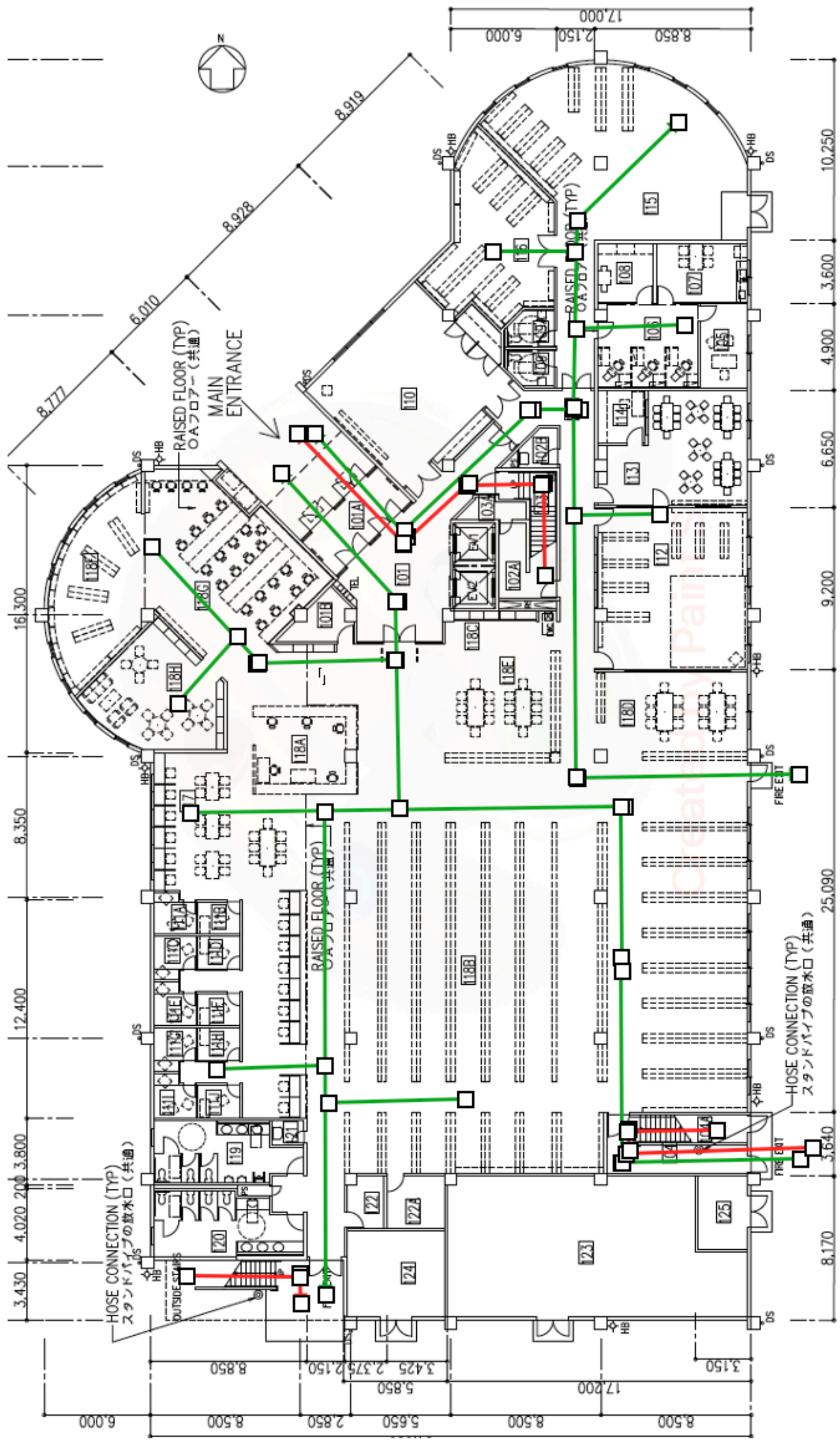


Figure 9: First Floor Plan Identification of Means of Egress

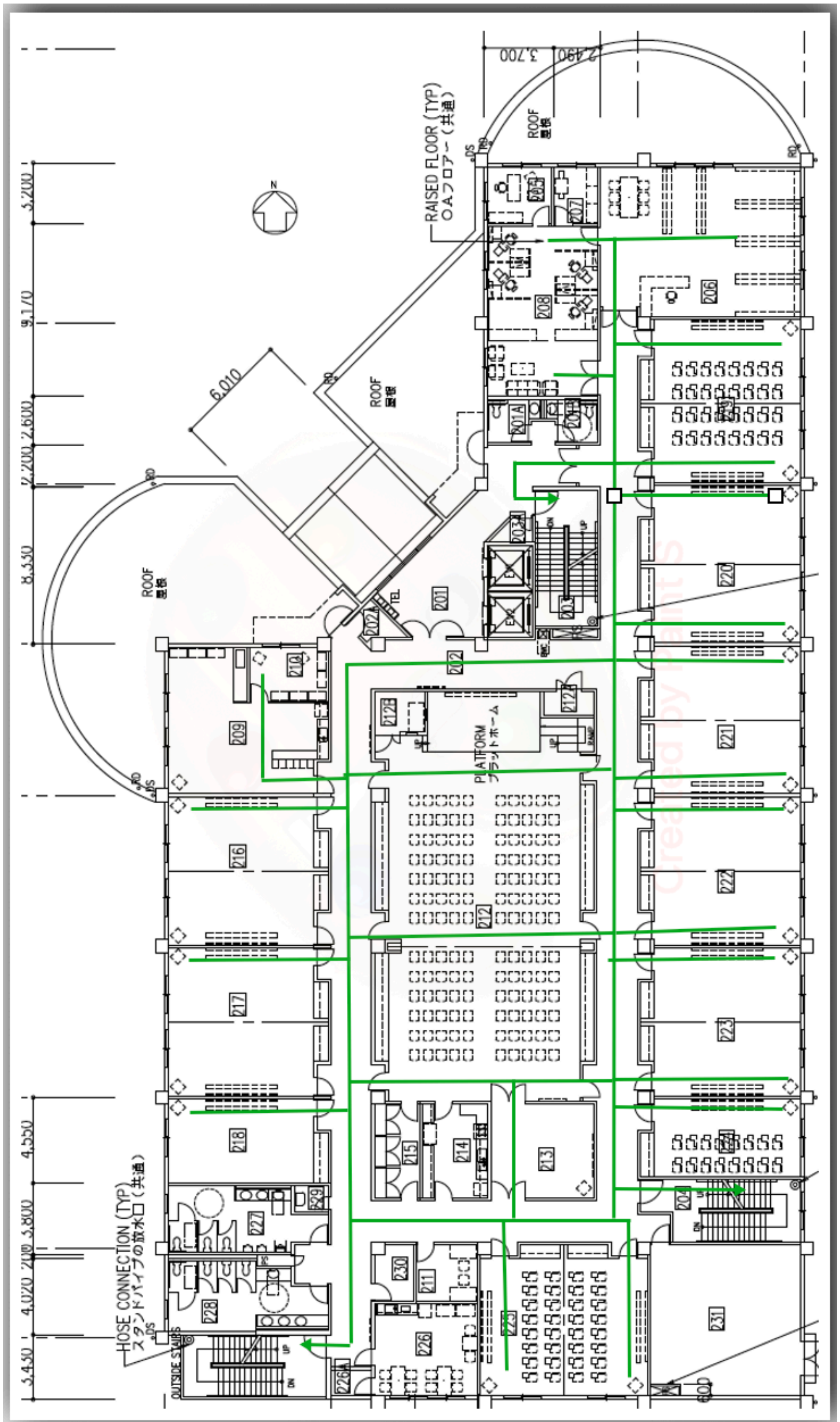


Figure 10: Second Floor Plan Identification of Means of Egress

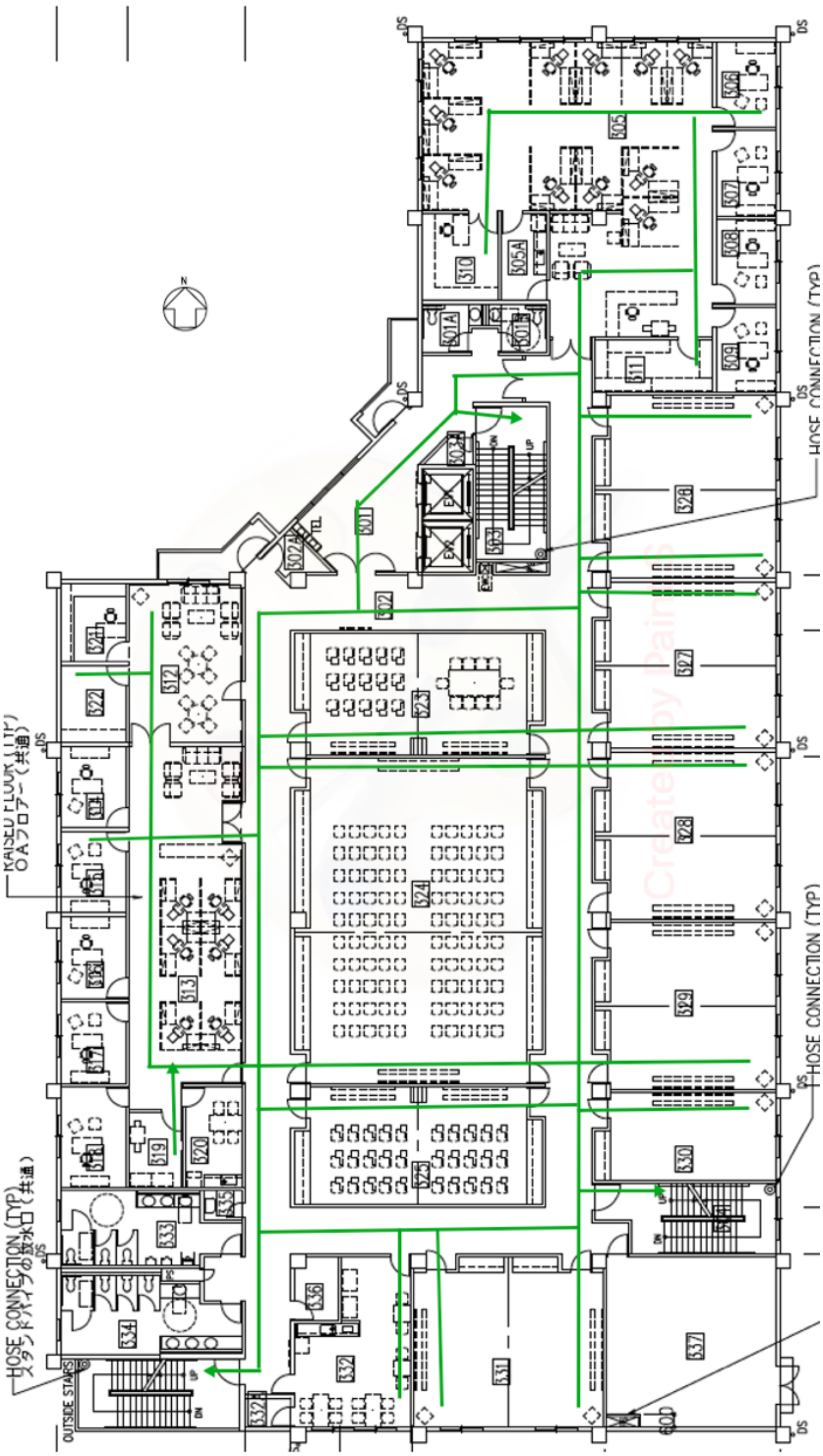


Figure 11: Third Floor Plan Identification of Means of Egress

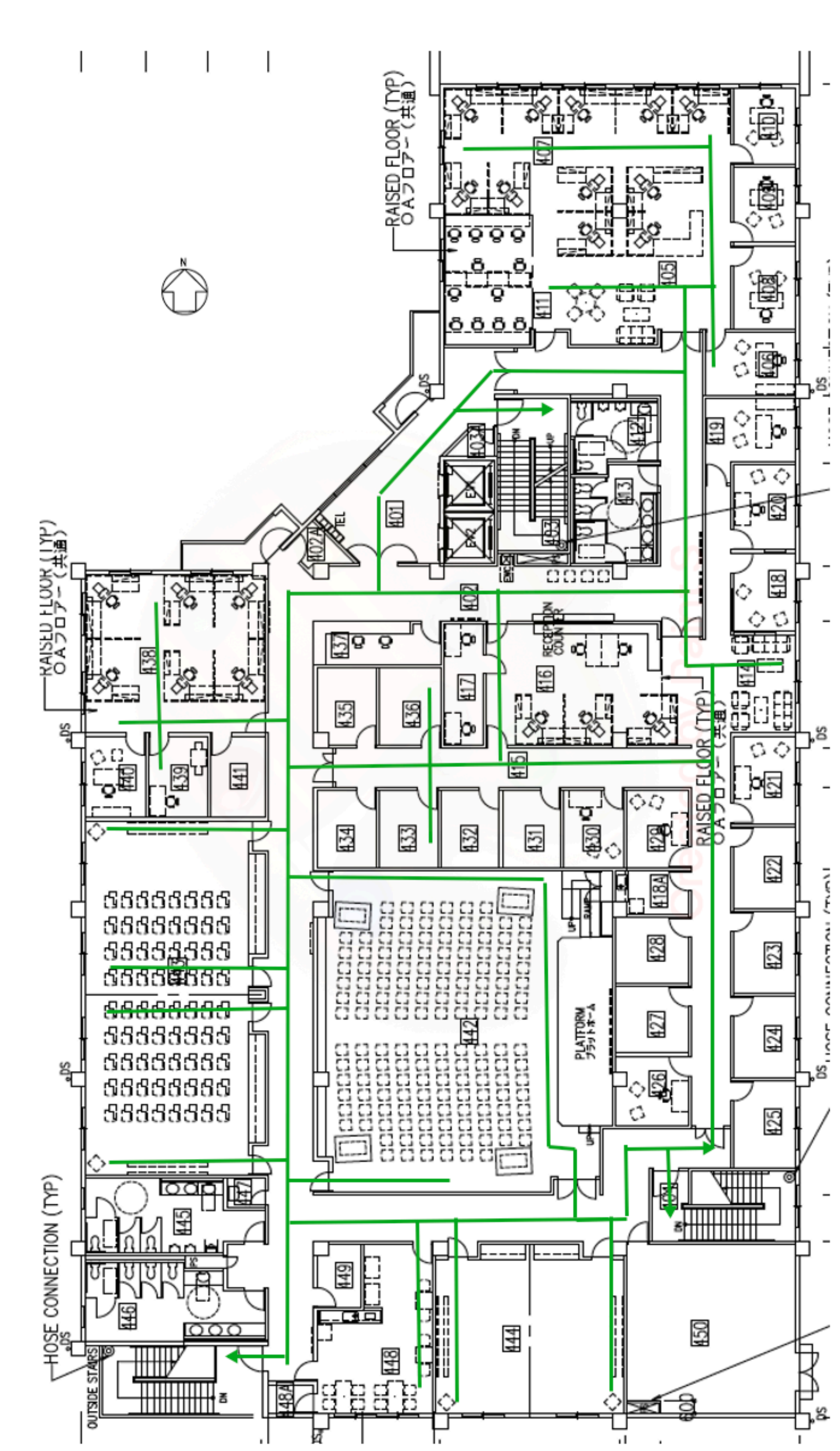


Figure 12: Fourth Floor Plan Identification of Means of Egress

OCCUPANT LOAD

The occupancy type and occupancy load factors according to the 2015 Life Safety Code, Table 7.3.1.2 were used to calculate the occupant load for each space identified in the Community Support Center floor plan. Table 5 is the occupancy load summary for the subject facility.

Table 5: Occupancy Load Summary for NA893 Community Support Facility

Occupancy	Area (sq ft)	Occupant Load Factor	Occupant Load
FIRST FLOOR			
Office	623	100	7
Library	11605	100	117
Study/Reading	1460	20	73
Assembly	981	15	66
Storage	1830	300	7
		SUBTOTAL	270
SECOND FLOOR			
Office	767	100	8
Classroom	6657	20	333
Library Reading	1023	50	21
Assembly	2067	15	139
		SUBTOTAL	501
THIRD FLOOR			
Office	3595	100	36
Classroom	6010	20	301
Assembly	609	15	41
		SUBTOTAL	378
FOURTH FLOOR			
Office	4609	100	47
Classroom	4795	20	239
Waiting	571	50	12
		SUBTOTAL	298

Verification that the number of exits are adequate for each floor / space

According to the 2015 Life Safety Code, Section 7.4.1.2, the number of means of egress from any story or portion thereof, other than for existing buildings as permitted in Chapters 11 through 43, shall be as follows:

(1) Occupant load more than 500 but not more than 1000—not less than 3
(2) Occupant load more than 1000 — not less than 4

According to the calculated occupant load for the second floor of this facility, the calculated occupant load is 501 people. In accordance with the 2015 Life Safety Code, not less than three exits will be required. According to the floor plans of the given facility, three exits have been provided.

For the occupant load calculated in the previous section of this project paper, the number of exits would be sufficient.

Calculation of the exit capacity from each floor / space

7.3.3.1 Egress capacity for approved components of means of egress shall be based on the capacity factors shown in Table 7.3.3.1, unless otherwise provided in 7.3.3.2.

7.3.3.2* For stairways wider than 44 in. (1120 mm) and subject to the 0.3 in. (7.6 mm) width per person capacity factor, the capacity shall be permitted to be increased using equation 7.3.3.2.

Table 6: Capacity Factors from NFPA101 Section 7.3.3.1

Table 7.3.3.1 Capacity Factors

	Stairways (width/person)		Level Components and Ramps (width/person)	
Area	**in.**	**mm**	**in.**	**mm**
Board and care	0.4	10	0.2	5
Health care, sprinklered	0.3	7.6	0.2	5
Health care, nonsprinklered	0.6	15	0.5	13
High hazard contents	0.7	18	0.4	10
All others	0.3	7.6	0.2	5

7.3.3.2* For stairways wider than 44 in. (1120 mm) and subject to the 0.3 in. (7.6 mm) width per person capacity factor, the capacity shall be permitted to be increased using the following equation:

$$C = 146.7 + \left(\frac{Wn - 44}{0.218}\right) \qquad \textbf{[7.3.3.2]}$$

where:

C = capacity, in persons, rounded to the nearest integer

Wn = nominal width of the stair as permitted by 7.3.2.2 (in.)

For the first floor, the occupants in the main library will be exiting through the two sets of double doors in the north, the single door exit to the west, and the double doors to the south-east.

North Exit Doorway Capacity: 4 x 47.2 in / (0.2 in/person) = 944 people
West Exit Doorway Capacity: 47.2 in / (0.2 in/person) = 236 people
South-East Exit Doorway Capacity: 2 x 47.2 in / (0.2 in/person) = 472 people

The Egress Capacity from the first floor is calculated to be 1,652 people. It should be noted that the occupants from the second floor through fourth floors exiting through the North Stairway will most likely exit through the Main Exit in the North. However, the capacity of the two sets of double doors in the North Exit is large enough to handle the capacity.

North Exit Stairway Capacity: 146.7 + (64 – 44) /0.218 = 238 people
West Exit Stairway Capacity: 146.7 + (64 – 44) /0.218 = 238 people
East Exit Stairway Capacity: 146.7 + (64 – 44) /0.218 = 238 people

North Exit Stairway Capacity calculated using equation 7.3.3.2 in the 2015 Life Safety Code since the width is 64 inches.

The egress capacity is equal to the sum of the East Exit Stairway Capacity, West Exit Stairway Capacity, and the North Exit Doorway Capacity since these are the limiting capacities.

Egress Capacity = 238 + 238 + 238 = 714 people

The Egress Capacity for the second through fourth floors are 714 people. The East and West Exit Stairways will exit directly to the exterior of the facility. The interior norther stairway will exit through the two sets of double doors in the north.

For the occupant load calculated in the previous section of this project paper, the egress capacity would be sufficient.

Verification that the arrangement of exits is appropriate

According to the 2015 Life Safety Code, Section 7.5.1.1, exits shall be located, and exit access shall be arranged, so that exits are readily accessible at all times.

According to the 2015 Life Safety Code, Section 7.5.1.3.3 In buildings protected throughout by an approved, supervised automatic sprinkler system in accordance with Section 9.7, the minimum separation distance between two exits, exit accesses, or exit discharges, measured in accordance with 7.5.1.3.2, shall be not less than one-third the length of the maximum overall diagonal dimension of the building or area to be served.

Based on the floor plan provided, the diagonal distance of the community support center is 73.8 meters. Therefore, the minimum separation distance between the exits should be 24.6 meters.

There is more than 30 meters between the north exit and the other two exits. There is 25.1 meters distance between the east and west exits. Therefore, the exits conform to the 2015 LSC standards as shown in Figure 13 below.

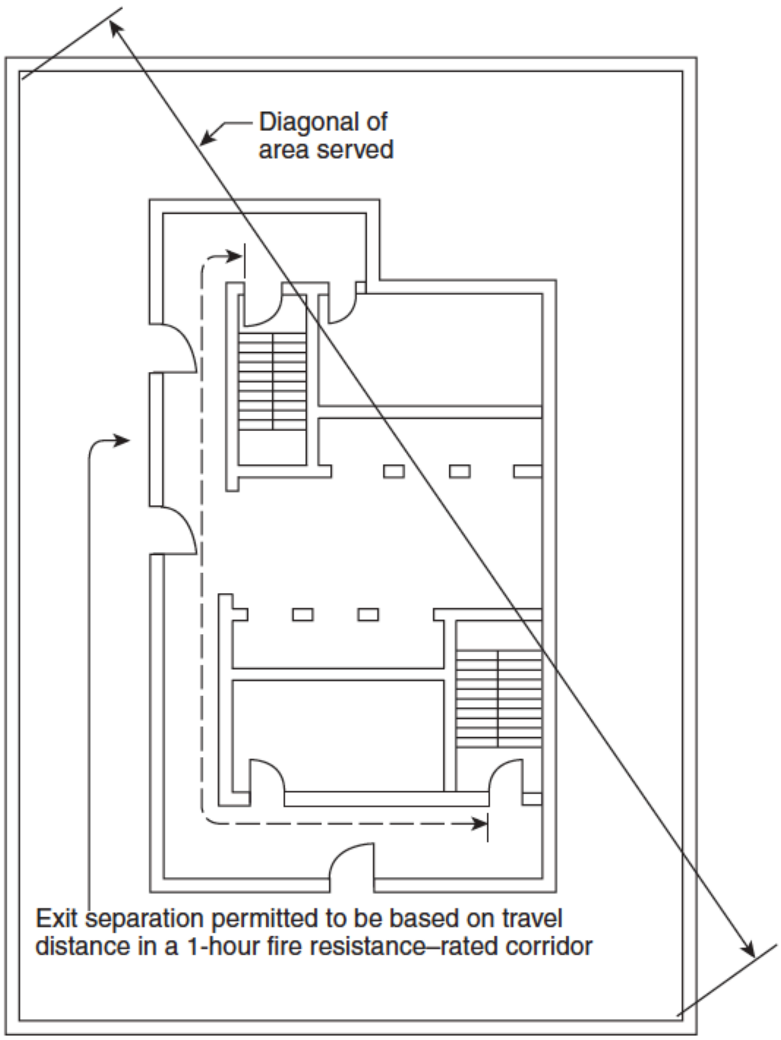


FIGURE A.7.5.1.3.4 Exit Separation Measured Along Corridor Path.

Figure 13: Exit Separation Measurement Method from NFPA101 Section 7.5.1

According to the 2015 Life Safety Code Table A.7.6, for an existing Assembly Occupancy, the travel distance limit is 76 meters for a sprinklered facility.

The community support facility is a sprinklered facility. The furthest travel distance in the community support center is from the northeastern corner of the building to the northern exit is 27.4 meters on all floors.

The travel distance in the community support facility is less than 76 meters and thus in compliance with the travel distance limit for an Assembly Occupancy for a sprinklered facility.

FIRE RESITANCE REQUIREMENTS

Identification of any horizontal exits that are used in the building

Horizontal exits are an egress design option recognized in accordance with *2015 International Building Code* (IBC), Section 1026 and/or 2015 NFPA 101, *Life Safety Code*, Section 7.2.4.

The concept of a horizontal exit is to create a safe refuge area separated from the fire area by a two-hour fire-resistance-rated separation. Horizontal exits are used to provide an exit from one area of the building to another area without the use of exit enclosures.

This building design currently does not utilize horizontal exits.

Identification required fire resistance ratings for corridors and stairways in the building

The Fire Resistance Ratings for the corridors and stairways are defined in both the 2015 Life Safety Code and the 2015 International Building Code.

According to the 2015 LSC Table 8.3.4.2 and 2015 IBC Section 1023, interior exit stairway enclosures shall have a Fire Resistance Rating of no less than 2 hours when connecting four stories or more.

According to the 2015 LSC Table 8.3.4.2 and 2015 IBC Section 1024, exit passages or corridors shall have walls, floors, and ceilings with a Fire Resistance Rating of no less than 1 hour.

Exit enclosures must terminate at an exit discharge, exit passageway or a public way. Where an exit passageway is used to extend the exit enclosure, the enclosure shall be separated from the passageway by a fire barrier or horizontal assembly with a Fire Resistance Rating equal to that required for the exit enclosure. A fire door assembly shall be installed in the fire barrier to provide a means of egress from the exit enclosure to the exit passageway. The “Exit Discharge” section of this report provides more detail about exit enclosure termination.

Identification where you would recommend placing exit signs on each floor

Marking of means of egress requirements are defined in 2015 LSC Section 7.10 and IBC section 1011. Means of egress shall be marked in accordance with Section 7.10 and IBC section 1011.

Exits, other than main exterior exit doors that obviously and clearly are identifiable as exits, shall be marked by an approved sign that is readily visible from any direction of exit access. Horizontal components of the egress path within an exit enclosure shall be marked by approved exit or directional exit signs where the continuation of the egress path is not obvious.

Access to exits shall be marked by approved, readily visible signs in all cases where the exit or way to reach the exit is not readily apparent to the occupants.
The path of egress travel to exits and within exits shall be marked by readily visible exit signs to clearly indicate the direction of egress travel in cases where the path of travel is not immediately visible to the occupants. Intervening means of egress doors within exits shall also be marked with exit signs. New sign placement shall be such that no point in an exit access corridor is in excess of the rated viewing distance or 100 ft (30 m), whichever is less, from the nearest sign.

According to LSC, Section 7.10.1.8, every sign required in Section 7.10 shall be located and of such size, distinctive color, and design that it is readily visible and shall provide contrast with decorations, interior finish, or other signs. No decorations, furnishings, or equipment that impairs visibility of a sign shall be permitted. No brightly illuminated sign (for other than exit purposes), display, or object in or near the line of vision of the required exit sign that could detract attention from the exit sign shall be permitted.

According to LSC, Section 7.10.1.9, the bottom of new egress markings shall be located at a vertical distance of not more than 6 ft 8 in. (2030 mm) above the top edge of the egress opening intended for designation by that marking. Egress markings shall be located at a horizontal distance of not more than the required width of the egress opening, as measured from the edge of the egress opening intended for designation by that marking to the nearest edge of the marking. Illuminated exit signs must illuminated at all times and provided with an emergency power source with a duration of at least 90 minutes from storage batteries or a generator.

According to LSC, Section 7.10.1.3, tactile signage shall be provided to meet all of the following criteria, unless otherwise provided in 7.10.1.4:

(1) Tactile signage shall be located at each exit door requiring an exit sign.
(2) Tactile signage shall read as follows: EXIT.
(3) Tactile signage shall comply with ICC/ANSI A117.1, American National Standard for Accessible and Usable Buildings and Facilities.

Exit signs applicable to the Project building are outlined on the attached floor plans sheets. These exit signs are only shown on the exterior egress doors, and are not shown on any interior circulation portions of the building.

Identification the interior finish requirements for (1) exits; (2) corridors; and (3) other spaces

Interior finishes need to comply with Chapter 8 of the IBC. IBC Table 803.5 gives interior wall and ceiling flame spread finish requirements by occupancy type for the room or area. As a general rule, the installation of a fire sprinkler system usually allows for a one "class" reduction for the IBC Table 803.5 requirements. According to the 2015 IBC Section 3, the first floor will be characterized as Assembly Group 3 as per Section 303.4. Also, as per the 2015 IBC Section 3, the second through fourth floors will be characterized as Business Group B as per Section 304.1.

Interior finishes are classified according to the ASTM E 84 standard according to three classes for ASTM E 84 flame spread and smoke developed indices:

- Class A: flame spread 0-25, smoke developed 0-450.
- Class B: flame spread 26-75, smoke developed 0-450.
- Class C: flame spread 76-200, smoke developed 0-450.

Table 7: Interior Finish by Occupancy according to 2015 IBC Table 803.11

GROUP	SPRINKLERED[l]			NONSPRINKLERED		
	Interior exit stairways and ramps and exit passageways[a, b]	Corridors and enclosure for exit access stairways and ramps	Rooms and enclosed spaces[c]	Interior exit stairways and ramps and exit passageways[a, b]	Corridors and enclosure for exit access stairways and ramps	Rooms and enclosed spaces[c]
A-1 & A-2	B	B	C	A	A[d]	B[e]
A-3[f], A-4, A-5	B	B	C	A	A[d]	C
B, E, M, R-1	B	C	C	A	B	C
R-4	B	C	C	A	B	B
F	C	C	C	B	C	C
H	B	B	C[g]	A	A	B
I-1	B	C	C	A	B	B
I-2	B	B	B[h, i]	A	A	B
I-3	A	A[j]	C	A	A	B
I-4	B	B	B[h, i]	A	A	B
R-2	C	C	C	B	B	C
R-3	C	C	C	C	C	C
S	C	C	C	B	B	C
U	No restrictions			No restrictions		

According to Table 803.11, interior wall and ceiling finish by occupancy, the following interior finishes shall apply:

This project facility is fully sprinklered. There are two different occupancies in this facility. The Group A-3 occupancy space shall have a Class B interior finish for the interior exit stairways and passageways and corridors and encloses for exit access stairways and ramps. The Group A-3 occupancy space shall have a Class C interior finish for the rooms and enclosed spaces. The Group B occupancy space shall have a Class B interior finish for the interior exit stairways and passageways. The Group B occupancy space shall have a Class C interior finish for the rooms and enclosed spaces and corridors and encloses for exit access stairways and ramps.

OCCUPANT TYPE AND PRE-MOVEMENT ACTIVITIES

Identification of occupants within the building

The project facility is located on a US military base in Japan. This facility is primarily designed for US military servicemen who are able bodied. This facility can also be used by the dependents of the US military as well as federal employees. Since this is an OCONUS (Outside the Continental United States) location, the US government will not allow civilians that are handicapped. Therefore, all the people who will be using this facility will be free of any handicap.

Since the project facility is a federal building on a US military installation, a fire warden will be appointed. It is the duty of the fire warden to ensure that the typical users of the facility are aware of the means of egress available and processes of evacuation. To ensure this knowledge, the fire warden must conduct fire drills of the facility annually and after large turnover of personnel.

Summary of the characteristics of occupants that will influence their egress times, including pre-movement and movement times

There are many factors that affect the pre-movement times of occupants in buildings when alerted to fire. Audio, visual and physical cues can all affect how fast an occupant will respond to a fire. How occupants are first notified has a potential impact on how quick they leave the area and the building.

Audio factors would include fire alarm and notification by others. Fire alarm systems required in accordance with the applicable requirements of NFPA 72, National Fire Alarm and Signaling Code. To ensure operational integrity, the fire alarm system shall have an approved maintenance and testing program complying with the applicable requirements of NFPA 70, National Electrical Code. This facility is equipped with a smoke alarm and detection systems in accordance with the 2015 LSC Section 9.6.2.10. Occupant notification shall be provided to alert occupants of a fire or other emergency where required by 2015 LSC Section 9.6.3.1. Audio occupant notification will be supported by a PA system that is also installed in this facility.

Visual factors would include seeing the fire, seeing smoke, or seeing something stemming from the impact of the fire. Visual fire alarm systems has been installed as per

2015 LSC Section 9.6.3.5. These visual cues will also help occupants realize that a fire is occurring in the facility.

Physical factors would include smelling the smoke, feeling the heat from the fire, feeling the building move from fire impact, or feeling an impact from the fire on the building. The activation of the fire sprinkler system would be an example of a physical factor. These physical cues will also help occupants realize that a fire is occurring in the facility.

According to the SFPE handbook, there are seven psychological and physical processes that are relevant to pre-movement time. The seven factors include recognition, validation, definition, evaluation, commitment, and reassessment.

Recognition: The occupant is first made aware of a potential fire through visual, audio, or physical cues. Although the occupant may not directly be aware of the fire itself, fire alarms or notification through others will make the occupant aware of the fire incident.

Validation: The second reaction to a potential fire event is to validate if there is an actual fire. During this process the occupant may try to obtain more information about the event. The occupant will try to verify if there is a fire through gathering more information or determine if it is a false alarm.

Definition: Once enough information is gathered, the occupant can determine if there is a fire. The occupant, at this phase, determine that there is a fire or not and begins to consider the next options.

Evaluation: Once that the occupant has determined that there is a fire in the definition, stage, he or she will consider or evaluate their options. Since there is a fire, the occupant will try to determine how best to egress the facility. There may be smoke coming out of one exit, so the occupant will need to use another exit. Otherwise, there may be instruction from fire officials telling the occupants how to best egress.

Commitment: During this phase, the occupant will determine the best course of action to get out of harms way. If there is a clear path out, the occupant must commit to leaving through that exit. If the means of egress is blocked, the occupant may need to commit to stay by a window to call for help from outside responders to the fire.

Reassessment: Reassessment is the final phase in which the occupants must consider if they made the correct choice or not. The greater the magnitude of the event the higher the reassessment process will occur over and over in the occupants mind.

Identification and justification of the pre-movement activities and times that you think are appropriate for your building based on the relevant occupant characteristics

Based off of these occupant characteristics, there are six building characteristics that can help reduce the pre-movement times of the occupants.

Types of warning systems: In accordance with the applicable requirements of NFPA 72, this facility will have fire alarm and detection systems installed. Furthermore, occupant notification shall be provided to alert occupants of a fire or other emergency where required by 2015 LSC Section 9.6.3.1. The audibility and intelligibility need to be very clear to ensure that the occupants can understand what they need to do and where they need to go.

Building layout and wayfinding: These visual cues will also help occupants realize that a fire is occurring in the facility. Signage will be provided so that occupants of the facility spends less time finding the best route to egress the building.

Visual Access: Visual fire alarm systems has been installed as per 2015 LSC Section 9.6.3.5. Visual access of the other occupants or the fire alarm signaling is helpful for the occupants in making the decision to leave. Seeing the other occupants fleeing, or remaining in place holds importance in the occupant's mind. Also, the ability to see clearly to the exits and seeing the exits defined has an impact on the occupant.

Training: Since this is a military installation and it is a federal building, it is mandated by the UFC 3-600-2 that occupants of the facility receive mandatory training on how to egress the facility in times of a fire event. Training of the occupants will help reduce the pre-movement time of the occupants.

Table 8: Pre-movement Time by Type of Occupancy

Occupancy	Number of observations	Distribution (s)	Mean (min–max) (s)	SD (s)
Office	45	Loglogistic $(\gamma = 0; \beta = 52.5; \alpha = 3.0)$	64.4 (12–201)	45.6
Cinema (voice alarms)	891	Loglogistic $(\gamma = 0; \beta = 40.5; \alpha = 5.8)$	44.0 (17–138)	18.0
Cinema (siren)	89	Lognormal $(\mu = 25.0; \sigma = 6.2)$	30.0 (14–179)	28.1
Cinema (alarm bell)	880	Loglogistic $(\gamma = 0; \beta = 29.5; \alpha = 5.0)$	32.5 (11–224)	17.2
Department store	229	Lognormal $(\mu = 35.9; \sigma = 18.3)$	35.9 (5–111)	17.7
Restaurant/Café	27	Weibull $(\alpha = 3.8; \beta = 58.1)$	52.5 (20–86)	15.7
School	72	Gamma $(\alpha = 3.0; \beta = 24.5)$	74.9 (13–170)	42.3
Night club (active staff)	62	Weibull $(\alpha = 2.7; \beta = 52.5)$	46.6 (11–87)	18.7
Night club (passive staff)	84	Loglogistic $(\gamma = 0; \beta = 50.6; \alpha = 2.3)$	65.4 (5–417)	64.0

The occupants of this facility are able-bodied personnel and are very well trained. The facility itself has very clear egress signage and has fire alarm systems to notify all its occupants on when and how to egress the facility. Due to these factors, there should be very little time spent on pre-movement activities.

During a fire drill, occupants on any military facility are trained to turn their attention to evacuation while leaving all their belongings in their place since they are aware that it is a drill and they will return to their posts in minutes. However, during a real fire, the occupants of this facility may take time to consider what to do. According to Guanquan and Sun, the effects of pre-movement time and occupant density on evacuation time was studied and the results are shown in Table 8. Schools are the most relevant to the subject project since the occupants are awake and aware of their surroundings. According to this study, the student occupants took an average of roughly 47 seconds to determine what to do and to prepare to leave the facility. Some of this time is spend on gathering one's belongings so they can evacuate the area. This scenario will be used as a conservative pre-movement time for the community support facility.

TIMED EVACUATION

Evacuation from First Floor: From Table 59.1 of the SFPE Handbook, the maximum specific flow through any 47.2 in door is 24 persons/min/ft effective width. Also, the effective width, We, of each door is 47.2 in - 12 in = 35.2 in or 2.93 ft. Therefore, using Equation 59.8, shown below in Figure 14, the flow through any door is limited to 24 persons/min/ft. The flow through the doors is 24 x 2.93 = 70.4 persons/min. In this case, there are six 47.2 in doors which would make the flow rate from the floor 70 x 3 = 420 persons/min. There are 270 people on the first floor so it will take 0.65 min for people from the first floor to evacuate.

$$F_c = F_s W_e \qquad (59.8)$$

where
F_c = Calculated flow
F_s = Specific flow
W_e = Effective width of the component being traversed

Figure 14: Calculated Flow Equation from SFPE Handbook

Evacuation from Second Floor: From Table 59.1 of the SFPE Handbook, the maximum specific flow through any 47.2 in door is 24 persons/min/ft effective width. Also, the effective width, We, of each door is 47.2 in - 12 in = 35.2 in or 2.93 ft. Therefore, using Equation 59.8, the flow through any door is limited to 24 persons/min/ft. The flow through the doors is 24 x 2.93 = 70.4 persons/min. In this case, there are three 47.2 in doors which would make the flow rate from the floor 70 x 3 = 210 persons/min. Since the flow capacity of the door is less than the flow capacity of the stairway served, the flow is controlled by the stairway exit doors. If all of the occupants in the second floor start evacuation, each stairway can discharge can discharge 70 persons/min per doorway/stairway. The population of 501 people from the second floor will require approximately 2.39 minutes (501 persons/210 persons/min = 2.39 min) to pass through the exits. An additional 0.44-minute travel time is required for the movement from the second floor to the first-floor exit. The total minimum evacuation time for the 501 persons located on the second floor is estimated at 2.83 minutes.

Evacuation from Third Floor: From Table 59.1 of the SFPE Handbook, the maximum specific flow through any 47.2 in door is 24 persons/min/ft effective width. Also, the effective width, We, of each door is 47.2 in - 12 in = 35.2 in or 2.93 ft. Therefore, using Equation 59.8, the flow through any door is limited to 24 persons/min/ft. The flow through the doors is 24 x 2.93 = 70.4 persons/min. In this case, there are three 47.2 in doors which would make the flow rate from the floor 70 x 3 = 210 persons/min. Since the flow capacity of the door is less than the flow capacity of the stairway served, the flow is controlled by the stairway exit doors. If all of the occupants in the third floor start evacuation, each stairway can discharge can discharge 70 persons/min per doorway/stairway. The population of 378 people from the third floor will require approximately 1.80 minutes (378 persons/210 persons/min = 1.80 min) to pass through the exits. An additional 0.80-minute travel time is required for the movement from the third floor to the first-floor exit. The total minimum evacuation time for the 378 persons located on the third floor is estimated at 2.60 minutes.

Evacuation from Fourth Floor: From Table 59.1 of the SFPE Handbook, the maximum specific flow through any 47.2 in door is 24 persons/min/ft effective width. Also, the effective width, We, of each door is 47.2 in - 12 in = 35.2 in or 2.93 ft. Therefore, using Equation 59.8, the flow through any door is limited to 24 persons/min/ft. The flow through the doors is 24 x 2.93 = 70.4 persons/min. In this case, there are three 47.2 in doors which would make the flow rate from the floor 70 x 3 = 210 persons/min. Since the flow capacity of the door is less than the flow capacity of the stairway served, the flow is controlled by the stairway exit doors. If all of the occupants in the fourth floor start evacuation, each stairway can discharge can discharge 70 persons/min per doorway/stairway. The population of 298 people from the fourth floor will require approximately 1.42 minutes (298 persons/210 persons/min = 1.42 min) to pass through the exits. An additional 1.22-minute travel time is required for the movement from the second floor to the first-floor exit. The total minimum evacuation time for the 298 persons located on the fourth floor is estimated at 2.62 minutes.

Table 9: Summary of Evacuation Rate Per Floor

Floor	Load	Evacuation Rate
First	270	0.65 min
Second	501	2.83 min
Third	378	2.60 min
Fourth	298	2.62 min

TOTAL EVACUATION TIME

Calculation of the total evacuation time

From Table 59.1 of the SFPE Handbook, the maximum specific flow through any 47.2 in door is 24 persons/min/ft effective width. Also, the effective width, We, of each door is 47.2 in - 12 in = 35.2 in or 2.93 ft. Therefore, using Equation 59.8, the flow through any door is limited to 24 persons/min/ft. The flow through the doors is 24 x 2.93 = 70.4 persons/min. In this case, there are three 47.2 in doors which would make the flow rate from the floor 70 x 3 = 210 persons/min.

Estimate flow capability of a stairway. From Table 59.1 of the SFPE Handbook, the effective width, W_e of each stairway is 64 in. – 12 in. = 52 in = 4.33 ft. Also, the effective width of each floor is 47.1 in – 12 in = 35.2 in = 2.93 ft. The maximum specific flow, F_{sm}, for the stairway from Table 59.5 of the SFPE Handbook is 18.5 person/min/ft effective width. Therefore, using Equation 4, the floor from each stairway is limited to 18.5 x 4.33 = 80.1 persons/min.

Since the flow capacity of the door is less than the flow capacity of the stairway served, the flow is controlled by the stairway exit doors.

Table 10: Summary of Total Evacuation Rate for Community Support Facility

Floor	Load	Evacuation Rate
Total	1447	6.05 min

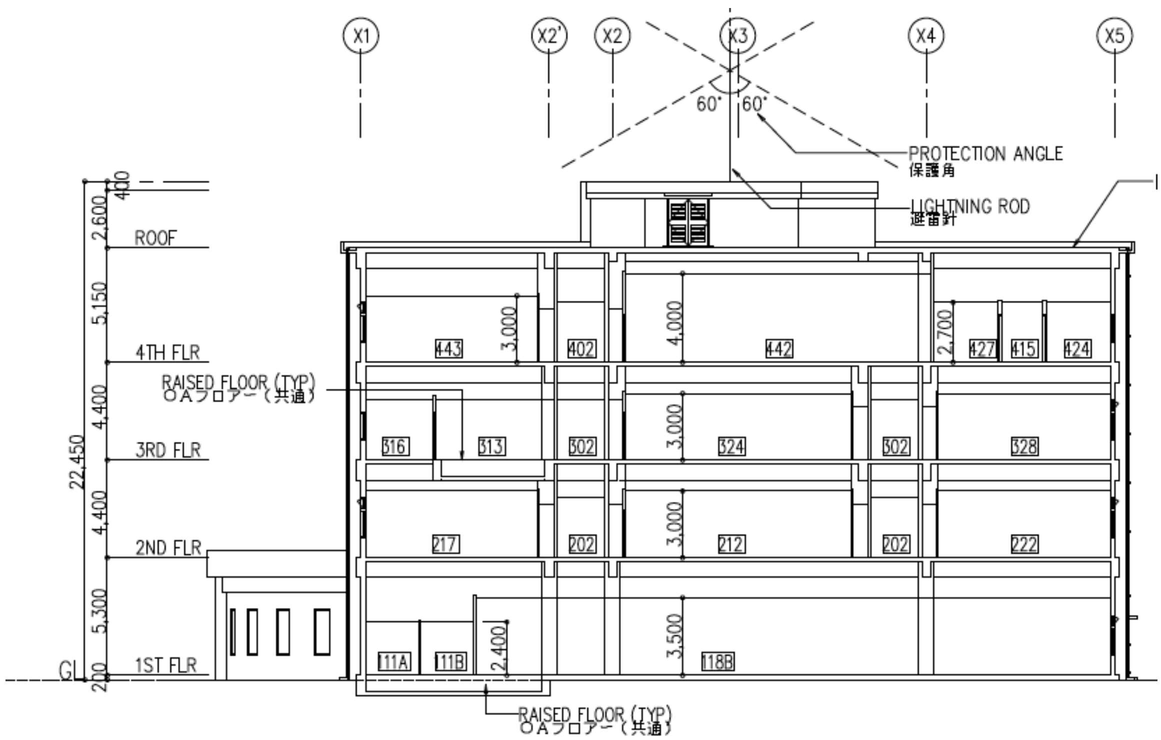


Figure 15: Section of NA893 Community Support Facility

Estimate building evacuation time. If all of the occupants in the building start evacuation at the same time, each stairway can discharge can discharge 70 persons/min per doorway/stairway. The population of 1,177 above the first floor will require approximately 5.61 minutes (1,177 persons/210 persons/min = 5.61 min) to pass through both exits. An additional 0.44-minute travel time is required for the movement from the second floor to the first-floor exit. The total minimum evacuation time for the 1,177 persons located on floors 2 through 4 is estimated at 6.05 minutes as shown in Table 10.

Significant assumptions for evacuation analysis

The facility used in the project paper uses a federal building fire in Japan. It is assumed that conventional US size is used in this building and therefore is presented in English units. The following are the assumptions made on the analysis of this building:

- There are four floors in this facility and the population above the first floor is 1,177 people. According to Figure 15, it is assumed that the floor-to-floor height is 12 ft since this facility is a standard office building from the second the fourth floor.
- The floor to floor height for the first floor is 15.6 ft (high ceiling) since it is a library.
- There are three stairways, located at the east, west, and north central corners.

- Each stairway is 64 in. wide with handrails protruding 2.5 in.
- It is assumed that the stair risers are 7 in. wide and the treads are 11 in. high since this facility is a standard office building.
- There are three 4 ft x 8 ft landings per floor of stairway travel.
- There are three 47.2 in. clear width door at each stairway entrance and exit.
- It is assumed that the first floor does not exit through stairways but through the main entrance/foyer of the building.
- Corridor terminates at stairway entrance door.

CONCLUSION FOR MEANS OF EGRESS

The NA893 Community Support Facility has three exits on the first floor: main entrance with two double doors to the north, a single door to the east, and a set of double doors to the south-east. There are three sets of stairwells in the facility which include an internal stairwell in the north which leads out from the main entrance in the north, an interior stairwell to the south-east, and an exterior stairwell to the south-west. The exits and stairwells are sized adequately to evacuate the facility with a full occupant load which is close to 1,500 people. The travel distances for egress is within the maximum allowable travel distance. The NA893 community support facility can be evacuated in 6.05 minutes.

FIRE ALARM AND DETECTION SYSTEM

INTRODUCTION

The facility that is used for the FPE596 project is a project that has been submitted for the Facilities Improvement Program in Japan. The Facilities Improvement Program is a program that is voluntarily executed by the Japanese Government for the US Forces in Japan as a cost sharing measure for maintaining a large US military presence in Japan.

The project that will be used for the FPE596 is NA893 Community Support Facility at Yokosuka Naval Base. The US government has proposed this project for adoption into the Facilities Improvement Program in 2000 and the project was designed and constructed by 2009.

The prepared planning document is a Criteria Package. The Criteria Package contains planning requirements for the subject facility but no design or construction activities has spent to create this document. According to congressional funding rules, only planning funds could be used during this phase of project development.

TYPE OF FIRE ALARM SYSTEM

This facility will be considered a federal facility once it is commissioned. Therefore, this facility will need to follow federal criteria. However, this facility will be designed and constructed under the Facilities Improvement Program of the Ministry of Defense of the Government of Japan. Therefore, this facility must meet Japanese standards as well. Finally, this facility is designed as a US military facility and must follow all applicable Unified Facilities Criteria dictated by the Department of Defense.

The fire alarm system will need to follow Federal Criteria, Department of Defense Criteria, and Japanese Government Criteria. Here are the specific applicable US requirements for the fire alarm system for this facility:

- International Building Code (IBC), 2015
- NFPA 30, Flammable and Combustible Liquids Code, 2015 Edition
- NFPA 45, Standard on Fire Protection for Laboratories Using Chemicals
- NFPA 70, National Electric Code, 2014 Edition
- NFPA 72, National Fire Alarm and Signaling Code, 2016 Edition
- NFPA 101, Life Safety Code, 2015 Edition
- UFC 3-460-01, Design Fuel Petroleum Facilities
- UFC 3-600-01, Fire Protection Engineering Facilities, 08 August 2016
- UFC 4-021-02, Mass Notification Systems
- UFC 4-310-03, DoD Fuels Laboratories Standards

Here are the specific Japanese Government requirements for the fire alarm system for this facility:

- Japanese Fire Service Law
- Smoke Exhaust and Damper Systems
- Standpipe Systems class II (Only Class I Standpipe is allowed by UFC 3-600-01)
- Fire Detector Systems (additional heat detection and Smoke detection beyond the requirements and recommendations of UFC3-600-01).

This report will concentrate of the fire alarm system for the facility. The fire alarm control panel will be located in Room 101, Vestibule, of this new building.

The single-line system diagram of the fire alarm and detection system is provided in this section in Figure 16 on the next page. The Fire Alarm Control Panel is connected to a power supply and is located in Room 101 Vestibule of the subject facility. Both initiating devices and alarm notification devices are connected to the fire alarm and detection system. The initiating devices include manual fire alarm stations, smoke detectors, and duct smoke detectors. These initiating devices will follow the criteria in accordance to the UFC 3-600-01, NFPA 72, or the Fire Service Law of Japan. Since there are many criteria to consider, the strictest criteria will be applied.

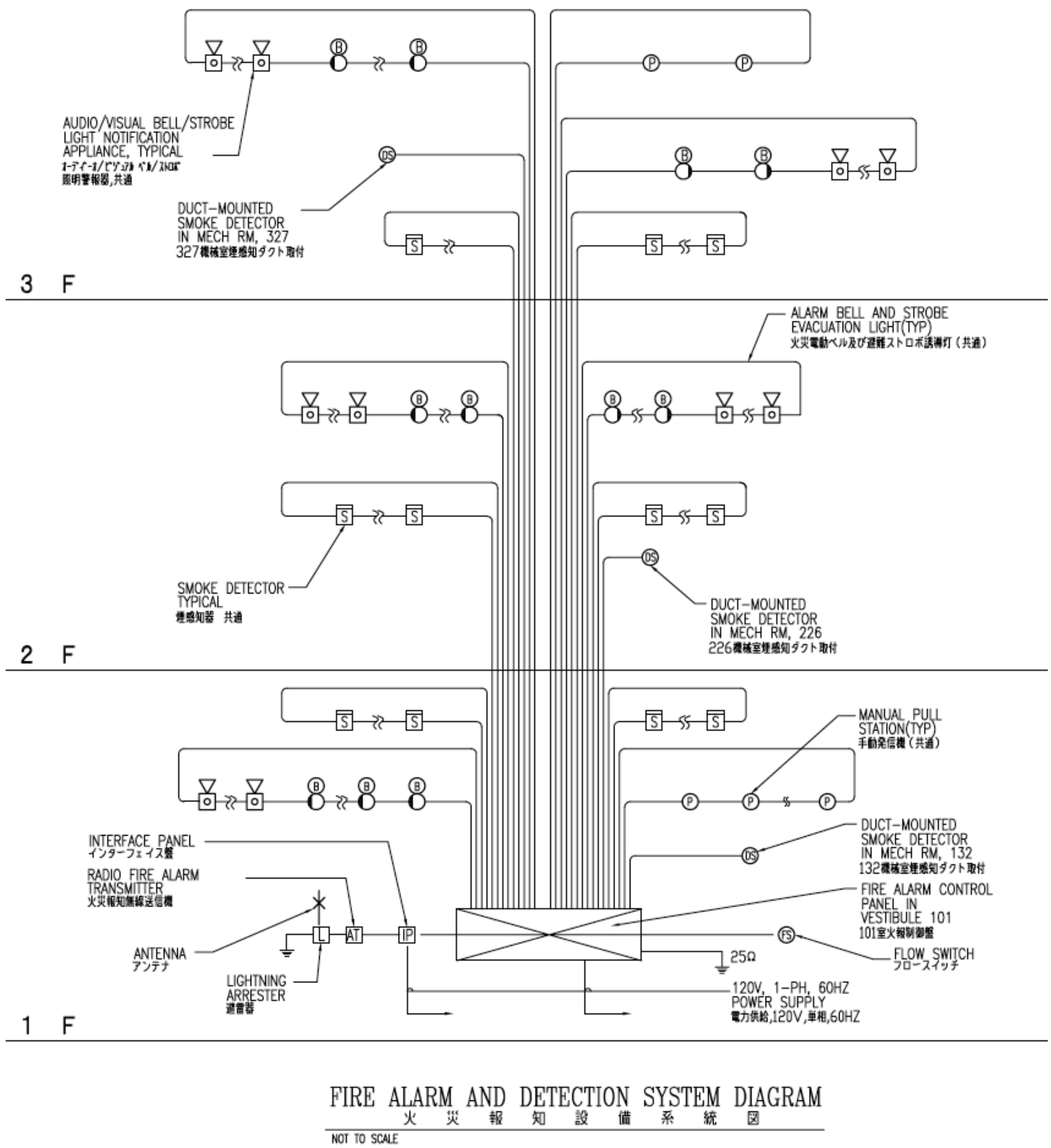


Figure 16: One Line Diagram of Fire Alarm and System Diagram

Notification appliances provides stimuli for initiating emergency action and provide information to users, emergency response personnel, and occupants. The NA893 Community Support Facility uses a combination of alarm horns or audible notification appliances, strobes or visual notification appliances, and horn/strobes or visual and audible notification appliances. In this project, the types and locations of alarm notification devices installed in the NA893 building will be identified and the location, spacing and placement of the alarm notification appliances installed in the building will be analyzed to see if it complies with the requirements of the National Fire Alarm Code 72.

According to the equipment list, the fire alarm panel will be acquired via the Facilities Improvement Program implemented via the Ministry of Defense of Japan. The fire alarm panel is identified as C-192, which means that it will be acquired and installed by the Japanese government. In this case, the fire alarm panel will be a Japanese product that meets the requirements of the US government. A sample fire alarm control panel by the manufacturer, Nittan, is shown below in Figure 17.

Figure 17: Sample Fire Alarm Control Panel by Nittan

The emergency public address system is required throughout the facility in accordance with NFPA 72 and Fire Services Act of Japan. The system may be used for general public address. Public address system shall be provided for an emergency audio distribution network, and shall include microphones, compact disk player, AM (and FM) radio tuner, (MD player) amplifiers, control for each input, output selector switches, wiring, loudspeaker, and all necessary accessories required to control and reproduce audio signals from any input source to any output location. . A single-line diagram of the emergency public address system is shown below in Figure 18.

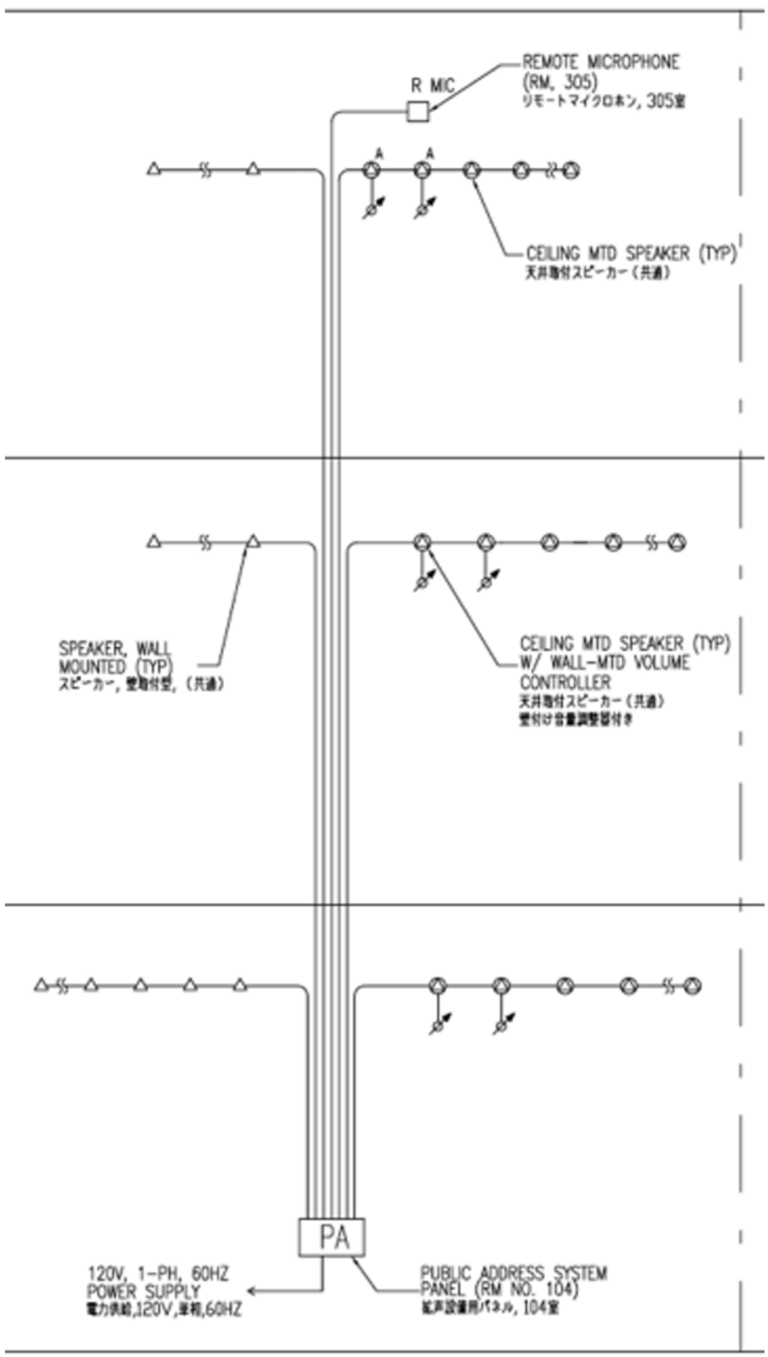


Figure 18: Single-Line Diagram for Public Address System

INITIATING DEVICES

There are several different types of initiating devices installed in the building. The initiating devices include manual fire alarm stations, smoke detectors, and duct smoke detectors. These initiating devices will follow the criteria in accordance to the UFC 3-600-01, NFPA 72, or the Fire Service Law of Japan. Since there are many criteria to consider, the strictest criteria will be applied.

Figure 19: Sample Manual Fire Alarm Station by Nittan

Manual fire alarm stations shall be located in the normal path of exit from the building. They shall be unobstructed and accessible. According to NFPA 72, Section 14, manually actuated alarm-initiating devices or manual pull stations shall be mounted not less than 42 in. (1.07 m) and not more than 48 in. (1.22 m) from the finished floor. Manual pull stations are also required to be located within 60 inches (1.52 m) of the exit doorway opening at each exit on each floor. Additional pull stations are required to be provided so that the travel distance to the nearest pull station will not be in excess of 200 feet (61.0 m), measured horizontally on the same floor. A sample manual fire alarm station by the manufacturer, Nittan, is shown below in Figure 19.

The manual fire alarm stations can be found in the following locations:

- Room 101 Lobby/Vestibule
- Room 118B Southeastern Staircase at Library
- Room 118B Eastern Exit from Library
- Room 118B Southwestern Exit from Library
- Room 124 Emergency Generator Room
- Room 125 Fire Pump Room
- Room 118C Display Room
- Room 123 Mechanical Room
- Room 201 Elevator Lobby

- Room 202A Computer Room
- Corridor outside room 212A Storage
- Corridor outside room 224 Classroom
- Corridor outside room 226 Breakroom
- Room 301 Elevator Lobby
- Corridor outside room 323 Training Room
- Corridor outside room 330 Classroom
- Corridor outside room 332 Breakroom
- Room 401 Elevator Lobby
- Room 416 Reception
- Corridor outside room 402 Doctor's Office
- Corridor outside room 444 Classroom
- Corridor outside room 448 Breakroom

There are 22 manual fire alarm stations in total for this facility.

Figure 20: Sample Smoke Detector by Nittan

According to NFPA 72 Section 17.7.3.2, spot-type smoke detector are required to be located on the ceiling, or wall mounted between the ceiling and 12 inches (300 mm) down from the ceiling to the top of the detector. In the absence of specific performance-based design criteria, one of the following requirements shall apply:

(1) The distance between smoke detectors shall not exceed a nominal spacing of 30 ft (9.1 m) and there shall be detectors within a distance of one-half the nominal spacing, measured at right angles from all walls or partitions extending upward to within the top 15 percent of the ceiling height.
(2) All points on the ceiling shall have a detector within a distance equal to or less than 0.7 times the nominal 30 ft (9.1 m) spacing (0.7S).

Smoke detectors shall be provided for corridors and passageways in accordance with Section 21 of the Fire Service Law of Japan. At least one smoke detector shall be provided for every 15 meters of vertical distance. Smoke evacuation system shall comply with Article 126, 2-1 of Building Standard Law of Japan. A sample smoke detector by the manufacturer, Nittan, is shown below in Figure 20.

The spot type smoke detectors can be found in the following locations:

- Room 101 Lobby/Vestibule
- 2 in Room 102 Corridor
- Room 103 Staircase
- Room 104A Staircase
- Room 115 Reading Room Entry/ Corridor
- Room 118B Library Bookstack Corridor
- Room 201 Lobby
- 6 in Room 202 Corridor
- Room 203 Staircase
- Room 204 Staircase
- Room 301 Lobby
- 8 in Room 302 Corridor
- Room 303 Staircase
- Room 304 Staircase
- Room 401 Lobby
- 8 in Room 402 Corridor
- Room 403 Staircase
- Room 404 Staircase

There are 32 spot type smoke detectors in total for this facility.

Air Duct Smoke Detector

According to NFPA 72 Section 17.7.5.5, detectors in air duct systems shall be mounted in accordance with the manufacturer's published instructions and shall be accessible for cleaning by providing access doors or control units in accordance with NFPA 90A. According to NFPA 90A Section 6.4, detectors in air duct systems shall be located downstream of the air filters and ahead of any branch connections in air supply systems having a capacity greater than 944 L/sec (2000 cfm). At each story prior to the connection to a common return and prior to any recirculation or fresh air inlet connection in air return systems having a capacity greater than 7080 L/sec (15,000 cfm) and serving more than one story. A sample air duct smoke detector by the manufacturer, Nittan, is shown below in Figure 21.

Figure 21: Sample Air Duct Smoke Detector by Nittan

Return system smoke detectors are not required where the entire space served by the air distribution system is protected by a system of area smoke detectors, or for fan units whose sole function is to remove air from the inside of the building to the outside of the building. Where provided, duct smoke detectors are required to be provided with a remote test station. Duct smoke detectors are required to automatically stop their respective fan(s) upon detecting the presence of smoke.

The air duct smoke sensors can be found in the following rooms:

- Room 123 Mechanical Room
- Room 231 Mechanical Room
- Room 337 Mechanical Room
- Room 450 Mechanical Room
- Room 501 Mechanical Room

There are five air duct smoke sensors in total for this facility.

Heat Detector

Provide 65 degree C fixed temperature type heat detector in the elevator machine room to initiate disconnection of the elevator power supply prior to the activation of the sprinklers. The heat detector shall provide individual zone of protection for the elevator, such that initiation of the heat detector shall trip the shunt breaker of the elevator.

ANALYSIS OF INITIATING DEVICES

Based on the Criteria Package drawings that were developed on September 2004, the location, spacing and placement of the fire detection devices installed in the building comply with the requirements of the National Fire Alarm and Signaling Code will be determined.

NFPA 72 Section 17 contains requirements concerning the location and operation of manual fire alarm boxes. Essentially, manual fire alarm boxes are located at each required exit in the natural path of egress. In a corridor with exits at each end, a manual fire alarm box is located at the door to each exit. The box should be located on the same side as the door handle so that someone exiting from the space will see it easily. In most cases, it is best to locate the box within the corridor, not on the other side of the door, so that the pull station is located within the space it serves. In addition to locations at required exits, additional manual fire alarm boxes are required to ensure that there is less than a 200 ft (60 m) travel distance to a station. It is good practice to provide manual fire alarm boxes near the telephone operator's area of a hotel or hospital and near portable extinguishers placed adjacent to hazardous operations in a factory. NFPA 72 requires the mounting height of boxes to be between 31⁄2 ft (1.1 m) and 41⁄2 ft (1.4 m), although some locally adopted codes for the disabled might limit the height to no more than 4 ft (1.2 m). The NA893 Criteria Package does follow these instructions and additional manual pull stations are not required.

NFPA 72 Section 17 classifies automatic fire detectors as either spot-type, line-type, or air-sampling detectors. Spot-spot-type detectors include conventional smoke and heat detectors. A spot-type detector's response to a given fire varies with the radial distance from the detector. The farther a fire is from the detector, the slower the response time of that detector. To illustrate, if a circle were drawn and the detector placed in the center, a given fire anywhere along the perimeter of the circle would result in the same response time. If the same fire were moved closer to the detector at the center of the circle, the response time would decrease. If placed farther away from the same fire, the same detector would have a longer response time. Engineers may adjust detector spacing in order to change the coverage radius and achieve shorter detection times for expected fires. Conversely, the spacing, and hence the radius, may be increased where longer response times are tolerable.

There does seem to be a lack of spot-type smoke detectors in the subject facility. It would be recommended to install smoke detectors in Room 104, Control and Monitoring Office, Room 109 Main Laboratory, and in many of the smaller occupied spaces adjacent to Room 109 within the 1st floor of the administration facility. On the 2nd floor of the administration facility, spot-type smoke detectors would be recommended in Room 203 Lunch/Break Room, Room 207 File Server Room, Room 209 Repair Shop, Rooms 214 and 216 Bunk Rooms, and 202 POL Office. On the 3rd floor of the administration facility, spot-type detectors would be recommended in Room 302 Conference Room, many of the offices, Room 310 Drawing File Storage, Room 313 Training/Conference Room, and Room 314 Computer Training Room. On the 1st floor of the shop area, spot-type detectors would be recommended in Room 141 Storage, Room 143 Carpentry Shop, Room 144 Metal Shop, Room 144 Electronics Shop, and Room 150 Paint Storage. These additional spot-type smoke detectors should bring the subject facility up to code in accordance to NFPA 72 Section 17.

Air-sampling detectors draw air samples from the protected area, through a tube or pipe, back to a remotely located detector. The tube or pipe might have several holes or sampling ports, or it might have only one. In any case, NFPA 72 treats the sampling port like a spot-type detector with respect to its location and spacing. The number and location of air duct smoke detectors seem to be adequate in accordance to NFPA 72 Section 17.

APPROPRIATE FIRE SCENARIO FOR PROJECT

Although there are many different functions within the NA893 Community Support Facility, Yokosuka Naval Base. The 4 story, reinforced concrete building generally houses the Light Hazard Occupancy functions such as the clinical space, offices, and classrooms. The first floor if the facility contains the Ordinary Hazard Group 2 Occupancy such as the main library.

The following is a brief summary of occupancy classifications for the different functions in the subject facility:

Classrooms:	Light Hazard Occupancy
Assembly Space:	Light Hazard Occupancy
Main Library:	Ordinary Hazard Group 2
Periodical Room:	Ordinary Hazard Group 2
Waiting Room:	Light Hazard Occupancy
Meeting Rooms Occupancy Classification:	Light Hazard Occupancy
Office Rooms Occupancy Classification:	Light Hazard Occupancy
Storage:	Ordinary Hazard Group 1

Library

The library consists of the majority of 1st floor and a reading room on the second floor of the facility. The main library consists of several large rooms with books and periodicals. The main library also consists of reading rooms, media rooms, and quiet study areas. The main library also has admnistrative spaces for the librarian and other staff. According to 2016 NFPA 13, the library is classified as a Ordinary Hazard Group 2 as per A.5.2.(7).

Meeting Rooms

The third floor includes a large conference room that can accommodate 64 people. According to 2016 NFPA 13, the meeting room is classified as a light occupancy hazard as per A.5.2.(5) educational.

Offices

All the floors of the NA893 Community Support Facility includes many single-occupant to multi-occupant offices. According to 2016 NFPA 13, the offices are classified as a light occupancy hazard as per A.5.2.(12) offices.

In this section, the appropriate fire scenarios and the expected response characteristics of the fire detection devices installed in the subject building will be identified and justified. The calculated fire size at the time of detector activation for the selected scenarios will be demonstrated. Although there are many occupancy types in this facility, the most common type of fire would be a fire in the main library. There will be three fire scenarios considered in the main library. The first is a fire in the main library book stacks, Room 118B. The second fire scenario would be in the small periodical room, Room 116. The final fire scenario would be in the media rooms, Room 111A-J.

Using a method recognized by Annex B of NFPA 72, the response of the smoke detection system to a workstation fire that starts as a computer monitor fire on top of a 30-inch high desktop and grows as a fast t-squared fire with a fire growth coefficient of α = 0.047 kW/s^2 is analyzed as follows as shown in Table 11:

Table 11: DETACT Input Table for NA893 Community Support Facility

INPUT PARAMETERS			CALC. PARAMETERS	
Ceiling height (H)	3.05	m	R/H	1.060
Radial distance (R)	3.2	m	dT(cj)/dT(pl)	0.289
Ambient temperature (To)	20	C	u(cj)/u(pl)	0.191
Actuation temperature (Td)	33.9	C	Rep. t2 coeff.	k
Response time index (RTI)	2	(m-s)1/2	Slow	0.003
Fire growth power (n)	2	-	Medium	0.012
Fire growth coefficient (k)	0.047	kW/s^n	Fast	0.047
Time step (dt)	1	s	Ultrafast	0.400

The ceiling height is defined in the problem statement to be 10 feet or 3.05 m. The radial distance is calculated based of a 30 feet square spacing. The ambient temperature is assumed to be 20 degrees Celsius. It is assumed that the workstation is made of wood. According to NFPA 72 Table B.4.7.5.3, the temperature rise for detector response is 13.9 degrees Celsius as shown in Table 12 below.

Table 12: Temperature Rise for Detector Response

TABLE B.4.7.5.3 Temperature Rise for Detector Response [18]

	Ionization Temperature Rise		Scattering Temperature Rise	
Material	*°C*	*°F*	*°C*	*°F*
Wood	13.9	25	41.7	75
Cotton	1.7	3	27.8	50
Polyurethane	7.2	13	7.2	13
PVC	7.2	13	7.2	13
Average	7.8	14	21.1	38

The actuation temperature is thus 33.9 degrees Celsius. The RTI should be small and assumed to be 2 $(m\text{-}s)^{0.5}$. The fire growth coefficient as a fast t-squared fire with a fire growth coefficient of $\alpha = 0.047\ kW/s^2$. The DETACT worksheet, which is a method recognized by Annex B of NFPA 72, is used to calculate when the first smoke detector would activate for this scenario. The photoelectric smoke detectors will activate right after 43 seconds for this scenario. The photoelectric smoke detectors will activate when the gas temperature reaches 33.9 degrees Celsius.

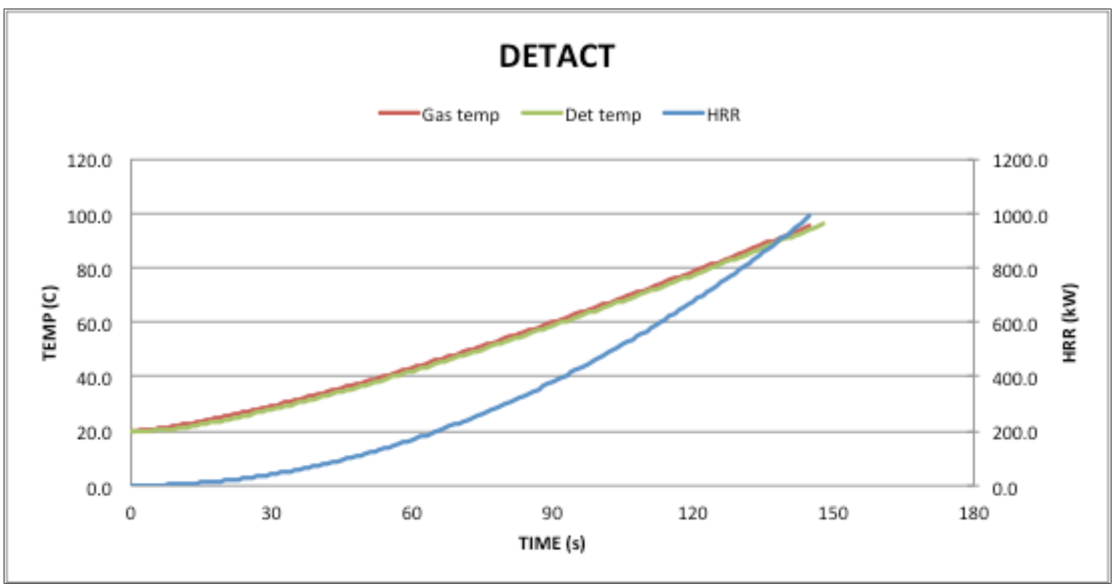


Figure 22: DETACT Graph for NA893 Community Support Facility

The heat release rate is approximately 87 kilowatts when first smoke detector activated as the gas temperature reaches 33.9 degrees Celsius at 43 seconds. Please refer to the attached Excel Worksheet for the justification in Appendix D.

ALARM NOTIFICATION DEVICE

Notification appliances provides stimuli for initiating emergency action and provide information to users, emergency response personnel, and occupants. The NA520 POL facility uses a combination of alarm horns or audible notification appliances, strobes or visual notification appliances, and horn/strobes or visual and audible notification appliances. In this section of the report, the types and locations of alarm notification devices installed in the NA893 building will be identified and the location, spacing and placement of the alarm notification appliances installed in the building will be analyzed to see if it complies with the requirements of the National Fire Alarm Code 72.

Audible Notification System

NFPA 72, Section 18.4 provides guidance on the location and system parameters of audible alarms. If ceiling heights allow, wall-mounted audible appliances are required to have their tops above the finished floors at heights of not less than 90 inches (2.29 m) and below the finished ceilings at distances of not less than 6 inches (150 mm). If combination audible/visible appliances are installed, the location of the installed appliance is determined by the requirements for visible notification appliances. For appliances that are an integral part of a smoke detector (sounder base), the appliance is required to be located in accordance with the requirements for smoke detectors. A sample audible notification system by the manufacturer, Nittan, is shown below in Figure 23.

Figure 23: Sample Audible Notification System by Nittan

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

Where audible appliances are installed to provide signals for sleeping areas, they shall have a sound level of at least 15 dB above the average ambient sound level or 5 dB above the maximum sound level having a duration of at least 60 seconds or a sound level of at least 75 dBA, whichever is greater, measured at the pillow level in the area required to be served by the system using the A-weighted scale (dBA).

Table 13: Average Ambient Sound Level per NFPA101

Table A.18.4.3 Average Ambient Sound Level According to Location

Location	Average Ambient Sound Level (dBA)
Business occupancies	55
Educational occupancies	45
Industrial occupancies	80
Institutional occupancies	50
Mercantile occupancies	40
Mechanical rooms	85
Piers and water-surrounded structures	40
Places of assembly	55
Residential occupancies	35
Storage occupancies	30
Thoroughfares, high-density urban	70
Thoroughfares, medium-density urban	55
Thoroughfares, rural and suburban	40
Tower occupancies	35
Underground structures and windowless buildings	40
Vehicles and vessels	50

As stated in previous sections, there are several different occupancies in this complex facility. In the reinforced concrete 3 story structure, the areas are made up of business occupancies which would have an average ambient sound level of 55 dBA, assembly occupancies which would have an average ambient sound level of 55 dBA, educational occupancies which would have an average ambient sound level of 45 dBA, institutional occupancies which would have an average ambient sound level of 5o dBA, and mechanical room occupancies which would have an average ambient sound level of 85 dBA, In the steel framed 1 story structure, there are storage occupancies which would have an average ambient sound level of 30 dBA, industrial occupancies which would have an average ambient sound level of 80 dBA, and mechanical room occupancies which would have an average ambient sound level of 85 dBA. The Nittan horn and horn strobe products have 33 audible settings and have the range and capacity to meet these requirements up to 105+ dBA.

The audible notification systems or alarm bells can be found in the following locations:

- Room 101 Lobby/Vestibule
- Room 102 Corridor
- Room 115 Technical Services Office
- Room 118B Main Library Stacks at Eastern Exit
- Room 118B Main Library Stacks at South-Western Exit
- Room 123 Mechanical Room
- Room 124 Fire Pump Room
- Room 125 Emergency Generator Room
- Room 201 Lobby
- Room 202 Corridor at Main Internal Exit
- Room 204 Outside of South-Eastern Exit
- Room 226 Outside of South-Western Exit
- Room 231 Mechanical Room
- Room 301 Lobby
- Room 302 Corridor at Main Internal Exit
- Room 304 Outside of South-Eastern Exit
- Room 322 Outside of South-Western Exit
- Room 335 Mechanical Room
- Room 401 Lobby
- Room 402 Corridor at Main Internal Exit
- Room 404 Outside of South-Eastern Exit
- Room 425 Outside of South-Western Exit
- Room 450 Mechanical Room
- Room 501 Smoke evacuation system room

There are 27 audible notification systems or alarm bells in total in this facility.

Visible Notification System

Visible fire alarm notification appliances often intended only to augment audible appliances. Although visible appliances may be the primary means of occupant notification in emergencies for hearing-impaired persons in the protected area or when ambient noise levels are high. Since this will be a military facility, everyone will need to be able-bodied personnel, so there will be no one assigned with a hearing handicap.

Figure 24: Sample Visible Notification System by Nittan

According to NFPA 72, Section 18.5, public mode visible signaling shall meet the requirements of Section 18.5 using visible notification appliances. Wall-mounted appliances shall be mounted such that the entire lens is not less than 80 in. (2.03 m) and not greater than 96 in. (2.44 m) above the finished floor or at the mounting height specified using the performance-based alternative of 18.5.5.6. A sample visible notification system by the manufacturer, Nittan, is shown below in Figure 24.

Spacing shall be in accordance with either Table 18.5.5.4.1(a) and Figure 18.5.5.4.1 or Table 18.5.5.4.1(b). Visible notification appliances shall be installed in accordance with Table 18.5.5.4.1(a) or Table 18.5.5.4.1(b). It seems that the visible notification devices in this facility are all wall mounted so Table 18.5.5.4.1(b) shall not be used.

In general, no place in any room space required to have a visual signal appliance shall be more than 45 ft (13.7 m) from the signal (in the horizontal plane). At a minimum, visual alarm signal appliance shall be provided in buildings and facilities in each of the following areas: restrooms and any other general usage areas (e.g., meeting rooms), hallways, lobbies, and any other area for common use.

Table 14: Room Spacing for Visible Appliances per NFPA101

Table 18.5.5.4.1(a) Room Spacing for Wall-Mounted Visible Appliances

Maximum Room Size		Minimum Required Light Output [Effective Intensity (cd)]	
ft	m	One Light per Room	Four Lights per Room (One Light per Wall)
20 × 20	6.10 × 6.10	15	NA
28 × 28	8.53 × 8.53	30	NA
30 × 30	9.14 × 9.14	34	NA
40 × 40	12.2 × 12.2	60	15
45 × 45	13.7 × 13.7	75	19
50 × 50	15.2 × 15.2	94	30
54 × 54	16.5 × 16.5	110	30
55 × 55	16.8 × 16.8	115	30
60 × 60	18.3 × 18.3	135	30
63 × 63	19.2 × 19.2	150	37
68 × 68	20.7 × 20.7	177	43
70 × 70	21.3 × 21.3	184	60
80 × 80	24.4 × 24.4	240	60
90 × 90	27.4 × 27.4	304	95
100 × 100	30.5 × 30.5	375	95
110 × 110	33.5 × 33.5	455	135
120 × 120	36.6 × 36.6	540	135
130 × 130	39.6 × 39.6	635	185

The visual notification systems or strobe lights can be found in the following locations:

- Room 101 Lobby/Vestibule
- Room 102 Corridor
- Room 115 Technical Services Office
- Room 118B Main Library Stacks at Eastern Exit
- Room 118B Main Library Stacks at South-Western Exit
- Room 123 Mechanical Room
- Room 124 Fire Pump Room
- Room 125 Emergency Generator Room

- Room 201 Lobby
- Room 202 Corridor at Main Internal Exit
- Room 204 Outside of South-Eastern Exit
- Room 226 Outside of South-Western Exit
- Room 231 Mechanical Room
- Room 301 Lobby
- Room 302 Corridor at Main Internal Exit
- Room 304 Outside of South-Eastern Exit
- Room 322 Outside of South-Western Exit
- Room 335 Mechanical Room
- Room 401 Lobby
- Room 402 Corridor at Main Internal Exit
- Room 404 Outside of South-Eastern Exit
- Room 425 Outside of South-Western Exit
- Room 450 Mechanical Room
- Room 501 Smoke evacuation system room

There are 27 visual notification systems or strobe lights in total in this facility.

Visible/Audible Notification System

Combination horn/strobes are most frequently used in this facility. The combination horn/strobes will need to comply with both audible and visual notification device spacing and location criteria of the NFPA 72. A sample visible/audible notification system by the manufacturer, Nittan, is shown below in Figure 25.

Figure 25: Sample Visible & Audible Notification System by Nittan

The EVCA-AP-SH Horn/Strobe Series provides a wide range of candela light output options in a single device. The candela settings include a 12- or 24-volt DC operation for the 15, 35 and 60 (75 on axis) candela settings and 24-volt DC operation for

the 15, 35, 60, 75, 95 and 110 candela settings. The candela setting is displayed through the front window and is selectable using a drum wheel.
The horn settings include Temporal, Non-Temporal, March Time and a Chime sound. The horn also has Low, Mid and High volume settings for each pattern and tone. The tones include 2400 Hz, Electro-Mechanical, Broadband and Chime. The voltage input can be either regulated DC or full wave rectified (FWR) 12 volt or 24 volt operation with an operating range from 8 to 33 V DC. The strobes can be synchronized using a control panel with an EVCA- AP-SMD10 sync module.

The strobe shall have six (6) candela settings. The candela settings shall be selectable using a drum roller and shall display the candela setting on the front of the device. The horn shall have 33 selectable settings configurable by dip switches. The sounder shall be capable of ANSI Temporal Code 3, March Time and produce a chime output. The horn shall have three distinct volume levels. The horn/strobe shall operate at 12 or 24 VDC regulated or full wave rectified. The horn/strobe shall have an operating range between 8 and 33 VDC. The strobes can be synchronized using a control panel with the EVCA-AP-SMD10 sync module.

The combination visual and audible notification systems or horn/strobes can be found in the following locations:

- Room 101 Lobby/Vestibule
- Room 102 Corridor
- Room 115 Technical Services Office
- Room 118B Main Library Stacks at Eastern Exit
- Room 118B Main Library Stacks at South-Western Exit
- Room 123 Mechanical Room
- Room 124 Fire Pump Room
- Room 125 Emergency Generator Room
- Room 201 Lobby
- Room 202 Corridor at Main Internal Exit
- Room 204 Outside of South-Eastern Exit
- Room 226 Outside of South-Western Exit
- Room 231 Mechanical Room
- Room 301 Lobby
- Room 302 Corridor at Main Internal Exit
- Room 304 Outside of South-Eastern Exit
- Room 322 Outside of South-Western Exit
- Room 335 Mechanical Room
- Room 401 Lobby
- Room 402 Corridor at Main Internal Exit
- Room 404 Outside of South-Eastern Exit
- Room 425 Outside of South-Western Exit
- Room 450 Mechanical Room
- Room 501 Smoke evacuation system room

There are 27 combination visual and audible notification systems or horn/strobe in total in this facility.

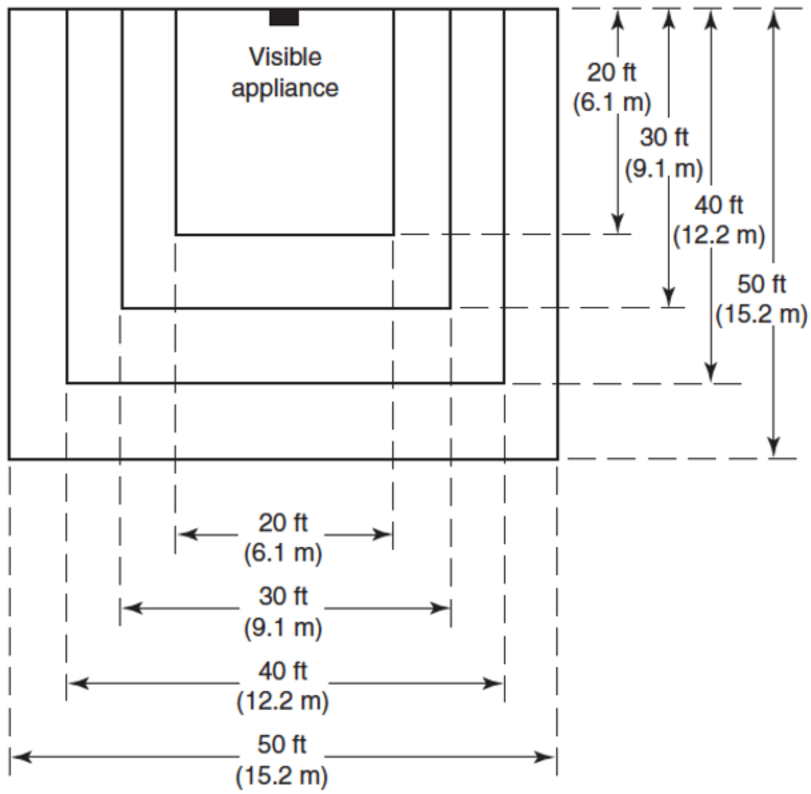


FIGURE 18.5.5.4.1 Room Spacing for Wall-Mounted Visible Appliances.

Figure 26: Room Spacing for Visible Appliance per NFPA101

In general, no place in any room or space required to have a visual signal appliance shall be more than 45 ft (13.7 m) from the signal (in the horizontal plane) based on visual devices with minimum 75 candela rating. At a minimum, visual alarm signal appliance shall be provided in buildings and facilities in each of the following areas: restrooms and any other general usage areas (e.g., meeting rooms, hallways, lobbies, and any other area) for common use. Installation requirements are provided in NFPA 72, the National Fire Alarm Code, and the location guidance is also found in the ADAAG (Americans with Disabilities Act Accessibility Guidelines).

ANALYSIS OF ALARM NOTIFICATION DEVICES

The NA893 Community Support Facility has been conceived almost two decades ago and does not seem to fully comply with the current NFPA 72 in terms of the location of visual and audible notification system. In this section, the expected performance of the audible and visible notification appliances based on their location, spacing and placement will be analyzed. Furthermore, a revised speaker layout that ensures intelligibility for a voice system may be elaborated if the current system does not meet the current NFPA 72 requirements.

First, the spacing and location of notification systems in the corridors in the subject facility seem to be lacking. The spacing and location of notification systems in the corridors shall be placed in accordance with NFPA 72 Section18.5.5.5. As shown in the previous section, notification devices are located on the two of the four corners in the corridor space on the 2nd and 3rd floors of the administration facility. There are notification devices located on one of the corners in the corridor space on the 1st floors of the administration facility as well as the entry points.

Upon entering the vestibule, Room 101, into the corridor labeled as Room 102, the notification appliances is located on the wall towards the elevator. According to NFPA 72 Section 18.5.5.5.6, if there is an interruption of the concentrated viewing path, such as a fire door, an elevation change, or any other obstruction, the area shall be treated as a separate corridor. If the notification appliances can be relocated to the opposing wall, there will be no an interruption of the concentrated viewing path.

There is a notification appliance on the corner of corridor Room 125. The length of the corridor is approximately 20 meters. The proposed notification appliance is rated at 110 cd and thus another notification appliances will be required at the western corner of corridor Room 125 for adequate coverage. The coverage of a 110 cd notification appliances is 16.5 meters. Also, according to NFPA 72 Section 18.5.5.5.5, visible notification appliances shall be located not more than 15 ft (4.57 m) from the end of the corridor with a separation not greater than 100 ft (30.5 m) between appliances.

On the 2nd and 3rd floor of the administration facility, there are two visible notification appliances on two of the four corners of the corridors. Assuming that the corner is considered as the beginning of the corridor, a visible notification appliances will be required as per NFPA 72 Section 18.5.5.5.5. It should also be further noted that in accordance to NFPA 72 Section 18.5.5.5.7, in corridors where more than two visible notification appliances are in any field of view, they shall flash in synchronization.

On the 1st floor of the administration facility, there are a couple L-shaped rooms that only have one visible notification appliance. Room 104, the Operations and Control Room, is a 13-meter office on its long end and one visible notification appliance can cover the space if the visible notification appliance is relocated to the corner of the room that is on the opposing wall of its current location. This visible notification appliance will need to be 110 cd to cover the entire Room 104 office space.

Another L-shaped area on the 1st floor of the administration facility is Room 109, Main Laboratory. This is a very long room and there is only one visible notification appliance on the northern end of the room. It is recommended that another visible notification appliance be located on southern end of the room by the main entrance of the laboratory for adequate coverage in accordance with NFPA 72 Section 18.

There are an ample number of ceiling mounted speakers for the public announcement system for the subject facility. The ceiling mounted speakers are less than 20 feet apart at its furthest points. Details on the public announcement system with mass notification system will be detailed and discussed in the next section.

EMERGENCY COMMUNICATIONS SYSTEMS

Public Announcement System with Mass Notification System

The emergency public address system is required throughout the facility in accordance with NFPA 72 and Fire Services Act of Japan. The system may be used for general public address. Public address system shall be provided for an emergency audio distribution network, and shall include microphones, compact disk player, AM (and FM) radio tuner, (MD player) amplifiers, control for each input, output selector switches, wiring, loudspeaker, and all necessary accessories required to control and reproduce audio signals from any input source to any output location.

Wiring between microphone and amplifiers shall be shielded to prevent electromagnetic coupling. Provide an empty conduit from PA amplifier to first floor communications room to allow Mass Notification System implementation.
The PA control panel shall be located in the Operation and Central Monitoring Room 104. Volume controls shall be provided at each remote room or area, and shall be user adjustable.

The system shall be provided with emergency power supply, and shall meet the requirements for emergency public address system in Fire Services Act of Japan.

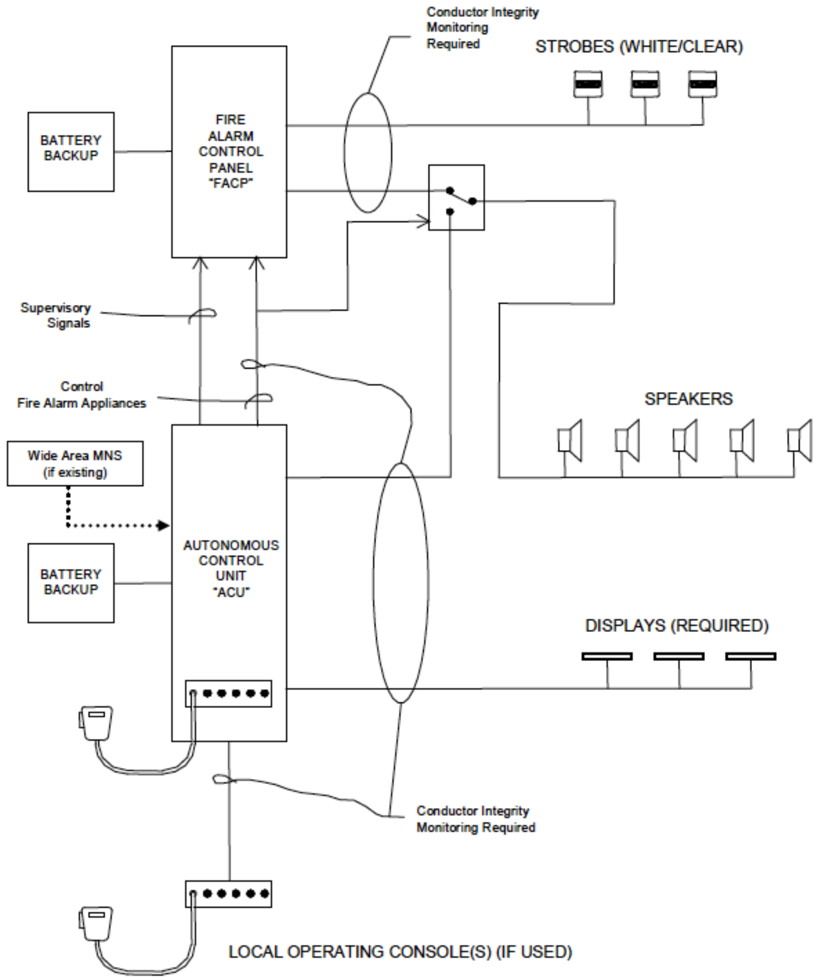


Figure 27: Mass Notification System One Line Diagram per UFC 4-021-01

A Mass Notification System that meets the UFC 4-021-01 requirements will be required for this facility since it is located on a US military base. Furthermore, this facility requires a Mass Notification System since it is the headquarters facility for Yokosuka Naval Base. A remote emergency shutoff capability for Mass Notification System to override the PA system is also required. I diagram of the mass notification system is shown in Figure 27.

Mass notification provides real-time information and instructions to people in a building, area, site, or installation using intelligible voice communications along with visible signals, text, and graphics, and possibly including tactile or other communication methods. The purpose of mass notification is to protect life by indicating the existence of an emergency situation and instructing people of the necessary and appropriate response and action.

Individual building MNS are intended to provide real-time information to personnel within and in the immediate vicinity of buildings on a DOD installation. These systems are required by UFC 4-010-01 for new construction and renovation of existing buildings. The NA893 Community Support Facilityi is planned as a new construction project, thus the UFC 4-021-02 is applicable. It discusses the requirements of the individual building MNS that is installed in new construction as part of a combined MNS/fire alarm system. In this case, the simplest and most economical approach for new construction will be to install a combined system that performs both as an individual building MNS and as the building fire alarm/voice evacuation system.

The UFC 4-021-01 requires that the individual building MNS shall be designed under the supervision of a registered fire protection engineer, by a registered professional engineer having at least four years of current experience in the design of fire protection and detection systems, or by an engineering technologist qualified at NICET Level IV in fire alarm systems. The individual's name, signature, and professional engineer number or NICET certification number shall be included on all final design documents. Navy systems shall be designed only by a registered fire protection engineer who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveys (NCEES).

A combined system is required by the Navy and is highly recommended by the Army and Air Force. The combined system design may be used by the Marine Corps when specifically approved by the AHJ based on the class and size of the building requiring the MNS. Otherwise, Marine Corps projects will use the technical criteria of Chapter 5 of UFC 4-021-01.

Intelligibility for Voice System

NFPA 72 defines intelligible as "capable of being understood; comprehensible; clear." Intelligibility is the degree to which we understand what is being said. Basically, if a voice message cannot be understood by building occupants, then the MNS has failed and may have caused more harm than good. Designers have the greatest effect on speech intelligibility by their choice of equipment, the number, distribution and placement of loudspeakers and the power at which they are driven.

It should be noted that intelligibility and audibility are not the same. Audibility refers to being able to hear a sound. However, intelligibility refers to being able to understand the message. In the previous sections, the NFPA 72 requirements for the audible notification systems defined audibility to the 15 dBA above the ambient sound levels. Audibility can be measured in quantitative terms.

The Fire Protection Research Foundation defines intelligibility "as a measureable aspect of electronic voice transmission systems that indicates the degree that human listeners will be able to understand the voice messages transmitted through them." The measurement of intelligibility is difficult since there is a qualitative aspect to it. The measurement of intelligibility is usually expressed as a percentage of a message that is understood correctly. There are many test methods available to measure intelligibility.

According to Module 8B in the FPE 522 lectures, there are several factors that affecting intelligibility of emergency communications systems. These factors include background noise, space configuration, acoustical properties of finish materials, distortion / bandwidth of sound equipment, and characteristics of person speaking (male / female, accent, and microphone technique).

Background noise is a significant factor in the intelligibility of emergency communications systems. If an occupant cannot hear a fire alarm signal or hear the message being conveyed over the background noise, the system will not be intelligible. Signal-to-noise ratio is a comparison of the sound level that is being produced by the speaker to the ambient or background noise in the room. In order to help achieve the needed intelligibility, it is important to ensure the speaker sound output is 15 dB over ambient noise. According to NFPA 72 Section 18.4.3.1 for Public Mode Audible Requirements, in order for audible public mode signals to be clearly heard, unless otherwise permitted by 18.4.3.2 through 18.4.3.5, they shall have a sound level at least 15 dB above the average ambient sound level or 5 dB above the maximum sound level having a duration of at least 60 seconds, whichever is greater, measured 5 ft (1.5 m) above the floor in the area required to be served by the system using the A-weighted scale (dBA). Going any higher than this results in diminishing returns in terms of improving intelligibility. Therefore, if a better intelligibility score is needed, more speakers should be used at lower tap settings as opposed to increasing the sound output on the existing speakers. Each time the distance between the listener and sound source is doubled, there is a 6-dB loss in loudness.

Distortion / bandwidth of sound equipment is another significant factor in the intelligibility of emergency communications systems. An occupant may not hear a message being conveyed over the sound system clearly if the voice transmission is distorted by the sound system itself. The figure in NFPA 72 Figure A.3.3.135 demonstrates the signal path that the voice communication must travel from the person that is trying to convey a message to the recipient occupant via an electronic sound system. The average person can detect as little as 2 percent distortion when listening to sound output. Once the sound output reaches 15 percent distortion, it is considered non-intelligible. The UL allows up to 20 percent distortion over the range 710-3,550 Hz. However, this would make for a poor sounding speaker. Therefore, the least amount of measurable distortion is desired. There are many factors that affect harmonic distortion, such as tolerance of the message generator and amplifier, loading of the audio amplifiers (load vs. available power), or mechanical factors, including wires touching the cone of the speaker, excessive voltage drop in the speaker line, vibration caused by poor installation, and damaged speakers. In addition, all manufactured equipment has distortion built into it. All of these different factors build on each other and have a cumulative effect on intelligibility. These are shown graphically in Figure 28.

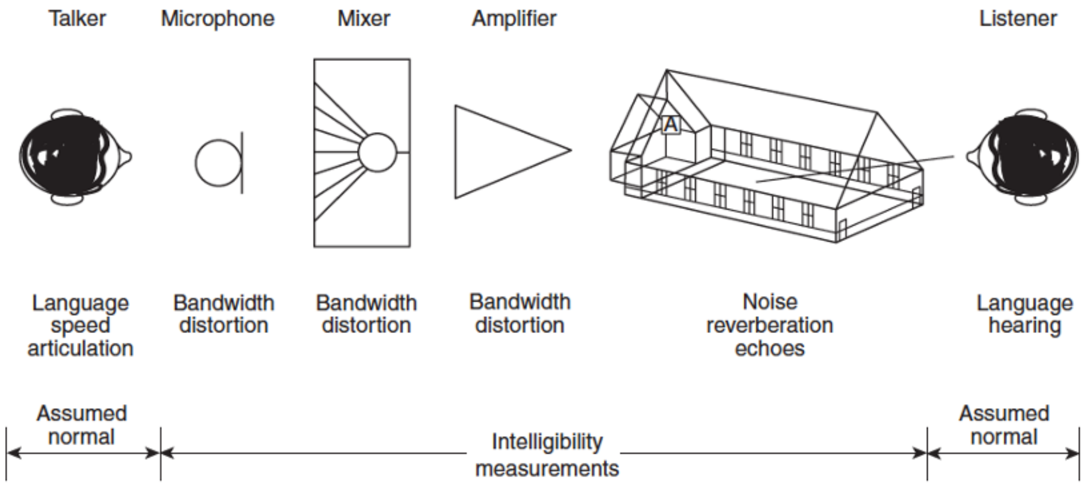


FIGURE A.3.3.135 Voice Signal Path. ***(Source: K. Jacob, Bose® Professional Systems)***

Figure 28: Intelligibility Process as per NFPA101

Space configuration is another significant factor in the intelligibility of emergency communications systems. When a room is large with a huge floor area and high ceilings or when a room is configured in a complex arrangement, there is a possibility of reverberation or echoes forming from surfaces and creating a situation where loud message may overlap each other and make the message unintelligible. Reverberation is the persistence of a sound through echoes and reflections after the initial sound source is removed. These echoes and reflections are the main reason why it is often difficult and sometimes impossible to achieve a required intelligibility score in certain environments, like large, open areas with very reflective surfaces. If echoes are spaced too closely together, the sound cannot be clearly distinguished by the recipient occupant, so minimizing reverberation is key to achieving the intelligibility score desired.

Some of the main factors that affect reverberation include room size, the reflective properties of the surfaces in the space, the orientation of the speaker, and the sound output of the speaker. There is some correlation with the factor of space configuration with other factors that affect intelligibility such as acoustical properties of finish materials and distortion / bandwidth of sound equipment.

There is great variation in the human element relating to intelligibility, specifically around the abilities of the talker and listeners. Talker abilities that could affect intelligibility would include accents, dialects, diction, frequency of voice, etc. Listener ability is the sensitivity of a listener's hearing.

There are additional challenges to this facility. Although it is a US military facility, more than half of its occupants are Japanese host nation workers that have limited English ability. Therefore, for this facility, certain messages may need to go out in bilingual format so instructions during emergencies are understood by all occupants.

POWER REQUIREMENTS FOR FIRE ALARM SYSTEM

In accordance with MIL-HDBK-1190, Chapter 9, Section B-3-c, (12), an emergency generator shall be provided for this facility. The generator shall be sized to support essential loads of this facility. The estimated capacity of the generator is 300 kVA, and rated for 120/208V, 3-phase, 4-wire, 60 Hz. The fuel supply capacity shall be sufficient to provide approximately 72 hours at 100% of the rated load. Provide remote monitor/control panel according to NFPA 110, Chapter 5.6.5. The emergency generator shall be located in Room 134, Emergency Generator Room.

The Uninterrupted Power Supply estimated capacity is 20 kVA at 208/120 volts, wye, 3-phase. The Uninterrupted Power Supply shall be able to supply all required power to full output kVA loads. Load voltage and bypass line voltage shall be 208VAC, three phase, four-wire plus ground. The AC input source and bypass input source shall be a solidly grounded wye service. The Uninterrupted Power Supply system shall consist of an Insulated-Gate Bipolar Transistor (IGBT) power factor-corrected rectifier, DC-DC converter and three-phase, transformer-free inverter, bypass static transfer switch, bypass synchronizing circuitry, protective devices and accessories. The system shall also include a battery disconnect breaker and battery system. The battery shall support the Uninterrupted Power Supply at 100% rated kW for at least 8 minutes at 25 degrees C (77 degrees F) at startup. The Uninterrupted Power Supply shall be designed for floor mounting. The Uninterrupted Power Supply shall be located in Room 108, Uninterrupted Power Supply Room.

Protected Premises Fire Alarm Systems and Emergency Communications Systems will be required in accordance with NFPA 72 Section 10.6.7.1. The secondary power supply shall have sufficient capacity to operate the system under quiescent load (system operating in a non-alarm condition) for a minimum of 24 hours and, at the end of that period, shall be capable of operating all alarm notification appliances used for evacuation or to direct aid to the location of an emergency for 5 minutes, unless otherwise permitted or required by 10.6.7.2.1.1 through 10.6.7.2.2. Battery calculations shall include a minimum 20 percent safety margin above the calculated amp-hour capacity required. The secondary power supply for in-building fire emergency voice/alarm communications service shall be capable of operating the system under quiescent load for a minimum of 24 hours and then shall be capable of operating the system during a fire or other emergency condition for a period of 15 minutes at maximum connected load. The secondary power supply capacity for supervising station facilities and equipment shall be capable of supporting operations for a minimum of 24 hours. The secondary power supply for high-power speaker arrays used for wide-area mass notification systems shall be in accordance with 24.6.5.2.

Table 15: Power Requirements for Fire Alarm System

ITEM	DESCRIPTION	STANDBY CURRENT PER UNIT (AMP)		QTY		TOTAL STANDBY CURRENT PER UNIT (AMP)	ALARM CURRENT PER UNIT (AMP)		QTY		TOTAL ALARM CURRENT PER UNIT (AMP)
1	FACP	0.11	x	1	=	0.11	1.75	x	1	=	1.75
2	Manual Pull Station	0	x	13	=	0	0.1	x	28	=	2.8
3	Smoke Detector	0.00003	x	27	=	0.00081	0.0475	x	27	=	1.2825
4	Horn/Strobe	0	x	35	=	0	0.121	x	35	=	4.235
5	Duct Smoke Detector	0.00003	x	3	=	0.00009	0.0475	x	3	=	0.1425
6	Heat Detector	0	x	1	=	0	0.05	x	1	=	0.05
7	Alarm Bell	0	x	14	=	0	0.084	x	14	=	1.176
8	Strobe	0	x	14	=	0	0.113	x	14	=	1.582
						0.1109					13.018

Required operating time of secondary power source from NFPA 72 10.5.6.3

Standby: 24 hours Alarm: 5 minutes or 0.0833 hours

Required standby time = 24 hours x 0.1109 amps = 2.6616amp-hours

Required alarm time = 0.0833 hours x 13.018 amps = 1.0848 amp-hours

Required battery capacity = Required standby time + Required alarm time
= 2.6616 amp-hours + 1.0848 amp-hours
= 3.7463 amp-hours

The secondary power supply shall consist of one of the following: (1) A storage battery dedicated to the system arranged in accordance with 10.6.10 and (2) An automatic-starting, engine-driven generator serving the branch circuit specified in 10.6.5.1 and arranged in accordance with 10.6.11.3.1, and storage batteries dedicated to the system with 4 hours of capacity arranged in accordance with 10.6.10. Secondary circuits that provide power to the control unit and are not integral to the unit shall be protected against physical damage. An emergency generator and Uninterrupted Power Supply are provided in the subject project.

FIRE ALARM SYSTEM DOCUMENTATION AND COMMISSIONING

Fire System Alarm System Design Documentation

Since the subject project is a Facilities Improvement Project of the Ministry of Defense of Japan, there are a lot of documentation which is very specific to this program. The programming document is titled US Forces Japan Standard Form 22. Then, a Criteria Package is prepared by the US Army Corps of Engineers, Japan District to define the US criteria that need to be followed for this project. The UFC 3-600-01, UFC 4-021-01, NFPA 101, NFPA 72, NFPA 70, as well as International Business Code requirements are identified in the Criteria Package. Then, a Definitive Detailed Drawings are prepared to bilaterally agree upon the criteria that will be followed for the subject project. Construction Drawings are then prepared that detail the specific fire alarm design. Once the design and complete and the construction is completed, as built drawings will be provided by the construction contractor and their respective sub-consultants.

Through the aforementioned documentation in the Facilities Improvement Project, the majority of the information that should be included in a comprehensive fire alarm system design required by the NFPA 72 will be provided. Where documentation is required by the authority having jurisdiction, the following list shall represent the minimum documentation required for new fire alarm systems, supervising station and shared communication equipment, and emergency communications systems, including new systems and additions or alterations to existing systems. The Facilities Improvement Project document where the information can be found will be listed in parenthesis in the NFPA 72 list:

(1) Written narrative providing intent and system description (Criteria Package)
(2) Riser diagram (Construction Drawings)
(3) Floor plan layout showing locations of all devices, control equipment, and supervising station and shared communications equipment with each sheet showing the following (Criteria Package, Construction Drawings, and As-Builts):
    a. Point of compass (north arrow)
    b. A graphic representation of the scale used
    c. Room use identification
    d. Building features that will affect the placement of initiating devices and notification appliances

(4) Sequence of operation in either an input/output matrix or narrative form (Construction Drawings)
(5) Equipment technical data sheets (Construction Drawings)
(6) Manufacturers' published instructions, including operation and maintenance instructions (As-Builts)
(7) Battery capacity and de-rating calculations (where batteries are provided) (Construction Drawings)
(8) Voltage drop calculations for notification appliance circuits (Construction Drawings)
(9) Mounting height elevation for wall-mounted devices and appliances (Construction Drawings)
(10) Where occupant notification is required, minimum sound pressure levels that must be produced by the audible notification appliances in applicable covered areas (Criteria Package)
(11) Pathway diagrams between the control unit and the supervising station and shared communications equipment (Construction Drawings)
(12) Completed record of completion in accordance with 7.5.6 and 7.8.2 (As-Builts)
(13) For software-based systems, a copy of site-specific software, including specific instructions on how to obtain the means of system and software access (password) (As-Builts)
(14) Record (as-built) drawings (As-Builts)
(15) Records, record retention, and record maintenance in accordance with Section 7.7 (As-Builts)
(16) Completed record of inspection and testing in accordance with 7.6.6 and 7.8.2 (As-Builts and commissioning report)

Record of Completion

The subject project is a Facilities Improvement Project of the Ministry of Defense of Japan. All formal government testing, inspection, and documentation will be in Japanese since it needs to be in compliance with the Japanese Fire Service Law. The US government is generally allowed to do its own testing of the fire alarm systems after the formal Japanese systems are completed. Normally, the base fire department with cooperation from related base support personnel such as the fire protection engineer. In addition to the Japanese documents, the US base personnel do complete a record of completion for the project building to the extent this is practical.

The record of completion shall be documented in accordance with NFPA 72 Section 7.5.6 and the UFC 3-600-01. There is other record of completion forms that are produced by the US Army Corps of Engineers, Japan District as part of the construction closeout procedures. The basic required information can be found in the record of completion forms, Figure 7.8.2(a) through Figure 7.8.2(f) of NFPA 72. The UFC 3-600-01 and US Army Corps of Engineers, Japan District forms are largely based on the NFPA 72 forms and do contains the information from Figure 7.8.2(a) through Figure 7.8.2(f) applicable to the installed system. The record of completion documentation is normally completed with the construction contractor by the construction representative and submitted to the authority having jurisdiction, which is the Navy Fire Protection Engineer, and the owner at the conclusion of the job. The record of completion documentation shall be permitted to be part of the written statement required in 7.5.2 and part of the documents that support the requirements of 7.5.8. The preparation of the record of completion documentation shall be the responsibility of the qualified and experienced person in accordance with NFPA 72 Section 10.5.2.

Where required by the authority having jurisdiction, compliance of the completed installation with the requirements of the NFPA 72, UFC 3-600-01, and IBC shall be certified by a qualified and impartial third-party organization acceptable to the authority having jurisdiction. For complex facilities, a third-party commissioning agent will be procured to implement this commissioning effort. For simple projects, the construction representative from the US Army Corps of Engineers, Japan District will implement a simplified commissioning effort. Verification of compliant installation shall be performed according to testing requirements and procedures specified in NFPA 72 Section 14.4.1 and 14.4.2. Verification shall ensure that: all components and functions are installed and operate per the approved plans and sequence of operation; all required system documentation is complete and is archived on site; for new supervising station systems, the verification shall also ascertain proper arrangement, transmission, and receipt of all signals required to be transmitted off-premises and shall meet the requirements of 14.4.1 and 14.4.2; for existing supervising station systems that are extended, modified, or reconfigured, the verification shall be required for the new work only, and reacceptance testing in accordance with Chapter 14 shall be acceptable; and written confirmation has been provided that any required corrective actions have been completed.

Inspection, Testing, and Maintenance

As stated above, for complex facilities, a third-party commissioning agent will be procured to implement this commissioning effort for inspection, testing, and maintenance. The commissioning contract for complex facilities starts during the design phase, goes through the construction phase, and has inspections up to 2 years after the construction is complete. For simple projects, the construction representative from the US Army Corps of Engineers, Japan District will implement a simplified commissioning effort. Inspection, testing, and maintenance will be the purview of the using agency once the facility is turned over. In this section, the inspection test and maintenance requirements for the fire alarm system and components installed in the building will be discussed.

The specific commissioning team members, activities, and level of rigor should be tailored to individual projects based on size, complexity, and the planned quality management. The requirements or guidelines in this chapter are specifically written for medium-high complexity MILCON projects. Lower levels of commissioning may be suitable for small, low complexity projects. A low complexity project is defined as a project with several small split-systems with no direct digital controls may only require the typical USACE contractor quality control and quality assurance. However, high complex projects require higher levels of commissioning may be necessary for large, very complex projects. The subject project should be considered a high complexity project.

Commissioning requirements for Army, Air Force, and other Department of Defense facilities are outlined by UFC 1-200-02 High Performance and Sustainable Building Requirements, ASHRAE Standard 189.1 Standard for the Design of High-Performance Green Buildings, and Engineering Regulation 1110-345-723 Total Building Commissioning Procedures. If a project has a Leadership in Energy and Environmental Design (LEED) requirement, commissioning requirements are imposed by the LEED Rating Systems. The design publications listed below should be used as sources of criteria for commissioning. The criteria from these sources may be supplemented, but not supplanted, by applicable criteria contained in nationally recognized codes, standards, and specifications.

Many of the referenced government engineer publications can be found in the Whole Building Design Guide at https://www.wbdg.org/ffc/dod. Design effort associated with the development of the design documents is typically based on all applicable requirements/criteria, including, but not limited to, the latest versions of the following. In the event any conflict is noted between any requirements/criteria, the more stringent typically applies unless specifically noted otherwise. The third-party commissioning requirements are dependent on the third-party rating tool that is selected.

In general, the testing plan documentation shall be provided in accordance with NFPA 72 Section 14.2.10. Periodic inspection and testing documentation shall be provided in accordance with NFPA 72 Sections 14.6.2 through 14.6.4. record of all inspections, testing, and maintenance as required by NFPA 72 Section 14.6.2.4 shall be documented using either the record of inspection and testing forms, NFPA 72 Figure 7.8.2(g) through Figure 7.8.2(l). The US government is generally allowed to do its own testing of the fire alarm systems after the formal Japanese systems are completed. A combination of US and Japanese testing and inspection will be done. The Japanese government must ensure that they got what they paid for. The US government must ensure that we have a safe facility.

FIRE ALARM SYSTEM DOCUMENTATION AND COMMISSIONING

This is a comprehensive report on the fire alarm and detection system for NA893 Community Support Facility. This facility has many functions to include the main base library, education center, community centers, and clinical spaces.
The Fire Alarm Control Panel is provided connected to a power supply and is located in Room 101 Vestibule of the subject facility. Both initiating devices and alarm notification devices are connected to the fire alarm and detection system. The initiating devices include manual fire alarm stations, smoke detectors, and duct smoke detectors. These initiating devices will follow the criteria in accordance to the UFC 3-600-01, NFPA 72, or the Fire Service Law of Japan. Since there are many criteria to consider, the strictest

criteria will be applied. However, since this Criteria Package was developed back in the early 2004-time frame, it has been determined that the number of smoke detectors does not meet the current NFPA 72. An analysis has been done on the initiating devices and locations for additional devices has been recommended to bring it up to current code.

Notification appliances provides stimuli for initiating emergency action and provide information to users, emergency response personnel, and occupants. The NA893 Community Support Facility uses a combination of alarm horns or audible notification appliances, strobes or visual notification appliances, and horn/strobes or visual and audible notification appliances. In this project, the types and locations of alarm notification devices installed in the NA893 building has been analyzed. Since this facility must confirm US codes, Department of Defense regulations, and Japanese criteria, the minimum requirements for fire alarm systems as required in the NFPA has been met and in many instances exceeded.

Finally, the secondary power supply requirements as well as the emergency communication systems for the subject project has been detailed. Intelligibility of the system has also been discussed. The testing, inspection, and maintenance of the subject facility was also discussed. These are all part of the engineering requirements to make this a fully usable building on a US military base operating in Japan. These fire alarm systems are necessary requirements much as the fire suppression systems which will be analyzed in the next section.

FIRE SUPRESSION SYSTEM

INTRODUCTION

The facility that is used for the FPE596 project is a project that has been submitted for the Facilities Improvement Program in Japan. The Facilities Improvement Program is a program that is voluntarily executed by the Japanese Government for the US Forces in Japan as a cost sharing measure for maintaining a large US military presence in Japan.

The project that will be used for the FPE596 is NA893 Community Support Facility at Yokosuka Naval Base. The US government has proposed this project for adoption into the Facilities Improvement Program in 2000. At the time of planning for the project, The Japanese Building Standard Law undergone a considerable change to adopt performance based. Therefore, there has been no design or construction of this facility at this time. Only the planning document has been prepared to propose the project for acceptance to the Japanese Government.

The prepared planning document is a Criteria Package. The Criteria Package contains planning requirements for the subject facility but no design or construction activities has spent to create this document. According to congressional funding rules, only planning funds could be used during this phase of project development. The design and construction of the project was completed in 2009.

An automatic sprinkler system throughout the building has been provided. The automatic sprinkler system shall be wet type in accordance with UFC 3-600-01, per 4-2, 6-6.1, and NFPA 13, 2002 Edition. As for sprinkler heads, special requirement is not required. As for the standpipe system, a class I standpipe system in accordance with UFC 3-600-01, par 4-5.1 has been provided. Standpipe systems shall be installed in accordance with NFPA 14. Portable fire extinguishers in accordance with NFPA 10 is required. In accordance with Japanese Fire Protection Law, a fire pump is required and water reservoir is required.

WATER SUPPLY ANALYSIS

Fire Hydrant Data from Hydrant #G-28

Static Pressure:	69 psi or 4.85 kgf/cm^2
Residual Pressure:	60 psi or 4.22 kgf/cm^2
Available Flow:	890 gpm or 3,396 L/sec

This fire hydrant test was performed by the Yokosuka Fire Department with the US Navy Authority Having Jurisdiction and Fire Protection Engineer on July 17, 2003. The underground fire main is a 6-inch pipe.

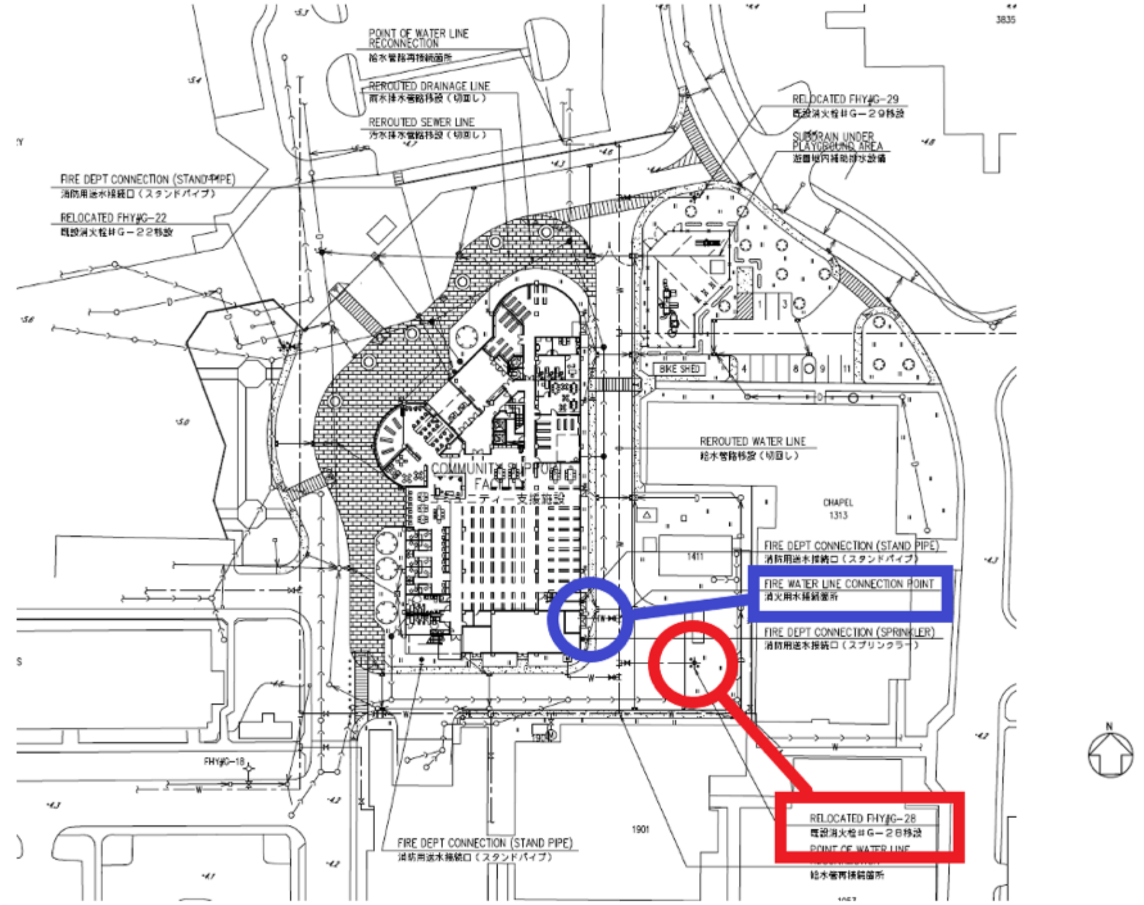


Figure 29: Location of Fire Hydrant and Connection Point to Facility

The fire hydrant G28 is located to the south-east of the subject facility. The point of connection to the facility is Room 128 mechanical room. Please see Figure 29 above.

SUMMARY OF OCCUPANCY CLASSIFICATIONS

Although there are many different functions within the NA893 Community Support Facility, the occupancy classification can be divided into two general categories. The 4-story, reinforced concrete building generally houses the Light Hazard Occupancy functions such as the classrooms and offices on the second through fourth floor with some Ordinary Hazard 1 storage spaces. The first floor is generally considered the Ordinary Hazard Group 2 Occupancy such as the library book stack area, periodical rooms, reading rooms, and circulation desks.

The following, Table 16, is a brief summary of occupancy classifications for the different functions in the subject facility:

Table 16: Occupancy Classification per Room for NA893 Community Support Facility

Room No.	Room Name	Occupancy Classification	Remarks
1ST FLOOR			
LIBRARY			
101	EV LOBBY (1ST FLR)	LH	
101A	VESTIBULE	LH	
101B	COMPUTER ROOM	LH	
102	CORRIDOR	LH	
102A	STORAGE	OH-1	NOTE: 1
102B	JANITORS CLOSET (1)	LH	
103	STAIRS (1)	LH	
103A	UTILITY ROOM	OH-1	NOTE: 1
104	STAIRS (2)	LH	
104A	STORAGE	OH-1	NOTE: 1
105	OFFICE (DIRECTOR)	LH	
106	OFFICE (ASST.DIR./ADMIN CLERK)	LH	
107	BREAKROOM (STAFF)	LH	
108	OFFICE (DATA MANAGEMENT)	LH	
109	TOILET (M/F)	LH	
110	MULTIPURPOSE ROOM	LH	
111A～J	MEDIA ROOM	LH	
112	CHILDRENS READING ROOM	LH	
113	STUDY ROOM (CHILDREN GROUP)	LH	
114	OFFICE/WORK RM (CHILDREN GROUP)	LH	
115	TECHNICAL SERVICE	OH-1	NOTE: 1
116	PERIODICAL/COMPACT STORAGE	OH-1	NOTE: 1
117	STUDY ROOM (PRIVATE BOOTH)	LH	
118	LIBRARY OPEN AREA	OH-2	NOTE: 2
118A	CIRCULATION DESK	OH-2	NOTE: 2
118B	BOOK STACK AREA	OH-2	NOTE: 2
118C	DISPLAY AREA	OH-2	NOTE: 2
118D	REFERENCE AREA	OH-2	NOTE: 2
118E	READING AREA	OH-2	NOTE: 2
118F	A/V & SPECIAL COLLECTIONS	OH-2	NOTE: 2
118G	PATRON ACCESS COMPUTERS	OH-2	NOTE: 2
118H	PERIODICAL	OH-2	NOTE: 2

Table 16: Occupancy Classification per Room for NA893 Community Support Facility (Continued)

Room No.	Room Name	Occupancy Classification	Remarks
OUTSIDE BOOK/AV RETURN			
119	TOILET (M)	LH	
120	TOILET (F)	LH	
121	JANITORS CLOSET (1)	LH	
122	COMPUTER ROOM (1ST FLR)	LH	NOTE: 3
122A	STORAGE	OH-1	NOTE: 1
123	MECH RM (1st FLR)	LH	
124	EMERGENCY GENERATOR ROOM	OH-2	NOTE: 4
125	FIRE PUMP ROOM	LH	
2ND FLOOR			
EDUCATION CENTER			
201	EV LOBBY (2ND FLR)	LH	
201A	TOILET (M)	LH	
201B	TOILET (F)	LH	
202	CORRIDOR	LH	
202A	COMPUTER ROOM (2 ND FLOOR)	LH	NOTE: 3
203	STAIRS (1)	LH	
203A	UTILITY ROOM	LH	
204	STAIRS (2)	LH	
205	OFFICE (CHAPLAIN)	LH	
206	OFFICE (EDUCATION) & LIBRARY	LH	
207	OFFICE (DATA MANAGEMENT)	LH	
208	OFFICE (ADMIN)	LH	
209	CHILDCARE ROOM	LH	
210	QUIET ROOM	LH	
211	OFFICE (EDUCATION STAFF)	LH	
212	FELLOWSHIP ROOM	LH	
212A	STORAGE (AV EQPT)	OH-1	NOTE: 1
212B	SOUND ROOM	LH	
213	MULTIPURPOSE ROOM	LH	
214	KITCHENETTE	LH	
215	PREPARATION ROOM	LH	
216	CLASSROOM (1)	LH	
217	CLASSROOM (2)	LH	
218	CLASSROOM (3)	LH	
219	CLASSROOM (4)	LH	
220	CLASSROOM (5)	LH	
221	CLASSROOM (6)	LH	

Table 16: Occupancy Classification per Room for NA893 Community Support Facility (Continued)

Room No.	Room Name	Occupancy Classification	Remarks
222	CLASSROOM (7)	LH	
223	CLASSROOM (8)	LH	
224	CLASSROOM (9)	LH	
225	CLASSROOM (10)	LH	
226	BREAKROOM	LH	
226A	STORAGE	OH-1	NOTE: 1
227	TOILET (M)	LH	
228	TOILET (F)	LH	
229	JANITORS CLOSET	LH	
230	COMPUTER ROOM (2ND FLR)	LH	NOTE: 3
231	MECH RM (2nd FLR)	LH	
3RD FLOOR			
RED CROSS			
301	EV LOBBY (3RD FLR)	LH	
301A	TOILET (M)	LH	
301B	TOILET (F)	LH	
302	CORRIDOR	LH	
302A	COMPUTER ROOM (3 RD FLR)	LH	NOTE: 3
303	STAIRS (1)	LH	
303A	UTILITY ROOM	LH	
304	STAIRS (2)	LH	
305	OFFICE (VOLUNTEER WORK AREA)	LH	
306	OFFICE (SM)	LH	
307	OFFICE (FOC)	LH	
308	OFFICE (SC)	LH	
309	OFFICE (VC)	LH	
310	OFFICE (DATA MANAGEMENT)	LH	
311	STORAGE	OH-1	NOTE: 1
	NAVY RELIEF	LH	
312	RECEPTION	LH	
313	WAITING AREA / OFFICE (CLERICAL)	LH	
314	OFFICE (XO)	LH	
315	OFFICE (OA3)	LH	
316	OFFICE (COV)	LH	
317	OFFICE (CW)	LH	
318	OFFICE (COUNSELOR)	LH	

Table 16: Occupancy Classification per Room for NA893 Community Support Facility (Continued)

Room No.	Room Name	Occupancy Classification	Remarks
319	OFFICE (DATA MANAGEMENT)	LH	
320	BREAKROOM	LH	
321	STORAGE (1)	OH-1	NOTE: 1
322	STORAGE (2)	OH-1	NOTE: 1
323	CONFERENCE / TRAINING ROOM	LH	
324	CLASSROOM (1)	LH	
325	CLASSROOM (2)	LH	
326	CLASSROOM (3)	LH	
327	CLASSROOM (4)	LH	
328	CLASSROOM (5)	LH	
329	CLASSROOM (6)	LH	
330	CLASSROOM (7)	LH	
331	CLASSROOM (8)	LH	
332	BREAKROOM	LH	
332A	STORAGE	OH-1	NOTE: 1
333	TOILET (M)	LH	
334	TOILET (F)	LH	
335	JANITORS CLOSET	LH	
336	COMPUTER ROOM	LH	NOTE: 3
337	MECH RM (3rd FLR)	LH	
4th FLOOR			
FAMILY SERVICE CENTER			
401	EV LOBBY (4TH FLR)	LH	
402	CORRIDOR	LH	
402A	COMPUTER ROOM (4TH FLR)	LH	NOTE: 3
403	STAIRS (1)	LH	
404	STAIRS (2)	LH	
ADMIN			
405	WAITING AREA	LH	
406	OFFICE (DIRECTOR)	LH	
407	ADMIN WORK AREA	LH	
408	OFFICE (TAMP MGR)	LH	
409	OFFICE (RAP MGR)	LH	
410	OFFICE (SOCIAL SERVICE REP.)	LH	
411	COMPUTER AREA	LH	
412	TOILET (M)	LH	
413	TOILET (F)	LH	

Table 16: Occupancy Classification per Room for NA893 Community Support Facility (Continued)

Room No.	Room Name	Occupancy Classification	Remarks
CLINICAL/FAB DIVISION			
414	WAITING AREA (PRIVATE)	LH	
415	CORRIDOR (CLINICAL)	LH	
416	RECEPTION / ADMIN WORK AREA	LH	
417	OFFICE (DATA MANAGEMENT)	LH	
418	CHILDREN'S PLAYROOM	LH	
419	OFFICE (CLINICAL/FAP DIV.HEAD)	LH	
420	OFFICE (CB/LSW)	LH	
421	OFFICE (CB/SW)	LH	
422	OFFICE (CB/SSS)	LH	
423	OFFICE (CB/I & T)	LH	
424	OFFICE (CB/SSS)	LH	
425	OFFICE (FAP/SAB LSW)	LH	
426	OFFICE (FAP/SAB SIW)	LH	
427	OFFICE (FAP/SAB SSA)	LH	
428	OFFICE (FAP/SAB SSA)	LH	
429	OFFICE (FAP/SAB SSA)	LH	
430	OFFICE (FAP/SAB SSA)	LH	
431	OFFICE (FAP/SAB SSA)	LH	
432	OFFICE (FAP/CAB LSW)	LH	
433	OFFICE (FAP/CAB SSA)	LH	
434	OFFICE (FAP/CAB SSA)	LH	
435	OFFICE (FAP/CAB NPS NURSE)	LH	
436	OFFICE (FAP/CAB SSA)	LH	
I & R DIVISION			
437	RECEPTION / WAITING AREA	LH	
438	ADMIN WORK AREA	LH	
439	OFFICE (DATA MANAGEMENT)	LH	
440	OFFICE (I & R DIV/SSA)	LH	
441	STORAGE	OH-1	NOTE: 1
442	CLASSROOM (AOB / ICR)	LH	
443	CLASSROOM (1)	LH	
444	CLASSROOM (2)	LH	
445	TOILET (M)	LH	
446	TOILET (F)	LH	
447	JANITORS CLOSET	LH	
448	BREAKROOM	LH	
448A	STORAGE	OH-1	NOTE: 1
449	COMPUTER ROOM (4TH FLR)	LH	NOTE: 3
450	MECH RM (4th FLR)	LH	

Table 16: Occupancy Classification per Room for NA893 Community Support Facility (Continued)

Room No.	Room Name	Occupancy Classification	Remarks
ROOF			
MECH ROOM			
501	STAIR (1)	LH	
502	EV MECH ROOM	LH	

Notes:

1. The stack height is less than 8 feet per UFC 3-600-01, Appendix B-1.2 and NFPA 13 para. 5.3.1. Ordinary hazard (Group 1) occupancies shall be defined as occupancies or portions of other occupancies where combustibility is low, quantity of combustibles is moderate, stockpiles of combustibles do not exceed 8 ft (2.4 m), and fires with moderate rates of heat release are expected.

2. The stack height is less than 12 feet per UFC 3-600-01, Appendix B-1.3 and NFPA 13 para. 5.3.2. occupancies or portions of other occupancies where the quantity and combustibility of contents are moderate to high, stockpiles of contents with moderate rates of heat release do not exceed 12 ft (3.7 m), and stockpiles of contents with high rates of heat release do not exceed 8 ft (2.4 m).

3. UFC 3-600-01, Appendix B-1.1 (Data Processing Area) and NFPA 13 para. A.5.2. Light hazard occupancies include occupancies having uses and conditions similar to the following:
   (1) Animal shelters
   (2) Churches
   (3) Clubs
   (4) Eaves and overhangs, if of combustible construction withno combustibles beneath
   (5) Educational
   (6) Hospitals, including animal hospitals and veterinary facilities
   (7) Institutional
   (8) Kennels
   (9) Libraries, except large stack rooms
   (10) Museums
   (11) Nursing or convalescent homes
   (12) Offices, including data processing
   (13) Residential
   (14) Restaurant seating areas
   (15) Theaters and auditoriums, excluding stages and prosceniums
   (16) Unused attics

   Note that it is not the committee's intent to automatically equate library bookshelves with ordinary hazard occupancies or with library stacks. Typical library bookshelves of approximately 8 ft (2.4 m) in height, containing books stored vertically on end, held in place in close association with each other, with aisles wider than 30 in. (750 mm) can be considered to be light hazard occupancies. Similarly, library stack areas, which are more akin to shelf storage or record storage, as defined in NFPA 232, should be considered to be ordinary hazard occupancies.

4. UFC 3-600-01, Appendix B-1.3. DoD occupancies, that might be classified as extra hazard, are often addressed by unique occupancy specific criteria/guidance rather than being addressed generically as extra hazard.

There will be three design fires considered in this project. The design fire are all on the first floor since all the Ordinary Hazard II classifications are located in the main library. The three design fires considered for this analysis would be a fire in the main library book stacks, the periodical room, and the media rooms. The following are descriptions of the rooms and their specific occupancy classifications.

- ***Room 118B Book Stack Area:*** Area where library books and materials are stacked. Area shall be provided with standard, vertical adjustable shelving. According to 2016 NFPA 13, the meeting room is classified as an Ordinary hazard (Group 2) as per A.5.3.2. (12) Libraries — large stack room areas.

- ***Room 116 Periodical/Compact Storage***: Room where back issues of periodicals and miscellaneous items are stored. Room shall be provided with storage shelving units. According to 2016 NFPA 13, the meeting room is classified as an Ordinary hazard (Group 2) as per A.5.3.2. (12) Libraries — large stack room areas.

- ***Room 111 Media Room***: Private cubicles for Audio & Video viewing/listening. Cubicles shall be provided with TV, video & audio player, acoustical treatment and view window on doors. According to 2016 NFPA 13, the meeting room is classified an Ordinary hazard (Group 2) as per A.5.3.2. (20) Post offices.

SYSTEM REQUIREMENTS

The main library portion of the facility which includes the library, periodical room, and media rooms are classified as an Ordinary hazard (Group 2). The majority of the second through fourth floor which include the education center and clinics are considered to be a light hazard. The sprinkler design demand and minimum K-factor will be dictated by the 2006 UFC 3-600-01 in this case.

Table 17: Sprinkler and Water Supply Design Requirements per UFC 3-600-01

Table 4-1 Sprinkler System and Water Supply Design Requirements for Sprinklered Facilities

OCCUPANCY CLASSIFICATION[a]	SPRINKLER SYSTEM DESIGN DENSITY L/min/m² (GPM/ft²)	SPRINKLER SYSTEM DESIGN AREA m² (ft²) [b]	HOSE STREAM ALLOWANCE L/Min (GPM)	DURATION OF SUPPLY Minutes
Light Hazard	4.1 (0.10)	280 (3000)	950 (250)	60
Ordinary Hazard Group 1	6.1 (0.15)	280 (3000)	1900 (500)	60
Ordinary Hazard Group 2	8.2 (0.20)	280 (3000)	1900 (500)	90
Extra Hazard Group 1	12.2 (0.30)	280 (3000)	2840 (750)	120
Extra Hazard Group 2	16.3 (0.40)	280 (3000)	2840 (750)	120

When compared to the 2016 NFPA 13 for Ordinary hazard (Group 2), the requirements of the UFC 3-600-01 is more stringent. For Ordinary hazard (Group 2), the design density is 0.20 gpm per square feet and the design area is 3000 square feet. The duration of the supply is 90 minutes.

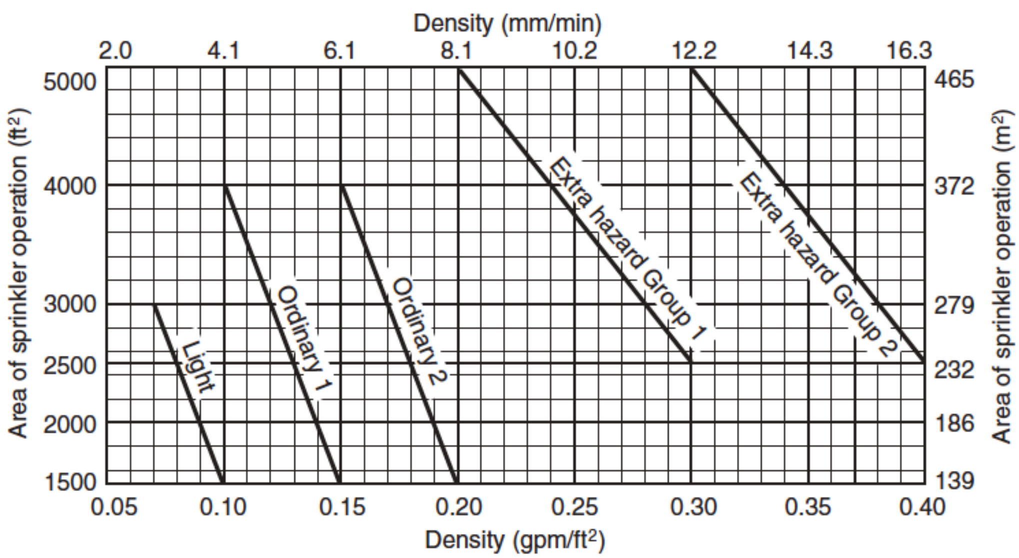


FIGURE 11.2.3.1.1 Density/Area Curves.

Figure 30: Density/Area Curves as per NFPA101

Using Figure 11.2.3.1.1 Density/Area Curves, the required sprinkler density and area are as follows:

Room 118B Book Stack Area:

Ordinary Hazard Group 2
Sprinkler Density: 0.20 gpm/ft^2
Design Area: 528.9 SM or 5693 ft^2

Room 116 Periodical/Compact Storage:

Ordinary Hazard Group 2
Sprinkler Density: 0.20 gpm/ ft^2
Design Area: 38.4 SM or 413.3ft^2

Room 111 Media Room:

Ordinary Hazard Group 2
Sprinkler Density: 0.20 gpm/ ft^2
Design Area: 61 SM or 656.6 ft^2

Table 18: Hose Stream Allowance and Water Duration Requirements as per NFPA101

Table 11.2.3.1.2 Hose Stream Allowance and Water Supply Duration Requirements for Hydraulically Calculated Systems

Occupancy	Inside Hose		Total Combined Inside and Outside Hose		Duration (minutes)
	gpm	L/min	gpm	L/min	
Light hazard	0, 50, or 100	0, 190, or 380	100	380	30
Ordinary hazard	0, 50, or 100	0, 190, or 380	250	950	60–90
Extra hazard	0, 50, or 100	0, 190, or 380	500	1900	90–120

Using Table 4-1 of the UFC 3-600-01, Table 4-1 Sprinkler System and Water Supply Design Requirements for Sprinklered Facilities, the hose stream allowances are as follows:

Room 118B Book Stack Area:

Ordinary Hazard Group 2	
Hose Stream Allowance:	1900 lpm (500 gpm) Min
Design Density:	8.2 lpm/sm (0.20 gpm/ft^2) Min
Design Area:	3000 SF (280 SM) Max
Protection Area:	130 SF (12.1 SM) Max
Duration:	90 Minutes

Room 116 Periodical/Compact Storage:

Ordinary Hazard Group 2	
Hose Stream Allowance:	1900 lpm (500 gpm) Min
Design Density:	8.2 lpm/sm (0.20 gpm/ ft^2) Min
Design Area:	3000 SF (280 SM) Max
Protection Area:	130 SF (12.1 SM) Max
Duration:	90 Minutes

Room 111 Media Room:

Ordinary Hazard Group 2	
Hose Stream Allowance:	1900 lpm (500 gpm) Min
Design Density:	8.2 lpm/sm (0.20 gpm/ ft^2) Min
Design Area:	3000 SF (280 SM) Max
Protection Area:	130 SF (12.1 SM) Max
Duration:	90 Minutes

It should be noted that the UFC 3-600-01, Table 4-1 Sprinkler System and Water Supply Design Requirements for Sprinklered Facilities is more stringent than 11.2.3.1.2 Hose Stream Allowance and Water Supply Duration Requirements for Hydraulically Calculated Systems.

4-2.3.6 **Sprinkler Coverage**.

In buildings protected by automatic sprinklers, sprinklers must provide coverage throughout 100 percent of the building except as permitted by NFPA 13. This includes, but is not limited to, telephone rooms, electrical equipment rooms, boiler rooms, switchgear rooms, transformer rooms, and other electrical and mechanical spaces. Coverage per sprinkler must be in accordance with NFPA 13, except that it must not exceed 21 square meters (225 square feet) for light hazard occupancies or 12.1 square meters (130 square feet) for ordinary hazard.

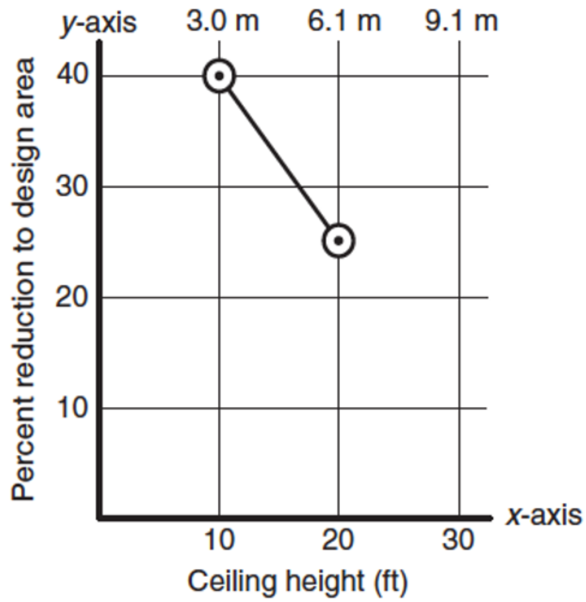
Figure 31: Sprinkler Coverage Requirement as per UFC 3-600-01

It should be noted that the sprinkler coverage is also defined in the UFC 3-600-01 in paragraph 4-2.3.6, Figure 31 above.

In a commercial facility, quick response sprinklers are assumed to be used in this situation. Using Figure 11.2.3.2.3.1 Design Area Reduction for Quick-Response Sprinklers, the design area has been reduced as follows:

Ordinary Hazard Group 2

Ceiling Height: 4.3 m
Original Design Area: 1500 ft^2
Area Reduction: 36%
Revised Design Area: 960 ft^2



Note: $y = \frac{-3x}{2} + 55$ for U.S. Customary Units

Note: $y = -4.8x + 54.6$ for S.I. Units

For ceiling height ≥10 ft and ≤20 ft, $y = \frac{-3x}{2} + 55$

For ceiling height <10 ft, $y = 40$

For ceiling height >20, $y = 0$

For SI units, 1 ft = 0.31 m.

FIGURE 11.2.3.2.3.1 Design Area Reduction for Quick-Response Sprinklers.

Figure 32: Design Area Reduction for Sprinklers as per NFPA101

Unfortunately, design area reduction is not allowed in the case of a DoD facility as per the below UFC 3-600-01 regulation:

9-7.3.7 The design area reductions in NFPA 13 for quick-response sprinklers are not permitted.

Figure 33: Sprinkler Coverage Requirement as per UFC 3-600-01

SYSTEM DESIGN

1. DESIGN REQUIREMENTS

a. Occupancy Classification	:	Ordinary Hazard, Group 2 (UFC 3-600-01, Appendix B)
b. Design Area	:	3,000 sf (280 sm) (UFC 3-600-01, Table 4-1)
c. Design Density	:	0.20 gpm / sf (8.2 lpm / sm) (UFC 3-600-01, Table 4-1)
d. Duration of Supply	:	90 minutes ((UFC 3-600-01, Table 4-1))
e. Coverage per Sprinkler	:	130 sf (12 sm) (NFPA 13, Table 4-2.2)

2. FIRE PROTECTION REQUIREMENTS

a. Sprinkler Pump	=	Design Area x Design Density
	=	280 sm x 8.2 lpm/sm
	=	2,296 lpm
b. Capacity of Fire Water Receiving Tank	=	Discharge Density x Discharge Area x Duration of Supply
	=	2,296 lpm x 90 minutes
	=	206,640 liters
	=	207 m^3

3. EXISTING WATER FLOW INFORMATION

Hydrant # G-28		
Static Pressure	:	69 psi (4.85 Kgs/cm^2)
Residual Pressure	:	60 psi (4.22 Kgs/cm^2)
Available Flow	:	890 gpm (3,369 lpm)

Figure 34: Fire Protection Requirement Summary for NA893 Community Support Facility

The Yokosuka water main runs north to south along the side road adjacent to the proposed facility. The connection point for water is taken from the nearest fire hydrant identified as G28. A water line is looped around the facility from this point. There is approximately 70 meters of length of piping from the Yokosuka main base water main to the facility.

The water line enters the facility on the southeastern corner of the building from Room 123, the mechanical room. A fire pump is required by the Japanese Fire Law which takes precedence since the Japanese government was proposed to build this facility for the US military. It is assumed that the riser is in the fire pump room. From this riser, water will need to be provided to the two structurally separate portions of the building, administrative and industrial.

For this 4-story, reinforced concrete building, the hydraulically most remote part of the building will be the northwest corner of the building on the fourth floor. The water line will go up to the fourth floor, be redirected to the cross mains which will travel through the middle of the facility to and branch off into the northwest corner of the building. Room 438 is the furthest room in the Light Hazard Occupancy portion of the building.

Room 118B Book Stack Area:

Ordinary Hazard Group 2
Room Area: 528.9 SM or 5693 ft^2
Ceiling Height: 3.50 m
Sprinkler Density: 0.20 gpm/ ft^2
K Factor: 8.0

Area of operation = 3000 sq. ft.
Area per sprinkler = 130 sq. ft. per sprinkler
Ns = 3000/120 = 23.07 say 24 sprinklers

According to NFPA 13 23.4.4.1.1.1:
$L > 1.2 \times (3000)^{1/2} = 65.73$ ft
Since the proposed sprinklers are 12 feet apart, 6 sprinklers are required along the branch line.

Room 116 Periodical/Compact Storage:

Ordinary Hazard Group 2
Room Area: 38.4 SM or 413.3 ft^2
Ceiling Height: 3.50 m
Sprinkler Density: 0.20 gpm/ ft^2
K Factor: 8.0

Area of operation = 413.3 sq. ft.
Area per sprinkler = 130 sq. ft. per sprinkler
Ns = 413.3/120 = 3.18 say 4 sprinklers

According to NFPA 13 23.4.4.1.1.1:
$L > 1.2 \times (413.3)^{1/2} = 24.39$ ft
Since the proposed sprinklers are 12 feet apart, 3 sprinklers are required along the branch line.

Room 111 Media Room:

Ordinary Hazard Group 2
Room Area: 61 SM or 656.6 ft^2
Ceiling Height: 2.70 m
Sprinkler Density: 0.20 gpm/ ft^2
K Factor: 8.0

Area of operation = 656.6 sq. ft.
Area per sprinkler = 130 sq. ft. per sprinkler
Ns = 656.6 /120 = 5.05 say 6 sprinklers

According to NFPA 13 23.4.4.1.1.1:
$L > 1.2 \times (656.6)^{1/2} = 30.75$ ft
Since the proposed sprinklers are 12 feet apart, 3 sprinklers are required along the branch line.

SYSTEM COMPONENTS

The hydraulically remote sprinklers in the administrative and industrial portions of the facility has been identified in the previous section. The sprinklers have been identified to have a K8.0 rating. A catalogue cut can be found in the appendix. The sprinklers are standard response sprinklers with a k-factor of 8.0 and an activation temperature of 162 degrees F.

The proposed wet-pipe automatic sprinkler system is illustrated in appendix. Piping is all Schedule 40 steel pipe, with the nominal pipe diameters shown on the plan. The sprinklers are spaced on a 12 ft by 10 ft grid as indicated. The cross main is centered between the branch lines running from south to north of the facility. The ceiling height in the administrative section is 2.7 meters and in the library portion 3.50 meter above the floor.

A 1" pipe is used between the most remote sprinkler and the second sprinkler along the branch line. A 1.25" pipe is used between the second sprinkler until the branch line. A 1.5" pipe is used between the branch line and the cross mains that run south to north along the facility. A combination of 2" and 2.5" pipe is used along the length of the cross mains. A 3" pipe is used from the riser nipple to the base of the riser (BOR). The 3" riser extends to an elevation of 36 feet above the floor and includes an 3" alarm valve.

Note that the underground pipe leading into the building is 4" pipe with a length of 230 ft. A post indicator valve is located in the underground pipe, approximately 6 feet from the building wall. There is also a city control valve in the underground line at the point of connection. The point of connection is indicated by the hydrant S-4 on the drawing.

HYDRAULIC CALCULATIONS

Hydraulic calculations are made for the both the administrative areas on the fourth floor of the facility and the main library area on the first floor. The fourth floor is a Light Hazard Occupancy and the requirements are summarized as follows. There are 8 sprinklers in the design area. There are 3 sprinklers per branch line. Here are the sprinkler requirements for the first branch line. The minimum required discharge rate for each of the sprinklers are as follows:

Sprinkler 1: 20.0 gpm at 12.0 psi
Sprinkler 2: 41.0 gpm at 24.8 psi
Sprinkler 3: 65.4 gpm at 38.3 psi

According to NFPA 13, 23.4.2.1.1 Pipe friction losses shall be determined on the basis of the Hazen–Williams formula, as follows:

$$p = \frac{4.52Q^{1.85}}{C^{1.85}d^{4.87}} \qquad \textbf{[23.4.2.1.1]}$$

where:
p = frictional resistance (psi/ft of pipe)
Q = flow (gpm)
C = friction loss coefficient
d = actual internal diameter of pipe (in.)

Figure 35: Pipe Friction Loss Equation

Please refer to Appendix B. The equivalent K-factor for the most remote branch line is calculated at 12.8. The K factor is calculated from NFPA 13 23.4.2.5 K-Factor Formula. K-factors, flow from an orifice, or pressure from an orifice shall be determined on the basis of the following formula:

$$K_n = \frac{Q}{\sqrt{P}} \qquad \textbf{[23.4.2.5]}$$

where:
K_n = equivalent K at a node
Q = flow at the node
P = pressure at the node

Figure 36: K-Factor Equation

It is assumed that tees are used when there is a 90-degree change in direction so that the cross mains can be cleaned out rather than just an elbow.

The system demand at the BOR is calculated to be 116.0 gpm and 33.8 psi.

The required flow and pressure at the point of connection (POC) to meet the required system demand is calculated to be 116.0 gpm and 36.2 psi.

Second, the hydraulic calculations are made for main library area on the first floor. Please refer to Appendix B for the hydraulic calculation sheet. There are 8 sprinklers in the design area. There are 4 sprinklers per branch line. Here are the sprinkler requirements for the first branch line. The minimum required discharge rate for each of the sprinklers are as follows:

Sprinkler 1: 24.0 gpm at 18.9 psi
Sprinkler 2: 48.4 gpm at 19.9 psi
Sprinkler 3: 73.4 gpm at 22.1 psi
Sprinkler 4: 99.7 gpm at 24.1 psi

According to NFPA 13, 23.4.2.1.1 Pipe friction losses shall be determined on the basis of the Hazen–Williams formula. The equivalent K-factor for the most remote branch line is calculated at 14.8. The K factor is calculated from NFPA 13 23.4.2.5 K-Factor Formula. K-factors, flow from an orifice, or pressure from an orifice shall be determined on the basis of the equation shown in Figure 36. The system demand at the BOR is calculated to be 146.8 gpm and 44.3 psi. The required flow and pressure at the point of connection (POC) to meet the required system demand is calculated to be 146.8 gpm and 47.1 psi.

WATER SUPPLY & DEMAND ANALYSIS

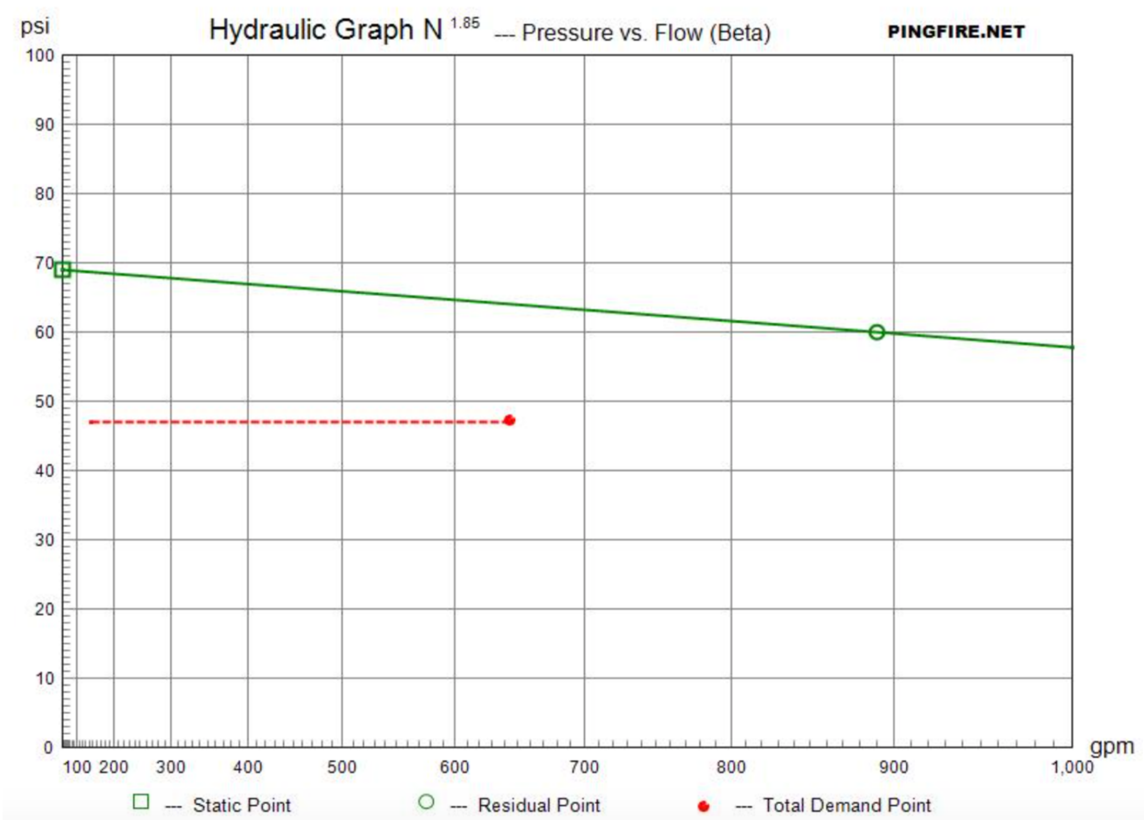


Figure 37: Hydraulic Supply and Demand Curve for NA893 Community Support Facility

Please refer to Figure 37 for the hydraulic supply and demand curve. A full-page version of the hydraulic supply and demand curve is located in Appendix C. As shown on the hydraulic supply and demand curve, the static pressure is 69 psi and the residual pressure is 60 psi and the available flow is 890 gpm. The water demand is shown on the graph at 47.1 psi and 146.8 gpm with a 500 gpm hose stream requirement. The water demand is based on sprinkler demand requirements on the northern most room on the first floor, which has been classified as Ordinary Hazard II. These requirements were slightly higher than the northern most room on the third or

Although the available water supply is adequate to meet the demands of the existing sprinkler system as well as the total hose stream demand, the Building Standard Law of Japan requires a fire pump in this situation. According to the Building Standard Law of Japan, a fire pump, an emergency generator, and a water tank that can accommodate the sprinkler requirement for the required duration, 90 minutes in this case, is provided since it is assumed that the water mains and power may be cut off during a seismic event. The fire pump, an emergency generator, and a water tank are a redundancy and is a prescriptive requirement since the subject facility is a high population facility and since it is designated an emergency evacuation facility.

INSPECTION, TESTING, AND MAINTENANCE

Since this facility will be designed and constructed by the Japanese Military of Defense by Japanese designers and contractors, the inspection and acceptance testing for this facility is different from just following the NFPA13 and relevant IBC sections.

During the design and construction of the facility, it should be noted that the facility must meet and pass the Japanese Fire Law. The acceptance and testing of the design documentation and construction turnover will be done in accordance with the Japanese Fire Law. However, since this facility will be designed and built on a US military base, it will have to follow US Federal regulations such as the NFPA and IBC as well as military regulations such as the UFC 3-600-01. The systems review and acceptance will be performed by the Authority Having Jurisdiction (AHJ) in Japan who is the Fire Protection Engineer at the US Army Corp of Japan or at the Naval Facilities Far East.

This facility will require the design, review and oversight services of a Qualified Fire Protection Engineer (DFPE). A QFPE must be involved in every aspect of the design, construction and testing/commissioning as it relates to fire protection and life safety. This includes, but is not limited to, building code analysis, life safety code analysis, design of automatic fire alarm, detection and suppression systems, water supply analysis, a multi-discipline review of the entire project, construction inspections and witnessing of fire protection acceptance testing/commissioning.

The design publications listed below should be used as sources of criteria for fire protection design. The criteria from these sources may be supplemented by applicable criteria contained in nationally recognized codes, standards, and specifications. Government engineering publications are located in the Whole Building Design Guide website at http://www.wbdg.org.

UNIFIED FACILITY CRITERIA (UFC)
UFC 3-600-01 Fire Protection Engineering for Facilities, Most Recent Edition

UNIFIED FACILITIES GUIDE SPECIFICATIONS (UFGS)
See the Whole Building Design Guide website for the most current UFGS fire protection specification sections.

INTERNATIONAL CODE COUNCIL (ICC)
International Building Code (IBC), Most Recent Edition

NATIONAL FIRE PROTECTION ASSOCIATION
Most Recent Editions

Fire suppression systems should be provided for facilities in accordance with UFC 3-600-01 and applicable NFPA criteria. System designs should be the performance-based type with detailed shop drawings, materials submittals, and hydraulic calculations prepared by qualified technicians. Installation of as required by UFC Standpipe and Hose Systems and NFPA standards Installation of Sprinkler Systems.

Tailor the sprinkler design criteria (occupancy, design area, density, hose demand, etc.) specifically for each building. Identify all of the performance criteria for the main library and business occupancy areas. The criteria should be specific. The drawings should identify the arrangement of the bookshelves, bookshelf height, clearance, items being stored, K-factor, number of heads operating, minimum pressure, hose demand, etc. such that the Government or Contractor does not have search NFPA 13 for the criteria or argue about the commodity, maximum storage height, etc.

Show the incoming water supply line location and risers. The riser has to be fully detailed complete with identifying all valves, switches, and piping. The conceptual design begins downstream of the riser and not at the pump. Important items need to be shown pictorially to indicate the design intent. The detail callouts on the plan need to match detail sheets. Show the layout and size of all piping and equipment from the point of connection to the water supply, to the sprinkler cross mains. The contract drawings should include a detailed sprinkler riser diagram. Show location and size of service mains, interior feed mains, control valves, sprinkler risers, drain lines, sectional valves, and inspector's test valves and switches on the drawings. Specify water flow data including hydrant flow results, including the location where the hydrant flow test was conducted, on the drawings. Indicate the location and size of existing mains and new water supply lines that will serve the sprinkler system (including all supervisory valves), and the location and size of all risers on the plans. Highlight or clearly indicate the area(s) to be protected by sprinklers on the drawings. Specify waterflow requirements including the design density, design area, the hose stream demand (including location of the hose stream demand), the duration of supply, and sprinkler spacing and area of coverage on the drawings. Show the location of the backflow preventer (including provisions for a drain and access for maintenance) where the potable water supply system is at risk of contamination by the sprinkler system on the drawings.

When connecting to an existing water distribution system, waterflow tests will be conducted in accordance with UFC 3-600-01 to determine available water supply for the sprinkler system. The Designer of Record should either perform or witness the waterflow test. The waterflow test results (including date test is performed) should be included in be included in the design documents no later than the concept submission. Note that the availability of the Designer to participate or witness the waterflow test will be necessary.

Provide hydraulic calculations and sketches complete with nodes, pipes, sprinklers, etc. The hydraulic calculations to follow the format of NFPA 13 to support the conceptual design and submitted in the Basis of Design. The designer (a fire protection engineer) must provide hydraulic calculations demonstrating that the design will provide an adequate water supply for the fire extinguishing system. Hydraulic calculations must be submitted before the first submittal. The A/E needs to provide hydraulic calculations based on a conceptual layout. Not rough conceptual calculations.

Commissioning requirements for Army, Air Force, and other Department of Defense facilities are outlined by UFC 1-200-02 High Performance and Sustainable Building Requirements, ASHRAE Standard 189.1 Standard for the Design of High-Performance Green Buildings, and Engineering Regulation 1110-345-723 Total Building Commissioning Procedures. If a project has a Leadership in Energy and Environmental Design (LEED) requirement, commissioning requirements are imposed by the LEED Rating Systems. The design publications listed below should be used as sources of criteria for commissioning. The criteria from these sources may be supplemented, but not supplanted, by applicable criteria contained in nationally recognized codes, standards, and specifications.

Once the facility has been commissioned and accepted, maintenance of the facility shall be done by the facility owner which is the Department of the Navy, Yokosuka Naval Base, Department of Public Works in this case. Maintenance of the fire suppression system will be carried our in accordance with the UFC 3-600-01 and best practices. The fire pumps will be periodically tested (3-6 months) by the Yokkosuka Fire Department and Yokosuka Public Works Department. Other system components such as backflow preventers, risers, and other components will be periodically tested as specified by the manufacturer's preventative maintenance recommendations.

This is a comprehensive report on the fire suppression system for NA893 Community Support Facility at Yokosuka Naval Base. This facility has many functions to include the main library, education center, clinical space, and other administrative functions.

This facility is a 4 story, reinforced concrete structure. The administrative, clinical, and educational portion of the facility has been classified as a Light Hazard Occupancy. The water suppression demand for this portion of the facility has been calculated to be 116.0 gpm at 36.2 psi.

The main library portion of the facility is located on the first floor. The library portion of the facility has been classified as a Ordinary Hazard Group 2 Occupancy. The water suppression demand for this portion of the facility has been calculated to be 146.8 gpm at 47.1 psi.

Based on the water supply information, there is amply flow and pressure to meet the fire suppression system requirements for the subject facility even with a 30-40% drop in water supply. Although not required by US codes and regulations, a fire pump and cistern will be installed based on the Japanese Fire Standard Law.

STRUCTURAL FIRE PROTECTION

INTRODUCTION

Within the context of structural fire protection, the concepts of implicit or prescriptive and explicit or performance-based safety have been covered. In this report, these two types of fire safety engineering design methods is discussed and compared. The implicit or prescriptive type of safety design guarantees safety through consensus approved solutions. The explicit or performance-based design assures safety through explicit demonstration of the adequacy of the design to meet the intent of the code with an accepted safety factor. Either method defines and demands the performance of a system. In recent years, explicit safety designs have increased in popularity due to the increase in complex and innovative structural and architectural designs coupled with the recognition of large cost-savings with explicitly defining the level of safety. In this project paper, both methods will be detailed and compared by using the NA893 Community Support Facility for the culminating project as a basis of comparison.

This report will be separated into three different components. First, there will be a fire resistance analysis of the student's building for the culminating project. Based on the International Building Code, the required construction classification will be identified. Then, the materials used to construct the columns, beams, floor assemblies, roof assembly, exterior walls, interior walls, door openings, joints, penetrations, and partitions will be distinguished. The fire resistance requirements for different elements of the building will also be summarized for this building. The fire safety strategy of the fire resistance in the building will be discussed. Finally, a diagram (structural drawings with markings, colors, and a legend) of the various fire resistance requirements throughout the building will be developed.

The next part of this section of the report is the design fire analysis. In order to discuss the structural fire safety of the building, this part of the report will consider three (3) potential realistic "worst-case scenario" design fires in your building. The heat transfer boundary conditions on the structural members surrounding the building will be calculated in each scenario.

The final part of this section of the report is the structural fire analysis. Based on the boundary conditions calculated in the previous section, the time to failure for the structural members in the vicinity of each design fire will be determined. An analysis will be performed both with and without structural protection. A protection scheme for the structural members will be recommended. A safety factor for the proposed design and if any cost savings can be made will also be considered.

Construction Classification

According to the JFY2000 NA893 Community Service Center, Yokosuka Naval Base, Japan, Criteria Package that was developed for the US Army Corps of Engineers, Japan District, the facility was only characterized as being occupied by the Assembly Group A-3 and Business Group B. The fire protection checklist was developed by a firm called SG Engineering and was approved by the Authority Having Jurisdiction in Japan.

Based on the analysis of as Assembly Group A-3 areas above, the amount of space allocated to this occupancy classification is as follows:

1st Floor 14,046 $ft^2 < 15,500\ ft^2$
2nd Floor 2,067 $ft^2 < 15,500\ ft^2$
3rd Floor 609 $ft^2 < 15,500\ ft^2$
Total 14,046 ft^2 + 2,067 ft^2 + 609 ft^2 = 16,487 $ft^2 < 62,000\ ft^2$

Based on the analysis of as Business Group B areas above, the amount of space allocated to this occupancy classification is as follows:

1st Floor 2,435 $ft^2 < 37,500\ ft^2$
2nd Floor 8,447 $ft^2 < 37,500\ ft^2$
3rd Floor 9,405 $ft^2 < 37,500\ ft^2$
4th Floor 9,975 $ft^2 < 37,500\ ft^2$
Total 2,435 ft^2 + 8,447 ft^2 + 9,405 ft^2 + 9,975 ft^2 = 30,280 $ft^2 < 150,000\ ft^2$

Table 18: Summary of Allowable Area per 2000 IBC

1.4 Allowable Area 認可面積:

Floor	Occupancy Group	A_t SQFT	F FT	P FT	W FT	I_s SQFT	A_a SQFT	AFA SQFT	AFA/ A_a	H FT	S FT
1	A-3	15,500	721	721	42	200	62,000	22,687	0.366	65	3
2～4	B	37,500	721	721	42	200	150,000	59,201	0.395	65	4
Total							212,000	81,888	0.761		

According to Table 506.1 of the 2000 IBC, for Type IIA construction and given that it is fully sprinklered at 4 stories, the maximum allowable area for Business Group B areas is 150,000 SF and Assembly Group A-3 is 62,000 SF as shown in Table 18 using the calculation method shown in Figure 38.

Floor (実施階) 、Occupancy Group Refer to Sec. 303 (占有用途 303 章参照)、S= Story 階数 (表 503), H= Height 高さ (FT), AFA=Actual Floor Area 実施各階面積 (SF), Refer to Table 503 and 2000 IBC Handbook "Fire and Life Safety Provisions" Application Example 302-1. IBC 表 503、2000 年 IBC ﾊﾝﾄﾞﾌﾞｯｸ消防安全規定/応用例 302-1 参照のこと。

Equation 5-1 (IBC Section 506.1)

A-3 $A_a = A_t + [A_t I_f/100] + [A_t I_s/100]$

= 15,500 + [15,500 x 100/100] + [15,500 x 200/100]

= 62,000 SF

B $A_a = A_t + [A_t I_f/100] + [A_t I_s/100]$

= 37,500 + [37,500 x 100/100] + [37,500 x 200/100]

= 150,000 SF

A_a = Allowable area per floor (square foot)
各階認可面積

A_t = Tabular area per floor IAW Table 503(square foot)
IBC200 の表 503 に記載されている面積。

I_f = Area Increase due to frontage (percent) as calculated IAW Section 506.2
506．2 章に基いた周囲空地に伴う面積割増係数。

I_s = Area Increase due to sprinkler protection (percent) as calculated IAW Section 506.3
506．3 章に基いた監視自動ｽﾌﾟﾘﾝｸﾗｰ設置よる面積割増係数。

Figure 38: Equation 5-1 of 2000 IBC

The area increases due to the frontage as calculated in accordance with Section 506.2 of the 2000 IBC as shown in Figure 39.

Equation 5-2 (IBC Section 506.2)

I_f = 100 [F/P-0.25] W/30

= 100 [721/721 – 0.25] x 42/30

= 105.00% USE 100% IAW section 506.3

I_f = Area Increase due to frontage (percent) as calculated IAW Section 506.2
506．2 章に基いた周囲空地に伴う面積割増係数。

F = Building perimeter which fronts on a public way or open space having 20 feet open minimum width.
公共道路又は空地に 20ft 以上の幅が面している建物の外周。

P = Perimeter of entire building. 建物の全周。

W = Minimum width of public way or open space.
公共道路又は空地等の最小幅員またはその最小幅。

Figure 39: Equation 5-2 of 2000 IBC

CONTRUCTION MATERIALS

Under the Japanese Building Code and Japanese Fire Service Law, this facility was built using high strength reinforced concrete. The requirement of the use of high strength reinforced concrete is derived from the fact that the facility would be built in a highly seismically active area. Similar to the International Building Code, the Japanese Fire Service Law also requires fire resistance requirements similar to the 2000 IBC.

FIRE RESISTANCE REQUIREMENTS

The JFY00 NA893 Community Support Center is designed to be center that provides information, education and training services, and counseling service for active duty population with services usable to dependents and retirees of all grades and ranks in order to enhance their potential to the military services. The first floor is designed as the base library that can be used by school age children, dependents, and active duty personnel. Therefore, the first floor is characterized as an A-3 Assembly occupancy. The second to fourth floors are occupied by the education center and family service centers. The Education Center provides services for advancing of the academic, technical, and vocational education of military personnel of all grades and ranks in order to enhance their potential to the military services. Although the activities are educational in nature, it will be classified as a Business occupancy since the people who will be using the facilities are adults. The Family Service shall provide information and referral services, education and training services, and counseling service for active duty population with services usable to dependents and retirees. Family services will also be characterized as Business occupancy since the people who will be using it are adults.

The actual area of the JFY00 NA893 Community Support Center is calculated to be 81,888 square feet and is a four-story building. The overall height of the facility is designed to be 63.7 feet tal as shown in Figure 40l. The maximum allowable height in accordance with the 2000 IBC Section 504.2 for Type II-A construction for both Assembly Group A-3 and Business Group B is 65 feet. There is a mechanical room for the elevator located on the roof but is not counted as an actual floor since it is less than one-eighth the floor area of the other floors.

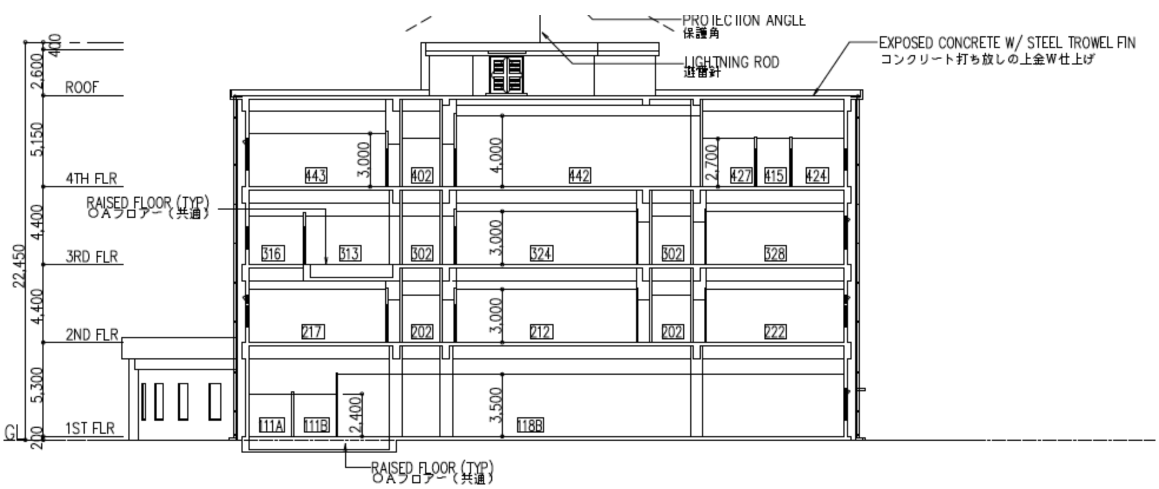


Figure 40: Section of NA893 Community Support Facility

According to, the fire resistance requirements are highlighted under Type II-A Construction below in Table 19 and 20. For Type IIA construction, the structural frame, exterior and interior walls are to have a fire-resistance rating of one hour as per Table 19.

The floor construction including supporting beams and joints as well as the roof components are also to have a fire-resistance rating of one hour.

Table 19: Fire Resistance Rating Requirement per 2000 IBC

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (hours)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A[e]	B	A[e]	B	HT	A[e]	B
Structural frame[a]	3[b]	2[b]	1	0	1	0	HT	1	0
Bearing walls Exterior[g] Interior	 3 3[b]	 2 2[b]	 1 1	 0 0	 2 1	 2 0	 2 1/HT	 1 1	 0 0
Nonbearing walls and partitions Exterior	See Table 602								
Nonbearing walls and partitions Interior[f]	0	0	0	0	0	0	See Section 602.4.6	0	0
Floor construction Including supporting beams and joists	2	2	1	0	1	0	HT	1	0
Roof construction Including supporting beams and joists	1 1/2[c]	1[c, d]	1[c, d]	0[c, d]	1[c, d]	0[c, d]	HT	1[c, d]	0

The NA893 Community Support Facility has an anti-terrorism/force protection set-back of ten meters since it is classified as a primary gathering facility. Therefore, the fire separation for the subject building is more than 30 feet. As per Table 20, for all types of construction, there is no fire-resistance rating required based on the fire separation distance. However, from Table 19, there is fire-resistance rating of one-hour since the subject facility is Type IIA construction.

Table 20: Fire Resistance Rating Requirement per 2000 IBC

TABLE 602
FIRE-RESISTANCE RATING REQUIREMENTS FOR EXTERIOR WALLS BASED ON FIRE SEPARATION DISTANCE[a, e]

FIRE SEPARATION DISTANCE = X (feet)	TYPE OF CONSTRUCTION	OCCUPANCY GROUP H	OCCUPANCY GROUP F-1, M, S-1	OCCUPANCY GROUP A, B, E, F-2, I, R, S-2, U[b]
X < 5[c]	All	3	2	1
5 ≤ X <10	IA Others	3 2	2 1	1 1
10 ≤ X< 30	IA, IB IIB, VB Others	2 1 1	1 0 1	1[d] 0 1[d]
X ≥ 30	All	0	0	0

The fire resistance requirements for Type II-A construction has also been captured in the summary statement below in the JFY00 NA893 Community Support Center criteria package that was developed by SG Engineering for the US Army Corps of Engineers, Japan District below:

Types of Construction – Fire Resistive Requirements 構造種別 – 耐火要求
(IBC Table 601)

Building Element 建物要素	Hours 時間
Exterior Bearing Walls 耐力壁 (外壁)	1
Interior Bearing Walls 耐力壁 (内壁)	1
Exterior Non-Bearing Walls 非耐力壁 (外壁)	Non-combustible
Structural Frame 骨組構造（柱、ｶﾞｰﾀﾞｰ、ﾄﾗｽ）	1
Permanent Partitions 恒久仕切壁	Non-combustible
Shaft Enclosures ｼｬﾌﾄ区画	2 (IAW 707.4)
Floors – Ceilings/Floors 床	1
Roofs – Ceilings/Roofs 屋根	1
Exterior Doors and Windows 外部部ドア・窓	Non-combustible (IAW 704.8)
Stairways 階段	Non-combustible (IAW 704.8)

Figure 41: Summary of Fire Resistance of Structural Elements for NA893 Community Support Facility

According to Table 19 and Figure 41, the exterior and interior bearing walls will have a fire resistance of 1 hour. According to Table 19 and Figure 40, the floors, ceilings, and roof will have a fire resistance of 1 hour.

DESIGN FIRE ANALYSIS

For the JFY00 NA893 Community Support Center building, the first floor functions as the Yokosuka Main Base's primary library. The floors above are classrooms and meeting rooms. Therefore, the first floor seems to be where most of the fire threat would be located since the library contains books and periodicals, which are combustible materials. Since this is a library, these books will be located in book stacks, which will concentrate the amount of combustible materials in one space and stacked on top of each other. These book stacks are also placed in a manner that if a fire does start, it can easily progress to the other end of the room through convection, conduction, and radiation in a short span of time and space. Although the facility will have automatic sprinklers, the bookracks will not have in-rack sprinklers like other commodity storage with combustible materials.

The three (3) potential realistic "worst-case scenario" design fires in this building will include a fire in Room 118B, the main bookrack area of the library, a fire in Room 116, the periodicals room, and a fire in one of many media rooms, Room 111x. All three fire scenarios are located on the first floor of the facility and have the capability of spreading to other parts of the first floor which all contain combustible materials and has the capability of affecting the ceiling structure and weakening the floor structure above until it becomes an unsafe structural situation. Furthermore, the first-floor fire scenario will also cause a lot of smoke which will lead up to the more densely occupied higher floors of the facility which may make evacuation more difficult.

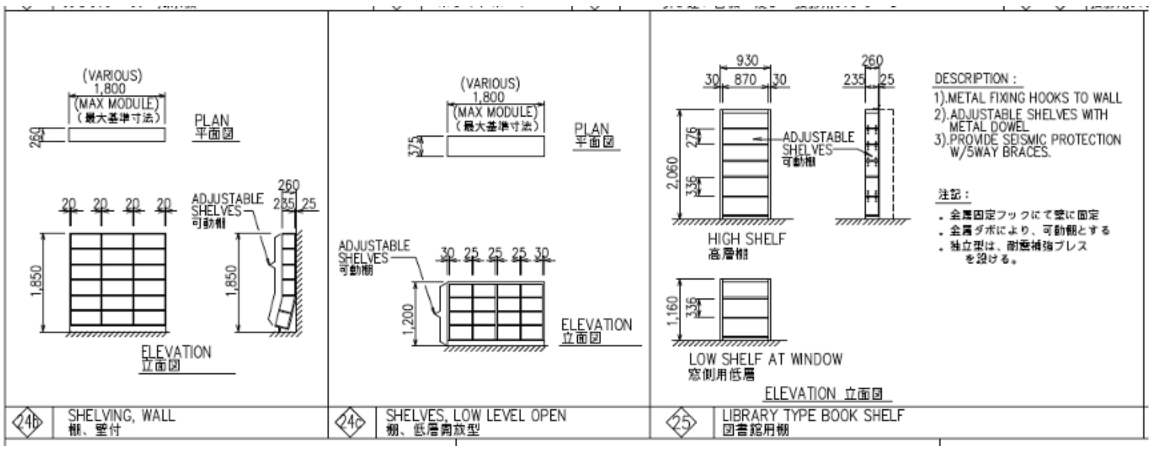


Figure 42: Typical Bookshelf Details for NA893 Community Support Facility

The worst-case scenario fire that I can imagine for this facility is a fire in the main library bookracks, Room 118B. This is an area where library books and materials are stacked. This open area is a large room (32 meters x 22 meters) and is provided with standard, vertical adjustable shelving. Details of the bookshelves are shown in Figure 42.

Another worst-case scenario fire would be in Room 116, the periodicals room. This room is where back issues of periodicals and miscellaneous items are stored. This room shall also be provided with storage shelving units. One difference between Room 118B and 116 is that Room 116 is a relatively compact room and this room can be consumed with fire relatively easily.

The final worst-case scenario fire would be in a fire in one of many media rooms, Room 111, A through J. The media rooms are private cubicles for viewing videos and listening to audio programs. These cubicles are very small rooms and are provided with TV, video & audio player, acoustical treatment and view window on doors. Within the confines of a very small room, a lot of equipment that can get heated if not properly cooled and ventilated. Due to the proximity of the other media rooms, a fire that starts in one room may be able to spread to other areas.

DESIGN FIRE CHARACTERISTICS

The design fires for the first two scenarios involve fires taking place in a library where the combustible fuel source will most likely be bookshelves filled with books or periodicals. Most shelves in libraries are open display and these shelves are lined up along aisles that are used to divide the space. This type of open shelf plan provides library patrons with an ordered and convenient environment that allows them to find their desired references. Although this is an excellent way to archive references in a library, the presentation and location of these shelves does not consider fire load and flammability of the situation. Although the library may want include as many references as possible for the patron, this densely packed amount of flammable products may result in quick fire spread or even create barriers in an evacuation path.

At present, the placement of bookshelves in libraries mainly concerns maximum effectiveness within limited areas and thus, aisle width considers first human engineering and then number of products displayed as well as shopping comfort. Librarians probably do not consider safe distance between shelves when arranging the bookshelves of a library. Although the discussion of safe distance between shelves with a full-size experiment acquires clear results, a large amount of resources is required. As a result, computer simulation is used globally in relevant fire studies to effectively save resources, change parameter setups, and acquire broader and more diversified results.   Sung-Yu Yuan and her associates provided a study in the Journal of Applied Fire Science titled *"A Study on the Safety Distance of Open Shelves in Malls"* in Volume 20(4), pages 289-310, in 2010. The heat release data from the study is shown in Figure 43. The validation tool adopts the US NFPA 92B for the calculation of radiant heat flux of fire source and lateral clearance and Fire Dynamics Simulator (FDS for the analysis of radiant heat flux to develop model of shelves and clearance aisles to measure the radiant heat flux of shelves on fire at different locations.

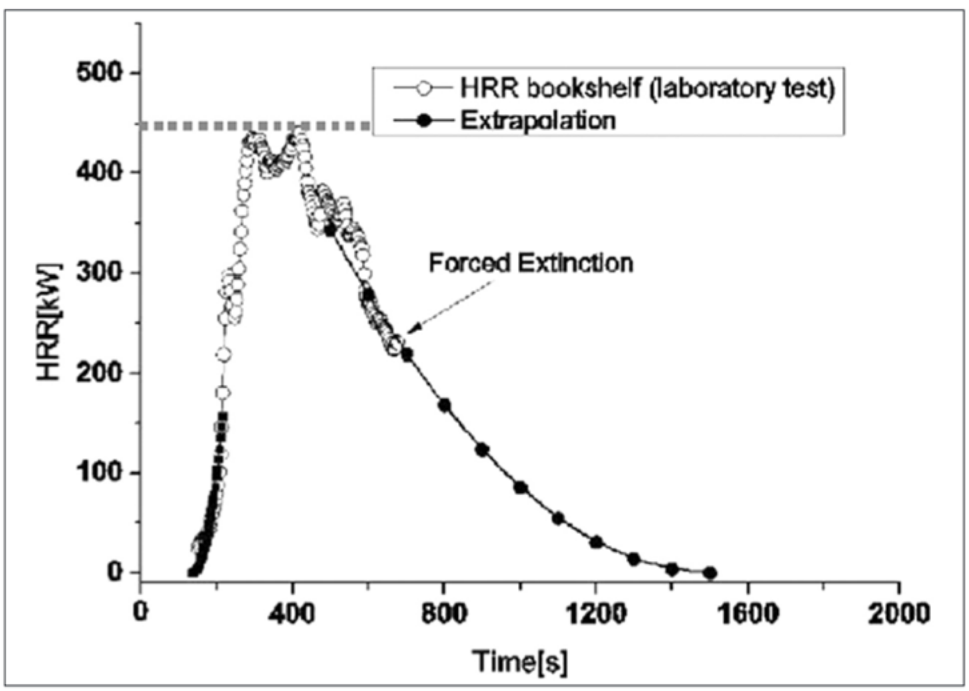


Figure 2. Heat release rate of book shelf (BRE Centre for the Fire Safety Engineering).

Figure 43: Heat Release Rate of Book Shelf in BRE Study

Simulations require actual fire load data from an actual combustion experiment but it is difficult to acquire relevant data, and most simulations used data from previous studies in a strict way. Most malls sell products with low fire risks such as cosmetics and clothing, and the requirement for the experimental scope of flammable limitation and fire occurrence is less strict than those of book shelves in this study. This study refers to the full-size experimental data of the UK BRE Centre for Fire Safety Engineering and reports the maximum heat release rate of a book shelf loaded fully with books and paper at about 450 kW/m^2. The maximum heat release rate of shelves at a duty-free shop is 1200 kW/m^{2}and some shelves are considered for the display on both sides with a dimension of 1.2m(W) x 1.8m(L) x 1.5m(H), about two times that of the book shelves including full loading on two sides. The fire load of these shelves is set up as two times that of book shelves (450*2 = 900 < 1200kW/m^2) for conservative evaluation.

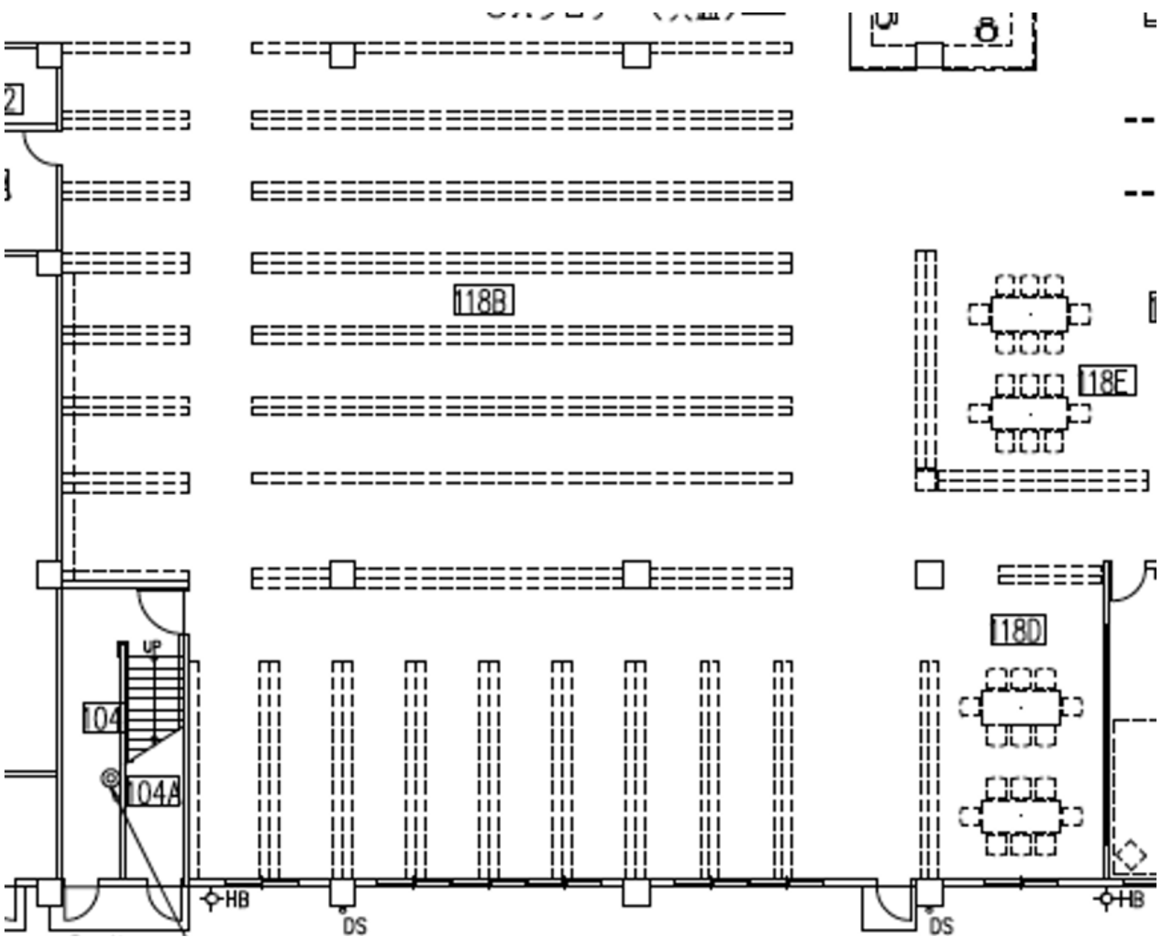


Figure 44: Room 118B Main Library Book Stack of NA893 Community Support Facility

Room 118B of the JFY00 NA893 Community Center is a large open space with library bookshelves lined up in its space as shown in Figure 44. The bookshelves appear to be fully loaded and are placed back to back. These shelves seem to be the tall shelving with the dimension of 1.2m(W) x 1.8m(L) x 1.5m(H). For the design simulation, the fire load of these shelves will be twice that of the book shelves at 1000 kW/m^2.

Since room 118B is a large open space, and since that it is not possible for the entire room to be ablaze at the same time, the fire design scenario will consider the Traveling Fire Methodology (TFM). Experimental studies and recent incidents have shown that large, open-plan compartments, typical of modern architecture, do not burn simultaneously throughout the whole enclosure. Instead, these traveling fires tend to move across the floor plates as flames spread, burning over a limited area at any one time.

Since room 118B is an odd shape, the room will be modeled as a simple rectangle. The dimensions of the room will be 32 meters long, 22.7 meters wide, and 3.5 meters high.

E. Zalok et al looked into fire loads in their paper "Fire loads in commercial premises" in Fire and Materials, 33, pages 67-78, in September 18, 2008. The authors conducted two series of experiments to determine the burning characteristics of different fuel packages, in both pre- and post-flashover fires, to develop data to characterize design fires for commercial premises. These fuel packages represented fuel loads determined from the survey of commercial buildings. Results suggest substantial differences in the burning characteristics of different stores. In this article, the description of the recommended design fires includes: (1) types of combustibles, (2) fire load density (MJ/m^2), (3) fire growth rate, and (4) yields of CO and CO2.

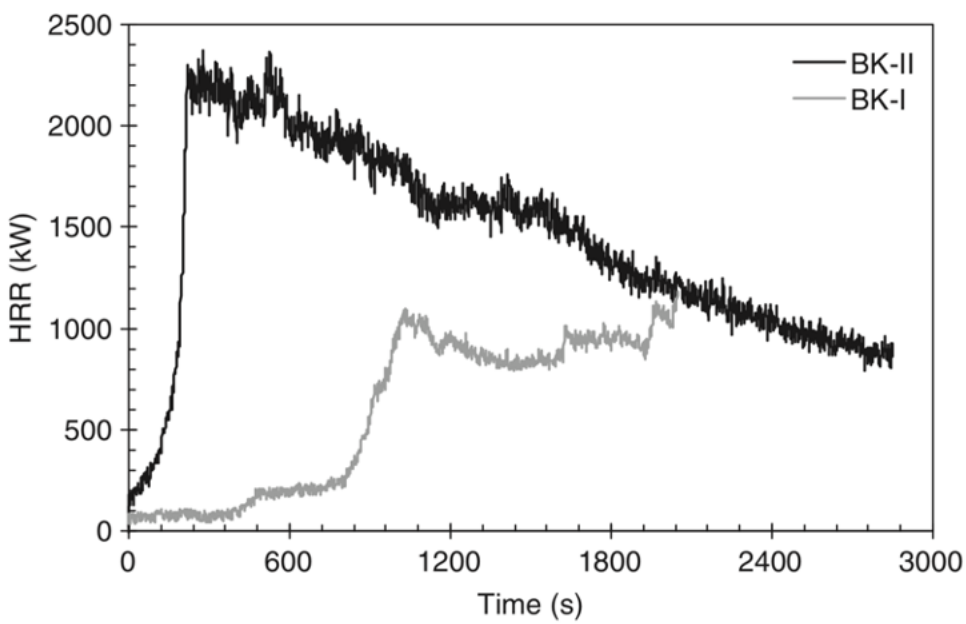


Figure 30. Heat release rate (HRR).

Figure 45: Heat Release Rate of Book Shelf in Zalok Study

The heat release rate of the bookshelves from the Zalok study is shown in Figure 45. The fuel package for the bookstore and storage area of the bookstore had a fire load

density of 5305 MJ/m^2. This fuel package represented the maximum fire load density of the surveyed bookstore, and bookstore storage area with fuel load density of 5305 MJ/m^2. In the bookstore test, three single-sided book-display cabinets were arranged to form a U-shape, representing an end of a corridor in a bookstore.
The development of the fire in the bookstore test was very slow, as it took 14min for the fire to reach the growth phase and to spread to all combustibles. The findings from this study correspond to Sung-Yu Yuan's study with a HRRPUA of 1000 KW/m^2. For the model simulation, a fire load density of 3000 MJ/m^2 will be used since the shelves are two sides rather than three-sided U-shape. The Zalok study also states that the fire spread rate in for books was fast.

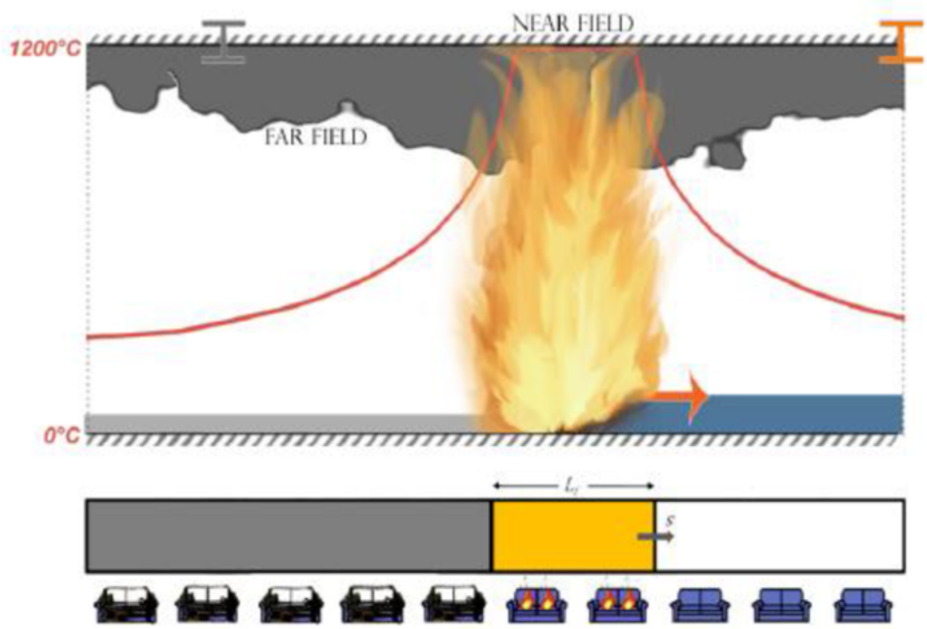


Figure 46: Illustration of Traveling Fire Method Concept

An illustration of the traveling fire concept is shown above in Figure 46. TFM considers a range of possible fire dynamics instead of just one or two design fires. In its inception, the methodology covered a wide range of fire sizes — a family of possible fires depending on the fire coverage of the total floor area, from 1 percent to 100 percent. Fire is assumed to spread at a constant fire spread rate, s along a linear fire path. The total fire duration depends on a fire size (or fire length, Lf) and is a function of the fuel load density (qf), heat release rate (Q''), and fire spread rate. In the latest TFM methodology, the new valid range of fire sizes reduces the family of fires passed to structural analysis and neglects unrealistic results. This is done by introducing the limiting realistic fire spread rates between 0.1 and 19.3 millimeters/second (0.0039 and 0.76 inches/second). They are based on the available experimental results and evidence from accidental fires.

Current design codes and consequently most of the understanding of behavior of structures in fire are based on the unrealistic assumption of uniform fire within the enclosure, especially in open large open areas. In the case of large open-plan compartments, non-uniform travelling fires have been observed. The Travelling Fires Methodology (TFM) has been developed to take into account this non-uniform fire behavior. The analytical equations used to represent the far-field temperatures are presented in continuous form. The concept of flame flapping is introduced to account for variation of temperatures in the near-field region due to natural fire oscillations. These updated near-field temperatures cover a range of temperatures between 800 and 1200 °C, depending on fire size and compartment characteristics. These incorporated changes are based on a fire model which can be used flexibly and adjusted to fit experimental data when it becomes available in the near future. TFM is applied to generic concrete and steel compartments to study the effect of non-uniform heating associated with the travelling fires by investigating the location of the peak temperature along the fire path. It is found to be mainly dependent on the fire spread rate and the heat release rate. Location of the peak temperature in the compartment mostly occurs towards the end of the fire path.

TFM considers design fires to be composed of two moving regions: the near-field (flames) and the far-field (smoke). The near-field represents the flames directly impinging on the ceiling and assumes peak-flame temperatures. The far-field model represents smoke temperatures, which decrease with distance away from the fire due to mixing with air. Any structural element will experience cooler far-field temperatures, which correspond to pre-heating and/or cooling, for a much longer duration than the short and hotter near-field.

The TFM states that any available temperature-distance correlation could be used to describe the far-field temperature depending on the accuracy required. In a recently published TFM analytical expression incorporating Alpert's ceiling jet correlation, is presented for the far-field. In the previous version of TFM, a discrete method was used. Alpert's correlation is based on a set of experiments created for sprinkler design. Despite its limitations, compared to other available solutions, Alpert's correlation provides results within acceptable limits of accuracy, and therefore, was chosen for its simplicity.

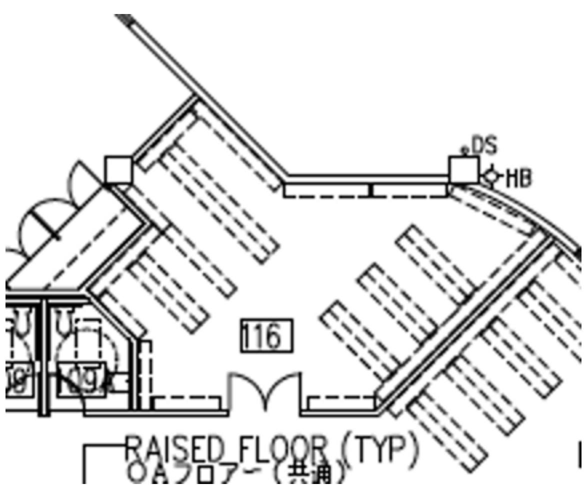


Figure 47: Room 116 Periodical Room

Room 116, the periodical room, is a small enclosed room on the first floor of the library, as shown in Figure 47. It seems like the same shelves in room 118B, the tall shelving with the dimension of 1.2m(W)*1.8m(L)*1.5m(H), are being used in this room. In the bookstore test, three single-sided book-display cabinets were arranged to form a U-shape, representing an end of a corridor in a bookstore. This configuration represented is very similar to the maximum fire load density of the surveyed bookstore in the Zalok paper. Therefore, the Room 116 fire load density will use the same fire load density of the bookstore storage area with fuel load density of 4000 MJ/m^2. The Zalok study also states that the fire spread rate for a combination of books and other materials such as plastics are involved, the speed increases. Therefore, it will be assumed that the fire will spread at a rate of 3 mm/s.

Since Room 116 is an odd shape, the room will be modeled as a simple rectangle. The dimensions of the room will be 8.5 meters long, 7.0 meters wide, and 3.5 meters high. There is only one double-door leading to the periodical room, which will measure 2 meters high by 2.4 meters wide. There are no windows even though Room 116 shares an exterior wall.

The third scenario is a little different from the library bookshelf scenarios provided as the first two worst-case fire scenarios at the library. In this final worst-case fire scenario, the fire occurs in a small, confined media room where a student can view videos or listen to audio programing while doing work on a desk. The media room will have a video monitor and a video playback station. Furthermore, the media room shall have headphones and audio playback systems as well. Since most video and audio programming are now available through network servers, it is very conceivable that media rooms will use multi-media computers to provide the audio and video playback. There will also be a desk and the student will probably bring other materials such as books or other writing materials to take note. There will also be a chair and maybe a waste-basket. In essence, the media station is very similar to an office workstation with a computer, desk, and chair. To approximate this fire, the workstation fuel package will be used. A sample of a workstation is presented in Figure 48.

Figure 48: Sample Visual of Workstation

The workstation fuel package is made of cellulosic materials as the main constituent (paper, books and the hardboard constituting the desk and workstation side panels) as well as plastic materials (office chair, letter tray, wastebasket, electronic devices and lining material of the workstation panels). Therefore, the HRRPUA is assessed to be 300 kW/m^2. According to Figure 49, the peak HRR is 3960 kW. Andrea Dussoa, Stefano Grimaza, and Ernesto Salzanob researched this situation in their paper titled "Rapid Estimation of the Heat Release Rate of Combustible Items" in Chemical Engineering Transaction in Volume 53 in 2016.

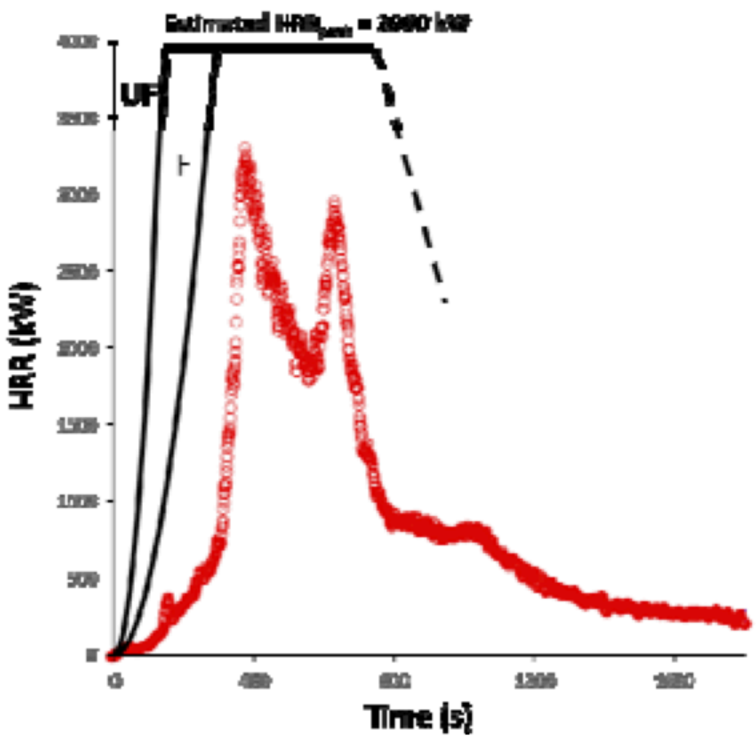


Figure 49: Heat Release Rate for Workstation

The fuel package in the computer room test had a fire load of 812MJ and a footprint of 1.0 m^2. The HRR in the computer room had an almost constant value with no clear distinction among the growth, developed, and decay phases. Therefore, the fire load density of 812 MJ/m^2 will be used for this model simulation.

The media rooms in the JFY00 NA893 Community Center were very small rooms (approximately 6 m^2) with a door with a desk and a computer station. This is displayed in Figure 50 below. If one of these rooms had an incident with a fire, the fire would consume the room very rapidly but will have a limited life due to the amount of material in the room. Since the other media rooms are directly adjacent to the media room, the fire may spread if the fire breaches the walls in between them

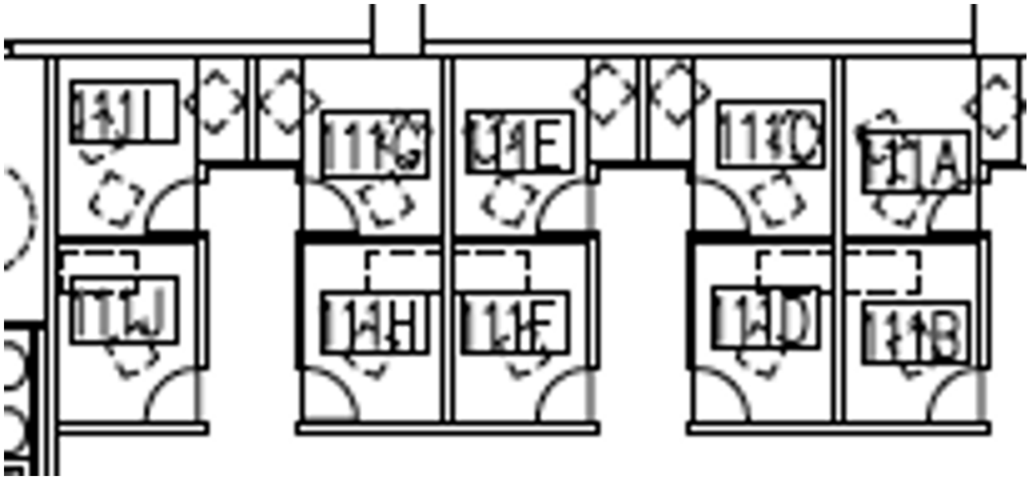


Figure 50: Room 111A-J Media Rooms in NA893 Community Support Facility

Since room 111x is an odd shape, the room will be modeled as a simple rectangle. The dimensions of the room will be 2.5 meters long, 2.4 meters wide, and 2.4 meters high. There is only one door per media room, which will measure 2 meters high by 1.2 meters wide. There are no windows even though room 111x shares an exterior wall.

HEAT TRANSFER TO STRUCTURAL MEMBERS

For Room 118B Book Stack Area, the Traveling Fire Methodology is used to approximate the heat transfer boundary conditions on the structural members surrounding your design. For this instance, the second supporting beam in the room from the far-left side of the room 118B is being analyzed. It is assumed that the fire starts at the far-left side of the room of room 118B at x = 0 meters. The ceiling jet temperature at 8.5 meters based on the simplified geometry of the building and the fire properties listed above will be used. The temperature vs. time curve are plotted below for the benefit of the reader.

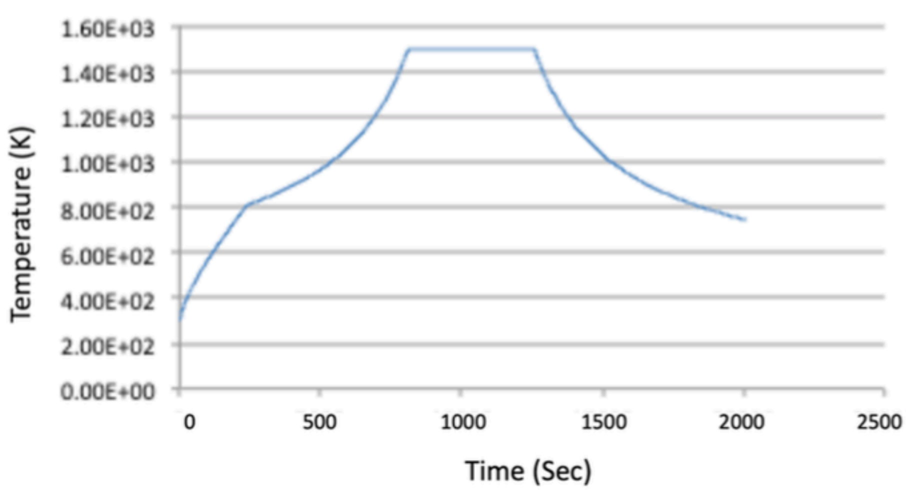


Figure 51: Temperature versus Time in Room 118B using TFM

The x-axis is time in the units of seconds and the y-axis in temperature in the units of Kelvin. Figure 51 represents the ceiling jet temperature in Room 118B and is from the perspective of the third support column from the southern end of the facility. It should be noted that sprinkler activation and smoke evacuation, both mechanical and static, are not considered in this analysis.

For Room 116 Periodical Room and the Media Rooms, Room 111A-J, the standard E119 temperature curve is used to approximate the heat transfer boundary conditions on the structural members surrounding the design. For both instances, the closest support beam in the room is being analyzed. In both situations, there is an 8.5-meter-long structural support beam in the room. The ceiling jet temperature at these locations based on the simplified geometry of the building and the fire properties listed above will be used. The temperature vs. time curve are plotted below for the benefit of the reader.

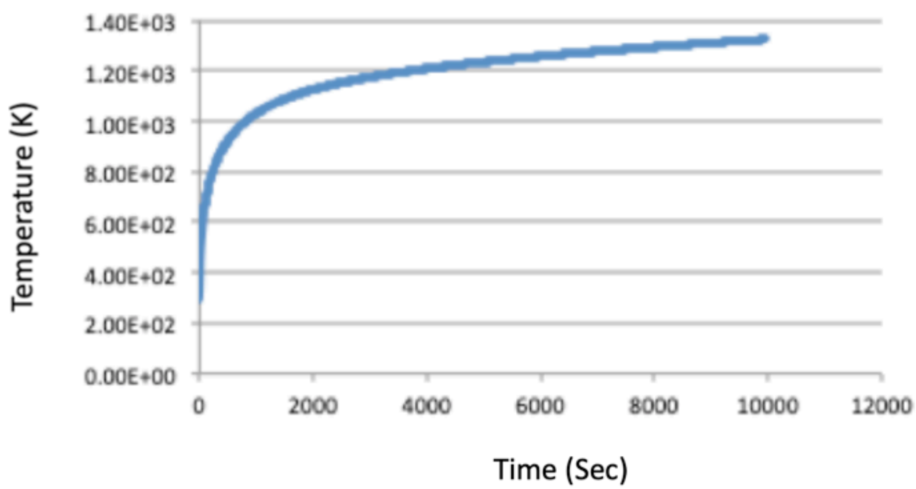


Figure 52: Temperature versus Time in Room 116 Periodical Room

The x-axis is time in the units of seconds and the y-axis in temperature in the units of Kelvin. Figure 52 represents the ceiling jet temperature in Room 116. It should be noted that sprinkler activation and smoke evacuation, both mechanical and static, are not considered in this analysis.

STRUCTURAL FIRE ANALYSIS

The time to failure for the structural members in the vicinity of each design fire is calculated. Since I did not have access to structural drawings and calculations for JFY00 NA893 Community Center, Yokosuka Naval Base, the following assumptions were made to undertake this analysis.

In Room 118B, the supporting beams at 8.5 meters were selected as a representative beam for analysis. The length of the beam is 8.5 meters long and is simply supported. The dead load (including self-weight of the beam and structure) is estimated at 160 psf and the live load is estimated at 80 psf. The steel rebar of the concrete beam has the following characteristics: As = 21 in2, b = 18” (0.46 m) d = 21” (0.54 m)) with 2¾” (0.06 m of cover). In the finite difference analysis of the concrete, the temperature of the steel is assumed to be the temperature of the concrete at 0.06m for simplicity.

Please see Figure 53 for the graph of the temperature vs time plot for rebar in the concrete in Room 118B.

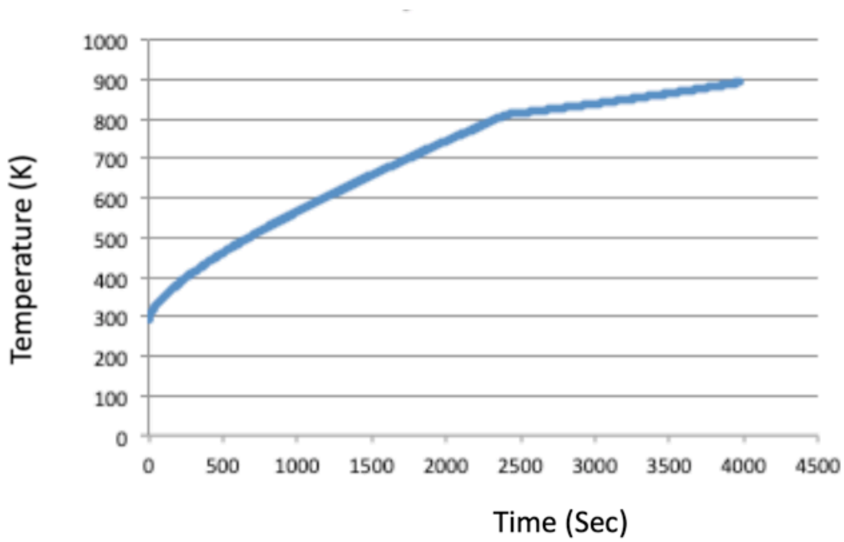


Figure 53: Temperature versus Time in Room 118B Library Stacks

The x-axis is time in the units of seconds and the y-axis in temperature in the units of degrees Kelvin.

	$0 < T \leq 600°C$	$600 < T \leq 1000°C$
Yield Strength	$\left[1.0+\frac{T}{900\ln\left(T/1750\right)}\right]\sigma_{yo}$	$\left[\frac{340-0.34T}{T-240}\right]\sigma_{yo}$
Modulus of Elasticity	$\left[1.0+\frac{T}{2000\ln\left(T/1150\right)}\right]E_o$	$\left[\frac{690-0.69T}{T-53.5}\right]E_o$

Figure 54: Yield Strength Equation for Steel from SFPE

The decrease in yield strength of the rebar in the concrete is analyzed. The SFPE Handbook yield strength and modulus of elasticity temperature reduction equations are used for this analysis, as shown in Figure 54.

The following graph is a graph of the decrease in moment capacity of the concrete beam vs. time.

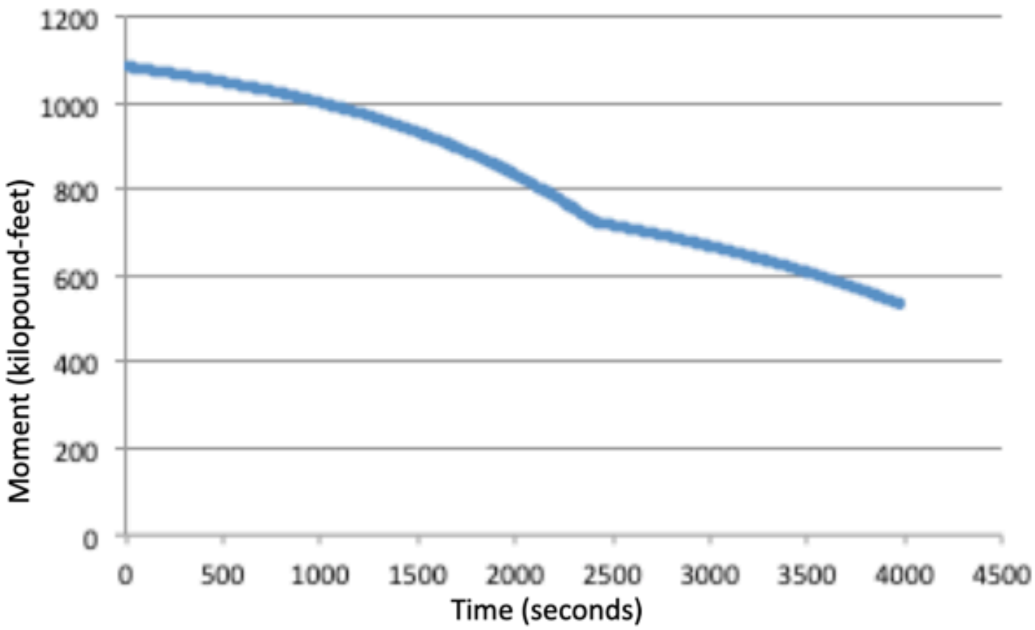


Figure 55: Yield Strength Analysis versus Time for Room 118B

For Figure 55, the x-axis is time in the units of seconds and the y-axis in moment in the units of kilopound-feet.

In Room 116, Periodical Room, the supporting beams at the east corner were selected as a representative beam for analysis. The length of the beam is 8.5 meters long and is simply supported. The dead load (including self-weight of the beam and structure) is estimated at 160 psf and the live load is estimated at 80 psf. The steel rebar of the concrete beam has the following characteristics: As = 21 in2, b = 18" (0.46 m) d = 21" (0.54 m)) with 2¾" (0.06 m of cover). In the finite difference analysis of the concrete, the temperature of the steel is assumed to be the temperature of the concrete at 0.06m for simplicity.

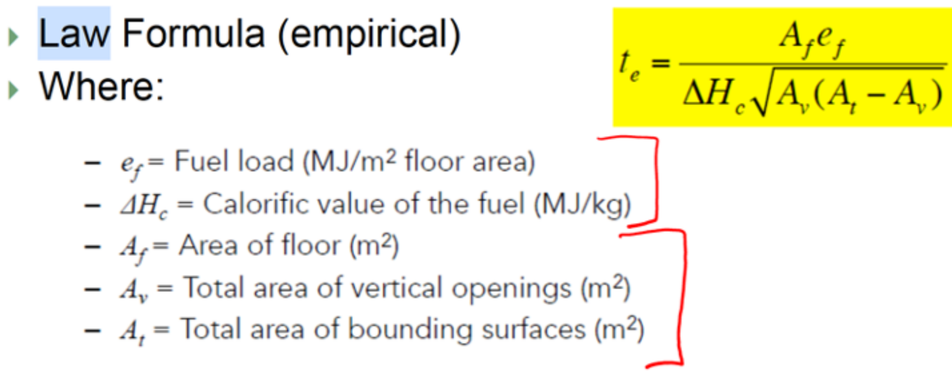


Figure 54: Margaret Law Equation

The Margaret Law time equivalency to the standard fire resistance test has been used to simulate the design fire in Room 116. Due to the large fuel load density provided by the periodicals, books, and other storage items, the fuel load density was estimated to be 4000 MJ/m^2 and thus the time equivalence was 246 minutes, which seems rather long.

Margaret Law developed the current time equivalent concept, which is studied in this report. According to Law, time equivalent is defined as the time of exposure of a protected steel member to the standard fire that would produce the same maximum temperature or same minimum load bearing capacity in the member exposed to a real fire. The Law time equivalent formula is a modification of Kawagoe and his colleagues' time equivalent formula. Note that the expression in the bracket represents the area of the solid surface of the compartment, that is, the 'net' internal surface area which excludes the ventilation area. The equation however also excludes the floor area in calculating this net solid surface due to the fact that the floors were thermally well insulated in the experiment. When further research shows that the floor area should be included in the solid surface, the formula was further modified to its final form, which is shown in Figure 54.

Based on the design analysis, the concrete beam will not fail for Fire Scenario 2. For the Design Fire given in Scenario 2, the applied moment is calculated at 629 kilo-pounds-feet. The applied moment does not exceed the moment resistance when the steel yield strength decreases due to the heat of the fire in accordance with the yield strength temperature reduction equations. Since there is a one-hour fire rating on these structural columns, the column will not fail within this one-hour period.

In Room 111A-J, Media Rooms, the supporting beams at the west corner were selected as a representative beam for analysis. The length of the beam is 8.0 meters long and is simply supported. The dead load (including self-weight of the beam and structure) is estimated at 160 psf and the live load is estimated at 80 psf. The steel rebar of the concrete beam has the following characteristics: As = 21 in2, b = 18” (0.46 m) d = 21” (0.54 m)) with 2¾” (0.06 m of cover). In the finite difference analysis of the concrete, the temperature of the steel is assumed to be the temperature of the concrete at 0.06 m for simplicity.

The Margaret Law time equivalency to the standard fire resistance test has been used to simulate the design fire in the Media Rooms. The fuel load density was estimated to be 812 MJ/m^2 and thus the time equivalence was 18.5 minutes. The time equivalency is also small since the room itself is relatively small.

The concrete beam will not fail in the fire scenario provided in the media room. For the Design Fire given in Scenario 3, the applied moment is calculated at 514.5 kilo-pounds-feet. The applied moment does not exceed the moment resistance when the steel yield strength decreases due to the heat of the fire in accordance with the yield strength temperature reduction equations.

PROTECTION SCHEME FOE THE STRUCTURAL MEMBERS

For all three worst-case scenarios, I would like to recommend the use of a fire retardant, intumescent coating by Nippon Paint. Although it is not a new concept, intumescent coatings have not been used very much on US military facilities in Japan. This could be due to lack of criteria on its application. For this report, I would like to recommend the use of this fire safety strategy for this building.

When selecting paint, there are some important factors to consider such as color richness, coverage, ease of wash, and low to zero VOC. However, flammability or fire protection was not a high consideration for this product. Up to this point, I had believed that walls and doors with fire resistance and other mechanical and electrical devices were the deterrence to fire. I was surprised to learn that the selection of the type of paint can greatly affect the fire protection of a facility. Here are the differences between high-performance and intumescent coatings.

High-performance coating is essentially extremely high-performance and long-lasting paint and coatings that you can use in the commercial sector. You will find this high-performance coating in factories, industrial settings, exterior's and more. High-performance coatings are generally something that's used when you need a coating that can stand up to weather, elements, wear and tear as well as years of use and abuse. High-performance coatings can come in specific enamels, acrylics and even nonstick anti-graffiti coatings as well. These high-performance coatings are easy to clean, extremely resilient and they will reduce the amount that you need to paint the surface as well as prepare it for industrial use. These high-performance coatings are especially useful in factories as they can work to repel dust and make sure that surfaces are easier to clean.

The fire-resistant intumescent coating has other special properties in addition to high performance coatings and are used in many of the same settings. Intumescent coatings can work to provide fire resistance to various materials that it's applied to. These types of coatings can be applied to wooden surfaces, plastic, structural steel, concrete and serves more to fire proof a facility and ensure that there is less chance of a fire breaking out in an industrial or residential setting. These types of coatings are usually used on buildings, aircraft, ships and offshore oil construction. This type of coating seems ideal if fire presents a hazard that could jeopardize the entire mission.

Intumescent coating is almost predominantly applied as undercoat, whereas a high-performance coating is always applied as an overcoat. The fire-resistant intumescent coating type of fireproof paint swells when the temperature reaches 200°C forming a solid foam-like char layer which insulates the substrate. Not only does it protect the substrate from ignition but also from the effects of the heat; steel loses its capacity to carry heavy loads starting at 300°C.

The Nippon Paint's foaming fire-resistant intumescent coating offers a smooth and attractive finish comparable to a conventional coating finish. Therefore, this new product may not need a high-performance overcoat. Furthermore, this product has an important advantage of a key ingredient, ammonium polyphosphate, which foams at high temperatures to form a heat-insulation layer. The coating system consists of an anti-corrosion layer, foam layer and top coating layer. The fire-resistant intumescent coating offers two important factors for fire resistance in new construction of facilities. First, the Nippon Paint's intumescent coatings has flame-retardant chemicals to achieve a reduction of flame spread. The coating effectively limits of flammability according to ASTM E84. This is different from most intumescent coatings that do not offer the reduction of flammability.

The second rating demonstrates coating efficacy for delaying and resisting the effects of fire and heat of structural steel through heat insulation. This is a normal function of an intumescent coating. An intumescent coating, according to SSPC's definition, is "a fire-retardant coating that when heated forms a foam produced by nonflammable gases, such as carbon dioxide and ammonia. This reaction results in a thick, highly insulating layer of carbon that serves to protect the coated substrate from fire. By comparison, heat resistance is defined by SSPC as "the ability of a coating to resist deterioration when exposed continuously or periodically to high temperatures at or below a given level. It is a thin film when it is sprayed on, but in case of a fire it will expand by 20-50 times creating a thermal barrier and protecting the steel frame from collapsing. When exposed to fire, the material starts to foam when the atmospheric temperature reaches 250 to 300 °C. The foam expands to a volume 25 to 50 times larger to provide superior heat insulation. The fire-resistant intumescent coating type of fireproof paint swells when the temperature reaches 200°C forming a solid foam-like char layer which insulates the substrate.

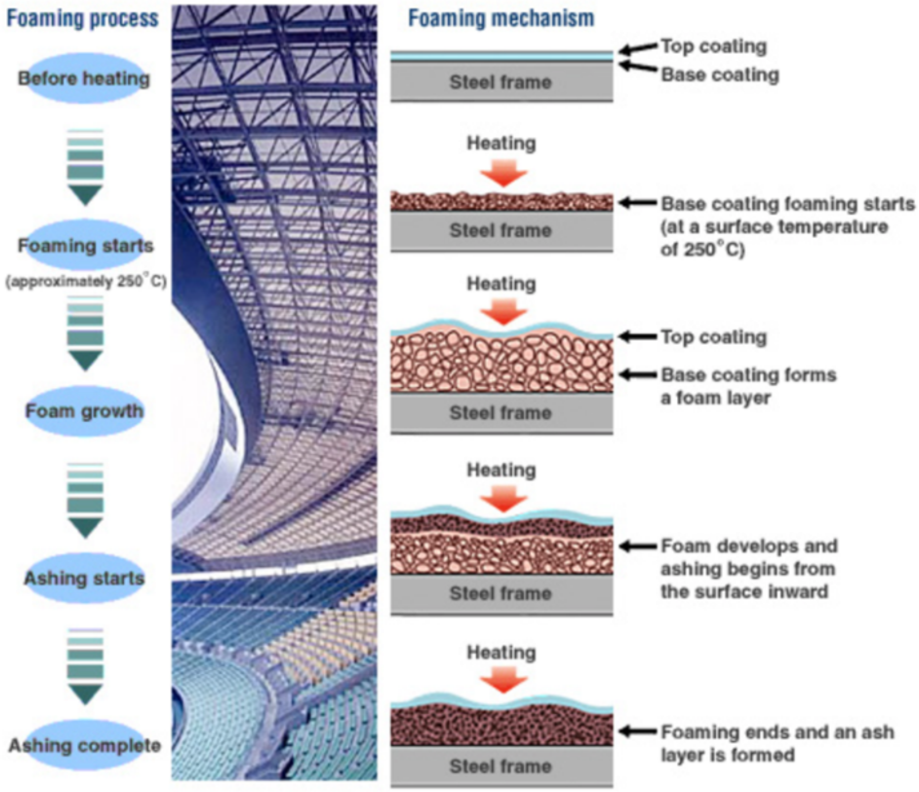


Figure 57: Demonstration of the use of Intumescent Coating

In summary, a high-performance coating and a heat-resistant, intumescent coating have different properties and chemistries. Therefore, the terminology should not be used interchangeably. A high-performance coating will protect a facility against weather and normal wear and tear but not protect against the dangers of fire. The intumescent coating insulates the substrate from fire and thus protecting it against heat transfer. The heat-resistant coating will resist ignition of the surface by fire, yet it does not insulate or protect the substrate from heat. Combined together, heat-resistant, intumescent coating will reduce the flammability or flame spread and resist the effects of heat and fire to the substrate.

If I were the project fire protection engineer, I would also recommend or ask the librarian and project architect if some simple changes could be made to make the entire building safer from a fire protection stand point.

In Room 118B Book Stack Area, the book-shelves are arranged in a way that they are continuous. I would like to ask the end user and project architect if the book-shelf layout could be changed so that they are discontinuous. In other words, if the book shelves were aligned in a manner that they had some separation between them, it would act as a fire break, as shown in Figure 58.

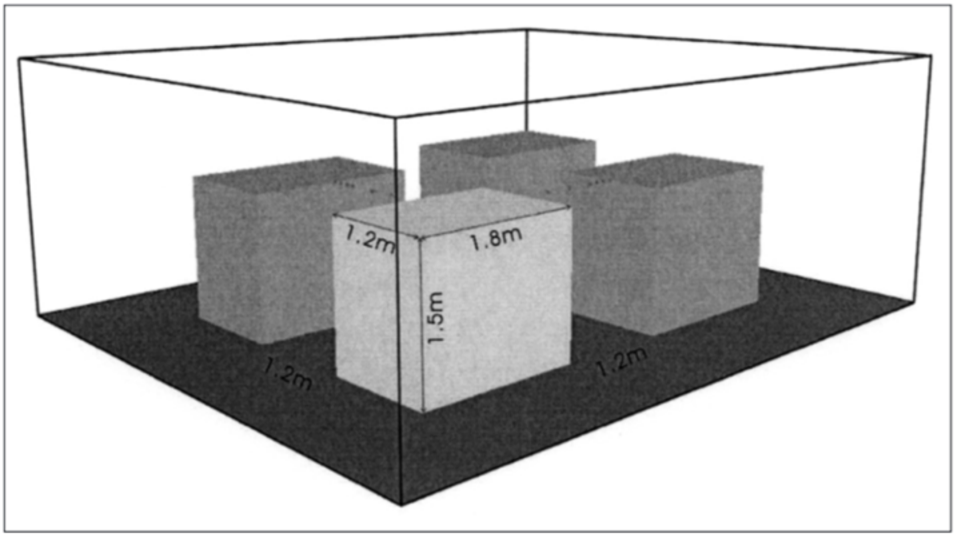


Figure 58: FDS Demonstration of Bookshelf Fire with Spacing

Shelves in the malls studied by Sung-Yu Yuan without the installation of an independent fire protection zone should reserve a clearance distance and impose limitations with strict calculation result of NFPA92B on the requirement not less than 1.2m to ensure prevention of fire spreading to the other side of shelves during a fire and harmful influence on personnel who are looking for shelter during a fire. The analysis ignores conservatively the effect of automatic water spread on the inhibition or extinguishing of fire. In practice, when a fire alarm is initiated, the automatic water spread system will further prevent fire spread to different shelves.
In addition, this study also found that the verification result of NFPA92B is more conservative than that of FDS and the result corresponds to conventionally applied concepts. A quick result is first acquired from the equation and if a more accurate analysis is required, a computer simulation will meet the request.

But the computer simulation takes a longer time and, in practice, the equation would be the first priority and when there is a concern, a computer simulation will then be used. Therefore, the analysis tool is selected according to subject substance and more accurate FDS should be adopted when the hazard is high and, for general concerns, NFPA92B is a better choice.

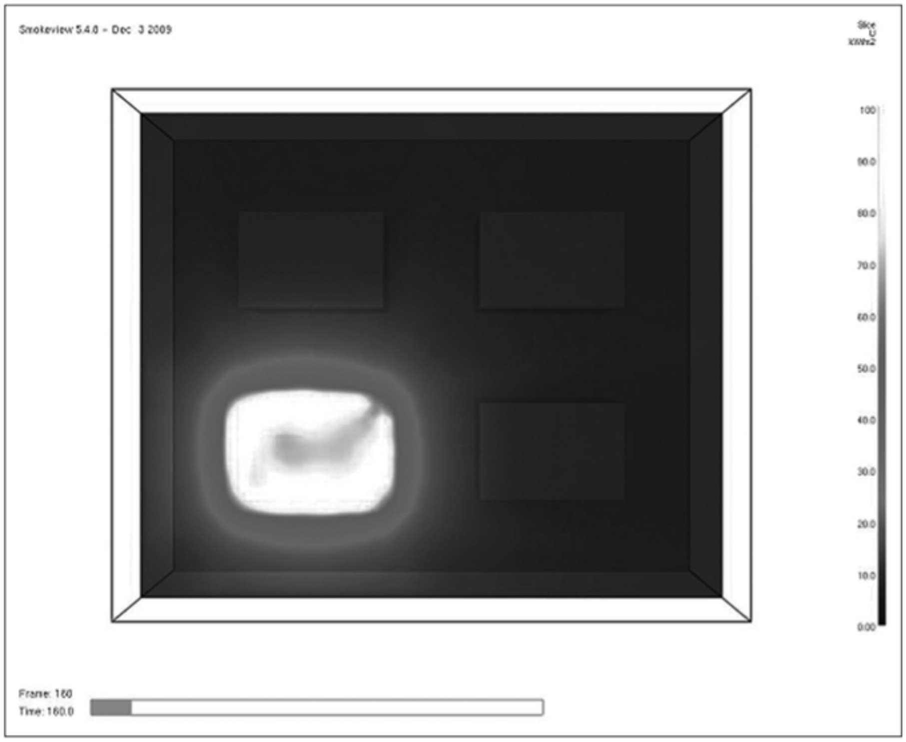


Figure 59: FDS Demonstration of Bookshelf Fire with Distance

Shelf distance is important data when a mall spatial layout is planned and the relationship between radiant heat flux and distance between shelves is critical. Measurement points at various distance setups according to FDS are able to establish a relationship equation of radiant heat flux and distance with relevant analysis. The relationship between radiant heat flux and distance of the case shelf with a short side dimension of 1.2m, long side 1.8m, and height 1.5m, as shown in Figure 59. Parallel direction is found in two trend lines. In order to prevent fire from spreading, shelf distance should be adjusted to increase the acceptance of radiant heat flux by distance and it is also important to effectively control fire load (heat release rate of products on shelves)

Although Room 116 is labeled as a periodical room, this room will serve more like a storage room for periodicals, books, and other items that need storage. This room seems to be more closed off to the general public and is more densely packed with storage shelves. Since other media other than books and periodicals will be stored in this area, such as audio and video media, the fire load density in this room will be much higher than that of the general library with almost double the fuel load density in a confined space. Although the entire first floor has been classified as an A-3 Assembly occupancy, I would recommend reclassifying this area as Group S-1 occupancy and rename the room as Library Storage or Periodical Storage. Since Room 116 is closed off from the public, has no windows, and is not in the general view of library staff, I would recommend the use of fire rated walls and doors for this room due to its potential fire hazard to the rest of the building.

For Room 111A-J Media Room, I would like to ask the end user and project architect if the layout of the rooms could be changed. Currently, the media rooms are very densely packed together allowing the possibility of a fire in one media room to spread to other media rooms. In other words, the fire load density of the media rooms are concentrated in one area. I would recommend that the media rooms be dispersed around Room 117 Study Area. The Media Rooms can be distributed so that there will be more than 3 rooms grouped together. Furthermore, if the media rooms can be relocated throughout Room 117, I would ask if they could be arranged in a way that they are not placed directly under a structural support beam. By removing the media room from under a support beam to a location further away, there will be less of a temperature affect to the support beams that support the rest of the facility.

COCLUSION

In conclusion, this section of the report was separated into three different components. First, there will be a fire resistance analysis of the NA893 Community Support Facility. The occupancy of the project building was determined to be a combination of Assembly Group A-3 and Business Group B. Based on the International Building Code, the required construction classification has been identified at Type IIA. The structure of the facility is reinforced concrete. The fire resistance requirements for different elements of the building has been summarized for this building. The fire safety strategy of the fire resistance in the building has been discussed.

The second section of the project paper is the design fire analysis. In order to discuss the structural fire safety of the building, this report has considered three (3) potential realistic "worst-case scenario" design fires in your building. The three worst-case scenario design fires were determined to take place in Room 118B, Book Stack Area, Room 116, Periodical Room, and Rooms 111A-J, Media Rooms.

The third section of the project paper is the structural fire analysis. Based on the analysis of the effect of fire on the structural members in the second section, the time to failure for the structural members in the vicinity of each design fire was determined to not fail. Within the context of structural fire protection, the concepts of implicit or prescriptive and explicit or performance-based safety were covered. In this project paper, these two types of fire safety engineering design methods were discussed and compared. For Rooms 116 and 111A-J, the implicit or prescriptive type of safety design has been used. For Room 118B, since the room was so large, the explicit or performance-based design assures safety through explicit demonstration of the adequacy of the design to meet the intent of the code with an accepted safety factor. However, in all of these fire scenarios, the facility did not lose its structural integrity.

Protection scheme for the structural members have been recommended. A general recommendation to use fire-resistant intumescent coating for all three scenarios. For Room 118B, it is recommended to make the book shelves discontinuous to create a fire break. For Room 116, it is recommended to add fire resistance to the entire room since it acts like a storage occupancy. For Rooms 111A-J, it has been recommended to re-layout the current scheme so the rooms are not clumped together and do not occur under structural members.

Since the ability of this facility to structurally withstand the three different fire scenarios in this section of the report, the next section will concentrate on performance-based design issues. The net part of the report will consider if occupants of the NA893 Community Support Facility will be able to safely egress the building while considering other fire factors such as smoke inhalation, temperature effects, and visibility as well as the actual time necessary to exit the facility.

PERFORMANCE BASED DESIGN

For a new facility design, a relatively new concept that is being used for fire safety is performance–based design. In the United States and Japan, performance-based design is becoming more common as facilities incorporate unique features to achieve aesthetic, cost and functional goals while maintaining safety levels for building occupants and emergency responders. The easiest way to understand the concept of performance-based design is to start with the traditional prescriptive-based design. Building codes have typically prescribed specific design criteria, such as the number of exits or the number of feet to an exit; these are numeric criteria that can be easily measured. This analysis has already been done for the NA893 Community Support Facility for the majority of this report.

By contrast, a performance-based code allows the use of any design that demonstrates compliance with the fire safety goals of the code. Those fire safety goals are explicitly spelled out in the code, as are methods that can be used to demonstrate compliance. A performance-based design starts with an analysis of fire scenarios to determine which design alternatives will meet those fire safety goals. The performance-based approach affords the design team greater flexibility than the prescriptive code requirements. The maximum travel distance is flexible, depending on the method used to maintain tenability along the means of egress. Tenability might be maintained for a distance significantly longer than 300 feet in a building where neither radiant heat transfer nor a descending smoke layer are an issue, such as in a building with an extremely large atrium. Other examples include modified smoke control configurations and means of egress arrangements, such as more exits or different exits to reduce travel time, resulting from timed egress analyses.

This section of the report is the performance-based analysis. The performance-based analysis will be analyzed in several sections. Performance-based life-safety design depends on a comparison between the time required for escape, also known as the Required Safe Escape Time (RSET) and the time to loss of tenability, also known as the Available Safe Escape Time (ASET). Both include several stages, involving a variety of processes and requiring a range of input data. The Fire Protection Engineer must evaluate all the stages in both ASET and RSET to develop a realistic outcome for the analysis. Some aspects of the RSET and the ASET are reasonably well understood and quantified, while others may be oversimplified. For this cumulative project paper, both RSET and ASET for NA893 Community Support Facility will be evaluated.

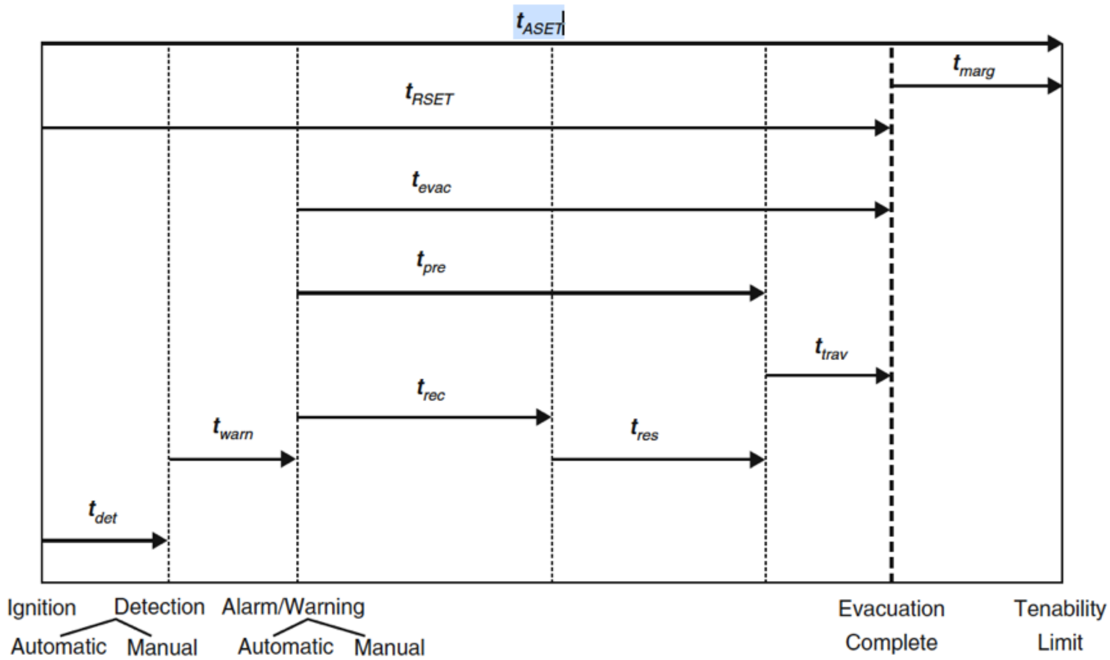


Figure 60: Visual of ASET versus RSET

REQUIRED SAFE ESCAPE TIME (RSET)

RSET is the sum of the amount of time for the fire to be detected, the fire alarm to be noticed by the inhabitants, the time the inhabitants consider what to do, and the time to actually egress the premise. As shown in Figure 50, after the fire ignition, these are termed as the time to detection, time of alarm warning, pre-movement time which includes the recognition time and response time, and the travel time. The detection time or alarm time is the time at which occupants first become aware of a fire through a building's automatic or manual fire alarm system. The evacuation delay time, or pre-movement time, is the time that elapses between activation of the occupant notification system and the time at which occupants make the decision to begin evacuating. Pre-movement activities might include an investigation to determine if the fire is real, gathering belongings, searching for friends and family, etc. Depending on the type of occupancy, the pre-movement time maybe a few seconds or a few minutes. Finally, the movement time is the time required for occupants to reach a protected exit enclosure or the exterior of the building once the decision to evacuate has been made and occupants begin moving toward exits. The movement time is calculated by applying empirical relations for walking speed and occupant flow rates through egress elements such as doors, stairs, and corridors.

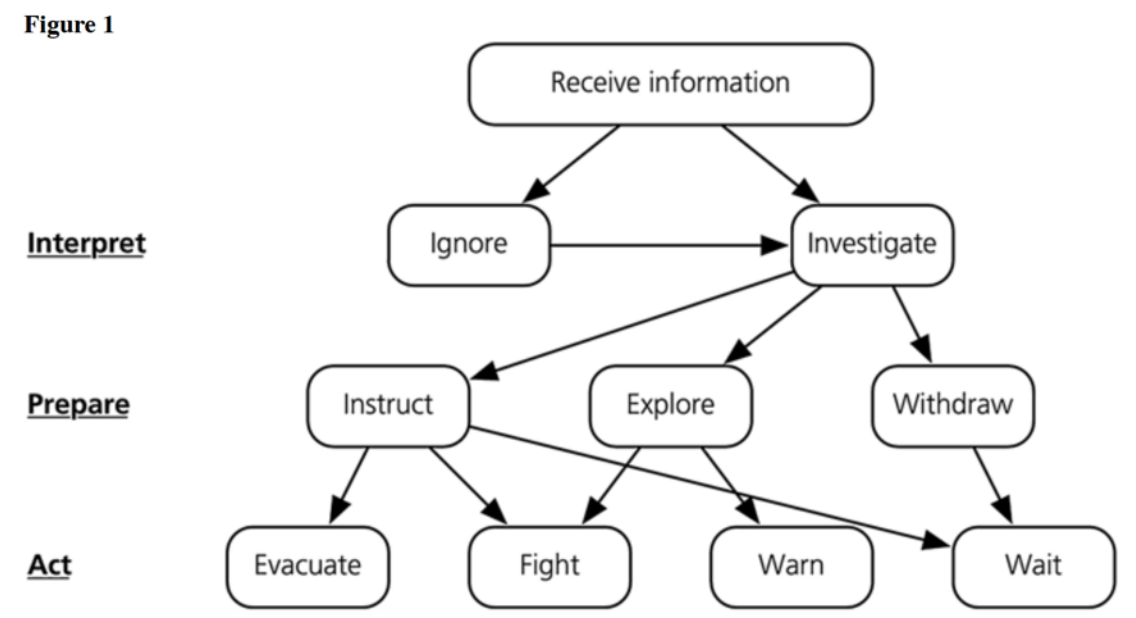


Figure 61: Decision Making Process During Fire Evacuation

For the RSET time line, most emphasis is usually placed upon the travel time component, representing the physical movement of occupants into and through the escape routes. However, the time required for occupants to engage in a range of behaviors before the travel phase (pre-movement time), often represents a greater component of the total escape time. Pre-movement time distributions are dependent upon key features such as occupancy type, warnings, occupant characteristics, building complexity and fire safety management strategy. It is proposed that a practical solution for the engineer is to apply pre-movement time distributions measured from monitored evacuations, fire incidents, or derived using behavioral models, and specified in terms of a number of "design behavioral scenarios" analogous to "design fire scenarios", classified according to the key features listed.

DETECTION TIME

Using a method recognized by Annex B of NFPA 72, the response of the smoke detection system to a library bookshelf fire and grows as a fast t-squared fire with a fire growth coefficient of $\alpha = 0.047$ kW/s^2 is analyzed as follows in Table 21. The ceiling height is defined by the facility section on the first floor to be 3.50 m. The radial distance is calculated based of a 30 feet square spacing. The ambient temperature is assumed to be 20 degrees Celsius. It is assumed that the workstation is made of wood. According to NFPA 72 Table B.4.7.5.3, the temperature rise for detector response is 13.9 degrees Celsius. This is summarized in Table 21.

Table 21: DETACT Input for Smoke Alarm for NA893

INPUT PARAMETERS			CALC. PARAMETERS	
Ceiling height (H)	3.5	m	R/H	0.924
Radial distance (R)	3.2	m	dT(cj)/dT(pl)	0.316
Ambient temperature (To)	20	C	u(cj)/u(pl)	0.214
Actuation temperature (Td)	33.9	C	Rep. t2 coeff.	k
Response time index (RTI)	2	(m-s)1/2	Slow	0.003
Fire growth power (n)	2	-	Medium	0.012
Fire growth coefficient (k)	0.047	kW/s^n	Fast	0.047
Time step (dt)	1	s	Ultrafast	0.400

Table 22: Temperature Rise for Detector Response from NFPA72

TABLE B.4.7.5.3 *Temperature Rise for Detector Response [18]*

	Ionization Temperature Rise		*Scattering Temperature Rise*	
Material	*°C*	*°F*	*°C*	*°F*
Wood	13.9	25	41.7	75
Cotton	1.7	3	27.8	50
Polyurethane	7.2	13	7.2	13
PVC	7.2	13	7.2	13
Average	7.8	14	21.1	38

The actuation temperature for wood is thus 33.9 degrees Celsius as shown in Table 22. The RTI should be small and assumed to be 2 $(m - s)^{1/2}$. The fire growth coefficient as a fast t-squared fire with a fire growth coefficient of $\alpha = 0.047$ kW/s^2. The DETACT worksheet, which is a method recognized by Annex B of NFPA 72, is used to calculate when would the first smoke detector activate for this scenario. The photoelectric smoke detectors will activate right after 47 seconds for this scenario. The photoelectric smoke detectors will activate when the gas temperature reaches 33.9 degrees Celsius.

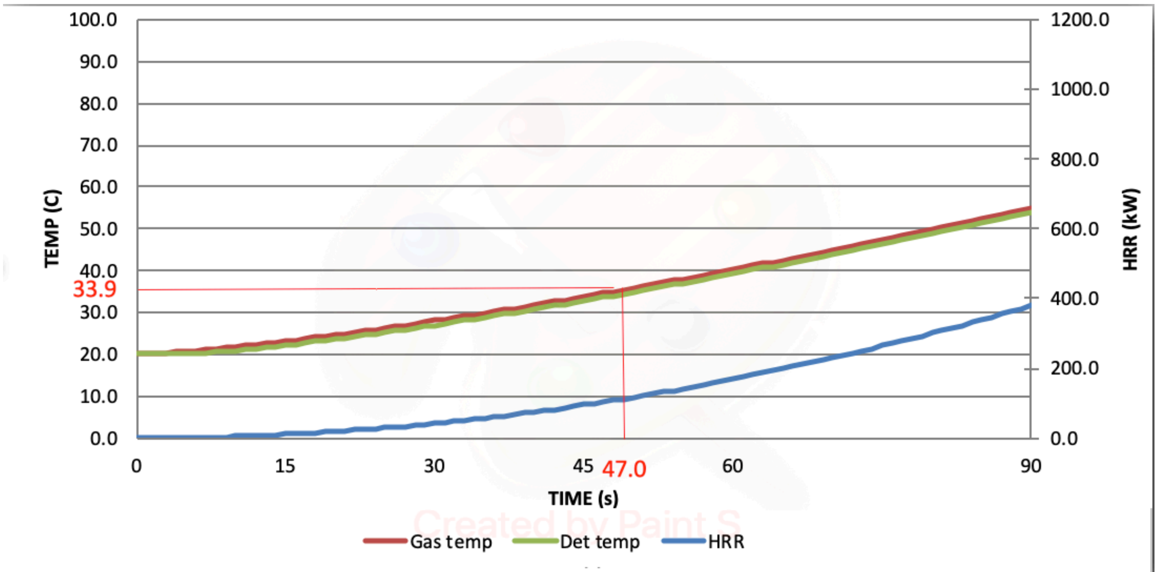


Figure 62: DETACT Graph for NA893 Smoke Detectors

The heat release rate is approximately 87 kilowatts when first smoke detector activated as the gas temperature reaches 33.9 degrees Celsius at 47 seconds as shown in Figure 62.

PRE-MOVEMENT TIME

The pre-movement time, has two major phases which are not as easily quantifiable as the detection time. First, there is the response time which is the time the alarm goes off and the time it takes the person to decide what to do next, stay in place or evacuate. Once the action to evacuate is made, the pre-movement time, the time between when occupants become aware of the emergency and when they begin to move towards the exits), consists of the time required to recognize the emergency and then carry out a range of activities before travelling to exits. Pre-movement time also must consider the time to gather one's effect and the time to determine which exit to use.

For detection, warning and pre-movement recognition and response times, most research on human behavior has been essentially qualitative. This has revealed the complexity of occupant behavior during fire emergencies and the importance of these behaviors with respect to escape time. In many situations they comprise the greatest part of the time required for escape. Despite the issue of human behavior during a fire, there has been little attempt to quantify the wide range of behavioral phenomena and the interactions between them, so that it is difficult to apply them to escape time calculations.

The NA893 Community Support Facility is located on a US military base in Japan. This facility is primarily designed for US military servicemen who are able bodied. This facility can also be used by the dependents of the US military as well as federal employees. Since this building is an OCONUS (Outside the Continental United

States) location, the US government will not allow civilians that are handicapped. Therefore, all the people who will be using this facility will be free of any handicap.

Since the project facility is a federal building on a US military installation, a fire warden will be appointed. It is the duty of the fire warden to ensure that the typical users of the facility are aware of the means of egress available and processes of evacuation. To ensure this knowledge, the fire warden must conduct fire drills of the facility annually and after a large turnover of personnel.

There are many factors that affect the pre-movement times of occupants in buildings when alerted to fire. Audio, visual and physical cues can all affect how fast an occupant will respond to a fire. How occupants are first notified has a potential impact on how quick they leave the area and the building.

Audio factors would include fire alarm and notification by others. Fire alarm systems are required in accordance with the applicable requirements of NFPA 72, National Fire Alarm and Signaling Code. To ensure operational integrity, the fire alarm system shall have an approved maintenance and testing program complying with the applicable requirements of NFPA 70, National Electrical Code. This facility is equipped with a smoke alarm and detection systems in accordance with the 2015 LSC Section 9.6.2.10. Occupant notification shall be provided to alert occupants of a fire or other emergency where required by 2015 LSC Section 9.6.3.1. Audio occupant notification will be supported by a PA system that is also installed in this facility.

Visual factors would include seeing the fire, seeing smoke, or seeing something stemming from the impact of the fire. Visual fire alarm systems have been installed as per 2015 LSC Section 9.6.3.5. These visual cues will also help occupants realize that a fire is occurring in the facility.

Physical factors would include smelling the smoke, feeling the heat from the fire, feeling the building move from fire impact, or feeling an impact from the fire on the building. The activation of the fire sprinkler system would be an example of a physical factor. These physical cues will also help occupants realize that a fire is occurring in the facility.

According to the SFPE handbook, there are seven psychological and physical processes that are relevant to pre-movement time. The six factors include recognition, validation, definition, evaluation, commitment, and reassessment.

1. Recognition: The occupant is first made aware of a potential fire through visual, audio, or physical cues. Although the occupant may not directly be aware of the fire itself, fire alarms or notification through others will make the occupant aware of the fire incident.

2. Validation: The second reaction to a potential fire event is to validate if there is an actual fire. During this process the occupant may try to obtain more

information about the event. The occupant will try to verify if there is a fire through gathering more information or determine if it is a false alarm.

3. Definition: Once enough information is gathered, the occupant can determine if there is a fire. The occupant, at this phase, will determine that there is a fire or not and begins to consider the next options.

4. Evaluation: Once the occupant has determined that there is a fire in the facility, he or she will consider or evaluate their options. Since there is a fire, the occupant will try to determine how best to egress the facility. There may be smoke coming out of one exit, so the occupant will need to use another exit. Otherwise, there may be instruction from fire officials telling the occupants how to best egress.

5. Commitment: During this phase, the occupant will determine the best course of action to get out of harm's way. If there is a clear path out, the occupant must commit to leaving through that exit. If the means of egress is blocked, the occupant may need to commit to stay by a window to call for help from outside responders to the fire.

6. Reassessment: Reassessment is the final phase in which the occupants must consider if they made the correct choice or not. The greater the magnitude of the event the higher the reassessment process will occur over and over in the occupants' mind.

Based off of these occupant characteristics, there are six building characteristics that can help reduce the pre-movement times of the occupants.

Types of warning systems: In accordance with the applicable requirements of NFPA 72, this facility will have fire alarm and detection systems installed. Furthermore, occupant notification shall be provided to alert occupants of a fire or other emergency where required by 2015 LSC Section 9.6.3.1. The audibility and intelligibility need to be very clear to ensure that the occupants can understand what they need to do and where they need to go.

Building layout and wayfinding: These visual cues will also help occupants realize that a fire is occurring in the facility. Signage will be provided so that occupants of the facility spends less time finding the best route to egress the building.

Visual Access: Visual fire alarm systems has been installed as per 2015 LSC Section 9.6.3.5. Visual access of the other occupants or the fire alarm signaling is helpful for the occupants in making the decision to leave. Seeing the other occupants fleeing, or remaining in place holds important in the occupants mind. Also, the ability to see clearly to the exits and seeing the exits defined has an impact on the occupant.

Training: Since this is a military installation and it is a federal building, it is mandated by the UFC 3-600-2 that occupants of the facility receive mandatory training on how to egress the facility in times of a fire event. Training of the occupants will greatly help reduce the pre-movement time of the occupants.

The occupants of this facility are able-bodied personnel and are very well trained. The facility itself has very clear egress signage and has fire alarm systems to notify all its occupants on when and how to egress the facility. Due to these factors, there should be very little time spent on pre-movement activities.

As shown in Table 23, a study by Martin Forrsberg titled "The Variation of Pre-movement Time in Building Evacuation" considered the pre-movement of large groups of people in various situations. For this study, the school scenario would be the closest situation to the NA893 Community Support Facilty since the occupants would be very aware of their surroundings and they will be awake.

Table 23: Pre-movement Response Time from Martin Forrsberg Study

Occupancy	Number of observations	Distribution (s)	Mean (min–max) (s)	SD (s)
Office	45	Loglogistic $(\gamma = 0; \beta = 52.5; \alpha = 3.0)$	64.4 (12–201)	45.6
Cinema (voice alarms)	891	Loglogistic $(\gamma = 0; \beta = 40.5; \alpha = 5.8)$	44.0 (17–138)	18.0
Cinema (siren)	89	Lognormal $(\mu = 25.0; \sigma = 6.2)$	30.0 (14–179)	28.1
Cinema (alarm bell)	880	Loglogistic $(\gamma = 0; \beta = 29.5; \alpha = 5.0)$	32.5 (11–224)	17.2
Department store	229	Lognormal $(\mu = 35.9; \sigma = 18.3)$	35.9 (5–111)	17.7
Restaurant/Café	27	Weibull $(\alpha = 3.8; \beta = 58.1)$	52.5 (20–86)	15.7
School	72	Gamma $(\alpha = 3.0; \beta = 24.5)$	74.9 (13–170)	42.3
Night club (active staff)	62	Weibull $(\alpha = 2.7; \beta = 52.5)$	46.6 (11–87)	18.7
Night club (passive staff)	84	Loglogistic $(\gamma = 0; \beta = 50.6; \alpha = 2.3)$	65.4 (5–417)	64.0

For this cumulative paper, the pre-movement time will be considered to take 75 seconds.

EVACUATION TIME

The total evacuation time of the entire facility has been calculated in the previous part of this report to be 6.05 minutes.

REQUIRED SAFE EVACUATION TIME

Required Safe Egress Time
= Time to notification
+ Reaction Time
+ Pre-evacuation activity time
+ Travel time

= 47 sec + 75 sec + 366 sec
= 488 sec or 8 min 8 sec

Figure 61: RSET for NA893 Community Support Facility

The required safe evacuation time (RSET) is the summation of the time to notification, reaction time, pre-evacuation activity time, and travel time as shown in Figure 61. Based on the calculations provided in this report, the RSET is calculated to be 488 seconds or 8 minutes and 8 seconds. In order for the performance-based analysis for NA893 Community Support Facility to be successful, the ASET must be greater than the RSET. The analysis of the ASET will be provided in the next section of this report.

AVAILABLE SAFE EGRESS TIME (ASET)

The available safe egress time (ASET) is generally defined by acceptance criteria based on temperature, visibility and toxicity of smoke within the fire escape routes. Criteria documents such as the NFPA and UFC 3-600-01 give advice about the tenability limits and provide the maximum or minimum values for various factors. The ASET can be modified and extended based on many factors that are not necessarily considered and specifically addressed within the prescriptive approach. For instance the ASET will consider the type and amount of combustible material or fire load, ceiling heights, smoke ventilation systems, physical barriers like smoke curtains, and the geometry of the room of fire origin.

A fire protection engineering approach utilizes these factors to calculate the specific ASET for the building or space, always considering adequate fire safety factors, to maintain a conservative approach. Although hand calculations remain a possibility to carry out such assessments, more visually user-friendly methods, such as computer modelling, are available to assess defined assessment criteria.

Two types of computer models are available for use in the FPE596 class when evaluating fire scenarios. First is the Fire Design Simulator (FDS) which creates the zone model and uses Computational Fluid Dynamics to simulate smoke and heat propagation. The other computer model is the zone models which are used to predict the height of smoke layers and tenability conditions in buildings or rooms with simple geometries. If assessment areas are more complex, the fire engineer usually uses a CFD model that is considered to be the most appropriate tool to assess conditions in the event of a fire. The basic capabilities of FDS models have been continuously validated, considering issues such as fire growth, flame spread, suppression, sprinkler/detector activation, and other fire specific phenomena. Pathfinder is another computer model which simulates the egress patterns and probability once given parameters such as the building geometry and personnel attributes are provided.

The ASET time line ends when occupant incapacitation is predicted from exposure to fire effluent such as heat or smoke. The ASET time line depends upon the time-concentration curves for the main toxic fire effluents, requiring inputs on smoke and toxic product yields under different fire conditions. Existing engineering calculations use only smoke density and carbon monoxide, with yields often treated as constants, usually for the well-ventilated fire case. A method is proposed, whereby yield data for major toxic effluent species can be obtained over a range of fire conditions, expressed in relation to the global equivalence ratio. Results are illustrated for carbon monoxide and hydrogen cyanide.

In the context of an ASET/RSET analysis, there are several tools at the designers' disposal that can be used to develop customized fire protection and life safety systems for the building under consideration. The ASET can be increased by limiting combustibles, providing adequate separation distances between fuel packages, providing customized fire suppression systems to suppress incipient fires or limit peak heat release rates or provide active or passive smoke control systems. On the RSET side, strategic placement of smoke detectors (spot-type, aspirated, or projected beam) or UV/IR flame detectors can be used to reduce the detection time. Pre-movement time can be reduced by specifying an occupant notification system equipped with voice occupant notification, particularly one that can communicate live voice messages to building occupants. Movement time can be reduced by strategically placing exit signage and arranging the means of egress in an intelligent way to prevent pinch points, excessive queuing, etc.

PERFORMANCE CRITERIA FOR PREVENTION OF COLLAPSE BY FIRE

The prevention of building collapse by fire, the fire spread to outside, and catching a fire from fires occurring outside are all required by the Building Standard Law of Japan as well as the NPFA and UFC 3-600-01. All these rules, laws, and criteria defines the principal structural members of fireproofed buildings shall either be of fireproof construction, or of construction that meets the technical requirements concerning their ability to withstand fire throughout complete process.

The first one is the conventional method that prescribes necessary fireproof ratings of construction. The second one is performance-based. The performance requirement in the enforcement order is described as follows in Article 108-3. There are several requirements that need to be satisfied when exposed to heat generated by a fire foreseeable to take place within the building. First, load bearing walls, columns, floors, beams, roofs and stairs shall not be damaged under the stress of fixed and movable loads (in heavy-snow areas, dead load, live load and snow load; hereinafter the same) (non-damage ability requirement). Walls and floors will require heat insulation property. Furthermore, exterior walls and roofs shall possess flame insulation property. The exterior walls will need satisfy many requirements when exposed to heat caused by fire that normally takes place outside of the building such as exterior walls constituting bearing walls shall not be damaged under the stress of dead or live load (non-damage ability requirement) as well as having heat insulation property.

According to the prescriptive method in the previous section, NA893 Community Support Facility has one-hour fire rated support beams in accordance with the Type IIA construction. Furthermore, performance-based analysis was performed on the structural members above the library floor based on the three given fire scenarios. Based on the analysis of heat transfer to the steel members using either the traveling fire method (TFM) for Room 118B or Margaret Law Theorem for Rooms 116 and 111x, it was calculated that the structural members will not fail for the given fire scenarios. Therefore, the building will not structurally collapse from the three fire scenarios provided in this report.

PERFORMANCE CRITERIA FOR EVACUATION SAFETY

In the enforcement order, there are only two performance-based clauses on evacuation in the revised Building Standard Law of Japan: Evacuation safety on the fire floor in Article 129-2 and Evacuation safety in the whole building in Article 129-2-2. These two clauses require the same performance that the smoke and gas resulting from fire in any location shall not block egress routes until all occupants are safely evacuated. These two provisions require the building plan to satisfy the legal performance requirements. They do not judge the safety level quantitatively, but evaluate the degree of satisfaction quantitatively. Article 129-2 only addresses the fire floor, so it cannot evaluate vertical egress routes such as staircases. Article 129-2-2 addresses evacuation of the whole building that requires a more comprehensive verification, including staircases, atria, etc. The functional requirements of evacuation facilities in the articles concentrate on evacuation safety in case of a fire. On the conventional prescriptive clauses, the law requires technical specifications for all equipment, for example, maximum distance to stairs, smoke exhaust volumes. However, for performance criteria, each specification transfers to input parameter for calculations. The revised Building Standard Law of Japan restricts provisions that are possible to pass over by verification.

The Community Support Facility building has been designed using the most stringent codes and criteria for fire protection between US and Japanese rules. However, the IBC does not give “performance-based” tenability design criteria, and therefore the Life Safety Code, Section 5.2, is utilized to provide this information. This section of the LSC gives four methods in which tenability for a particular building can be determined.

According to the NFPA101 Life Safety Code, one of the methods below can be used to avoid exposing occupants to untenable conditions.

Method 1. The design team can set detailed performance criteria that ensure that occupants are not incapacitated by fire effects.

Method 2. For each design fire scenario, the design team can demonstrate that each room or area will be fully evacuated before the smoke and toxic gas layer in that room descends to a level lower than 6 ft above the floor.

Method 3. For each design fire scenario, the design team can demonstrate that the smoke and toxic gas layer will not descend to a level lower than 6 ft above the floor in any occupied room.

Method 4. For each design fire scenario, the design team can demonstrate that no fire effects will reach any occupied room.

For this project analysis, Method 1 will be used. This method is the simplest and the most conservative approach, which assumes that the occupants are not directly exposed to the smoke from the fire. This is achieved by maintaining the smoke layer above the head height of the occupants.

The smoke hazard management design prescribed by the Japanese Fire Law is based on this approach, and requires the smoke layer to be maintained not less than 2 meters above the floor level. This goal is achieved by having a smoke evacuation louver in occupied areas that are sized appropriately. These louvers are activated in event of smoke.

In this approach, convected heat and toxic gas exposures can be ignored. However, the occupants can still be exposed to radiant heat from the hot smoke layer above. It is noted that the Japanese Fire Law does not specify any limit for radiant heat. However, criterion for radiant heat is still applicable to ensure safety of the occupants.

With the availability of advanced analyses methods, a more rigorous assessment of heat and toxic gas exposure may be carried using Fractional Effective Dose (FED) calculations. This method takes into account the variation of the exposure environments with time and the combined effects of the exposures to various effects of the fire.

There are a few main byproducts of fire events that can lead to the above conditions. Two that are always found in fire events are carbon monoxide (CO) and carbon dioxide (CO_2). In fires where there are nitrogen-based materials, hydrogen cyanide (HCN) is also found. CO and HCN are deemed as asphyxiants, which outlined above can lead to catastrophic damage within the human body. The LSC outlines the FED value for incapacitation as 0.8 for non-lethal exposure, and a FED value of 0.3 for non-incapacitating exposure. Purser states a value of 1.0 for incapacitation using the

FED concept. On this basis a simplified version of the overall FED equation (Equation 63.38) for asphyxiants is as follows in Figure 64:

$$F_{IN} = [(F_{I_{CO}} + F_{I_{CN}} + FLD_{irr}) \times VCO_2 + FED_{I_O}] \text{ or } F_{I_{CO_2}}$$

where

F_{IN} = fraction of an incapacitating dose of all asphyxiant gases

$F_{I_{CO}}$ = fraction of an incapacitating dose of CO

$F_{I_{CN}}$ = fraction of an incapacitating dose of HCN (and nitriles, corrected for NO_2)

FLD_{irr} = fraction of an irritant dose contributing to hypoxia (This term represents a correction for the effects of irritants on lung function and is developed in the section on irritants. This term may be omitted if the effects of asphyxiant gases only are under consideration)

VCO_2 = multiplication factor for CO_2-induced hyperventilation

FED_{I_O} = fraction of an incapacitating dose of low-oxygen hypoxia

$FED_{I_{CO_2}}$ = fraction of an incapacitating dose of CO_2

Figure 64: Fractional Effective Dose Equation from NFPA101

The main cause of incapacitation and death during and immediately after fires is exposure to asphyxiant gases. Incapacitation results from loss of consciousness due to the combined effects of carbon monoxide, hydrogen cyanide, and carbon dioxide, with some additional effects from low-oxygen hypoxia and inhaled irritants. Loss of consciousness prevents escape and further uptake of asphyxiants while comatose is likely to result in death within a further minute or so. The most useful tenability endpoint to work to is, therefore, considered to be loss of consciousness, with design limits set to prevent an occurrence. Based on simple calculations using excel, the FED does not exceed a value of 1.0 within the RSET of 488 seconds.

For NA893 Community Support Facility, the smoke control system is one of typical cases that are specified by both the Building Standards Law and Fire Service Law, and it is usually designed in accordance to the Building Standards Law.

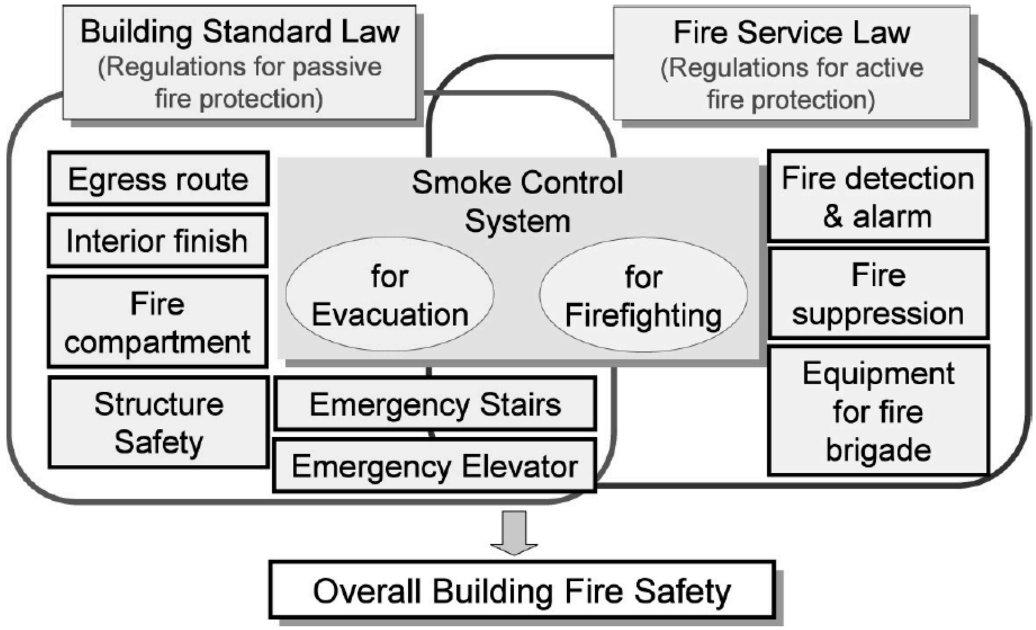


Figure 65: Relation between Fire Service Law and Building Standard Law from the viewpoint of building fire safety.

The purpose of smoke control system differs essentially according to the stages of evacuating occupants and conducting firefighting because of the difference in the envisioned use of smoke control systems in each stage. In other words, while the smoke control system for evacuation is used for the purpose of ensuring the safety of occupants during their evacuation from a building in an early stage of fire, the smoke control system for firefighting is used to facilitate the safe and smooth firefighting activities of fire brigades in a fully developed fire. Actually, smoke control system is listed first as a "required system for firefighting" in Article 7 of the Enforcement Ordinance of the Fire Service Law. From the viewpoint of firefighting, therefore, it is desirable that smoke control systems continue to operate even as fire develops and spreads. However, since smoke control system specifications are usually designed according to Building Standards Law, there is a contradiction with the mechanical smoke control systems in such a case when smoke control fans stop due to the activation of a closing apparatus (fire damper) that is provided in smoke exhaust ducts to prevent the spread of fire.

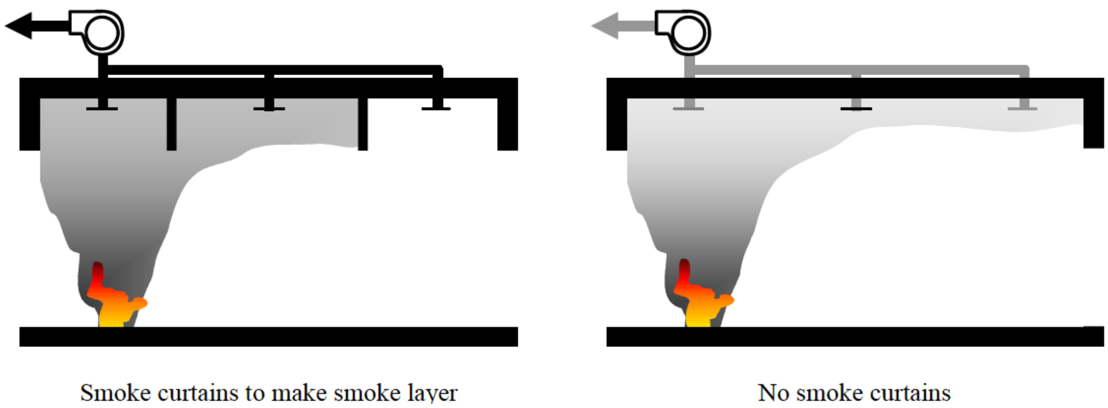


Figure 66: Smoke Evacuation System Required by Building Standard Law of Japan

According to the Building Standard Law of Japan, a mechanical smoke evacuation system is required for a high occupancy building such as the NA893 Community Support facility. A diagram of this system is provided in Figure 66 above. There are vents located in all inhabited spaces of the facility and ducting and vents accumulate the smoke towards a smoke evacuation system which is located on or near the roof of the facility.

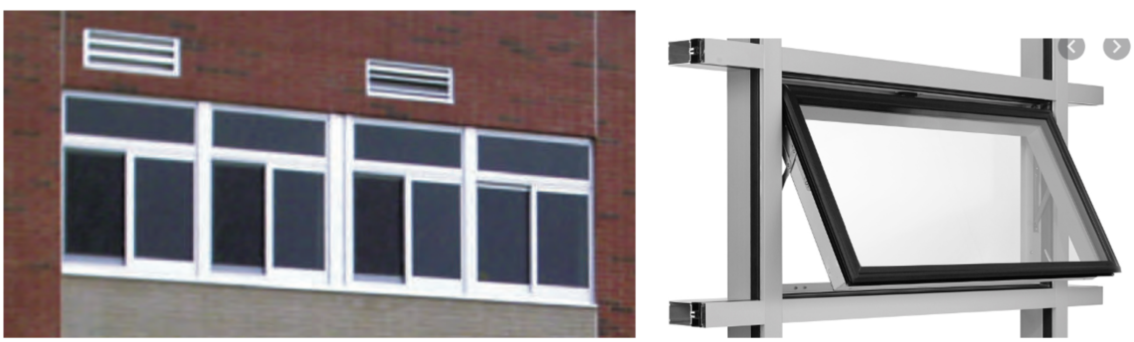


Figure 67: Smoke Evacuation Louvers and Windows Required by Building Standard Law of Japan

Smoke evacuation systems such as windows or louvers are also required by the Japanese Building Standard Law. The smoke exhaust louvers or windows shall be located above the door height to allow smoke to not accumulate in the room to allow occupants to egress through the doors with good visibility and lack of smoke. Sample smoke evacuation louvers and windows are provided in Figure 67 above.

It is natural that the required performance of smoke control systems for each purpose differs because evacuation is carried out for an unspecified number of people including children, the elderly and people awoken from sleep wearing clothing not designed for fire protection, while firefighting activity is carried out by firefighters wearing fire coats, masks and breathing equipment. In this sense, pressurized smoke prevention systems can be considered as desirable smoke control systems that accomplish both the purpose of ensuing evacuation routes at the early stage of fire and protecting a staging area even under a fully developed fire.

FDS ANALYSIS

As part of this report, a Fire Dynamics Simulator (FDS) analysis has been conducted of the library floor of NA893 Community Support Facility. Fire Dynamics Simulator (FDS) is a computational fluid dynamics (CFD) model of fire-driven fluid flow. The computer program solves numerically a large eddy simulation form of Navier-Stokes equation appropriate for low-speed, thermally-driven flow, with an emphasis on smoke and heat transport from fires, to describe the evolution of fire. FDS is free software developed by National Institute of Standards and Technology (NIST) of the United States Department of Commerce,

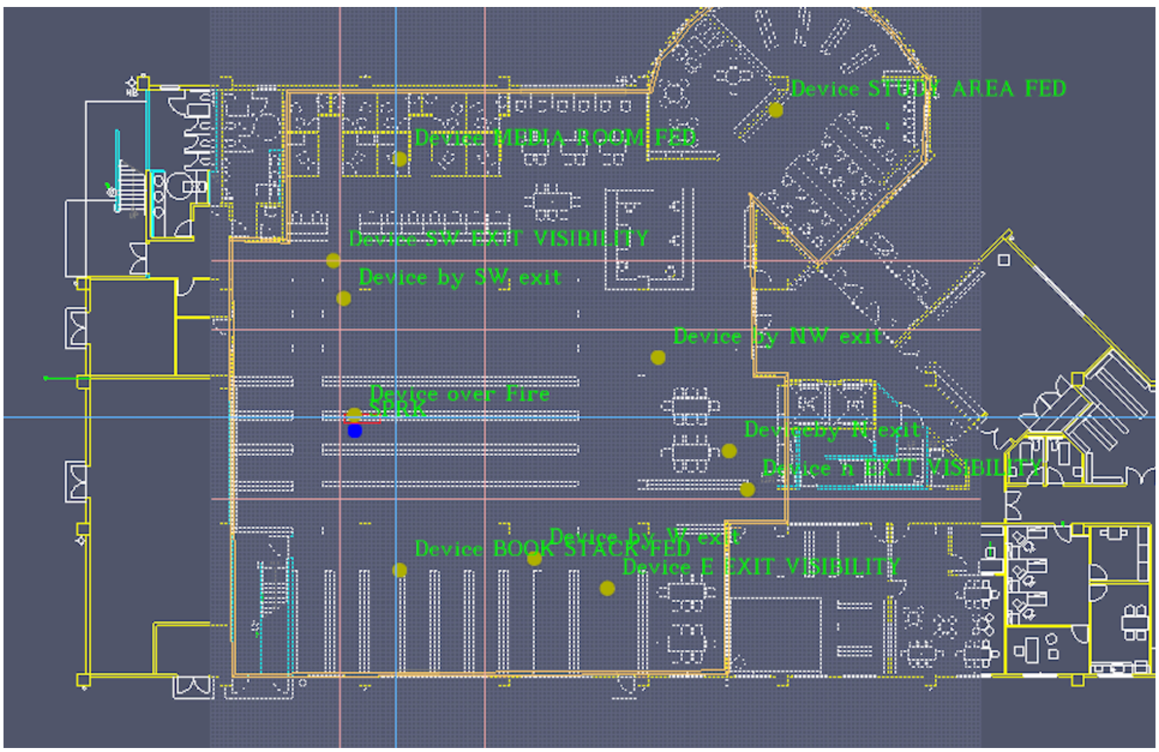


Figure 68: Pyrosim Model of Library Floor of NA893 Community Support Facility

The FDS simulation was set up using Pyrosim. The floor plan of the facility was imported into Pyrosim and a fire was simulated in the center of the main library stacks in Room 118B. It was assumed that two library bookshelves were to ignite and a duration of 600 seconds was used. The heat release rate from the Yuan study was used and shown in Figure 42. However, the Yuan study's heat release rate stops growing at 100 seconds since the fire load is consumed and starts decreasing since there is no more material to be burned. For the FDS simulation, the heat release rate grew to 450 kW and stayed at that rate since the bookshelf is over 20 meters and it is assumed that the fire load will not be consumed within the time of the simulation. The fire is simulated as a fast αt^2 fire as referenced in the Yuan study. The fire source will be approximated as wood since the bookshelves are made of wood and the books themselves can be approximated as wood. The location of the fire is under one of the structural beams. A sprinkler was located close to the bookshelf that was on fire. Although there is a mechanical smoke evacuation system in this facility, the details were not obtained so the mechanical smoke evacuation system were not simulated. The smoke evacuation louvers were activated and they were placed in the FDS model in accordance with the floor plan and elevations. FED monitors, thermocouples, and visibility were monitored by placing devices in strategic locations in the facility. A Pyrosim model with devices for the subject facility is shown in Figure 68 above.

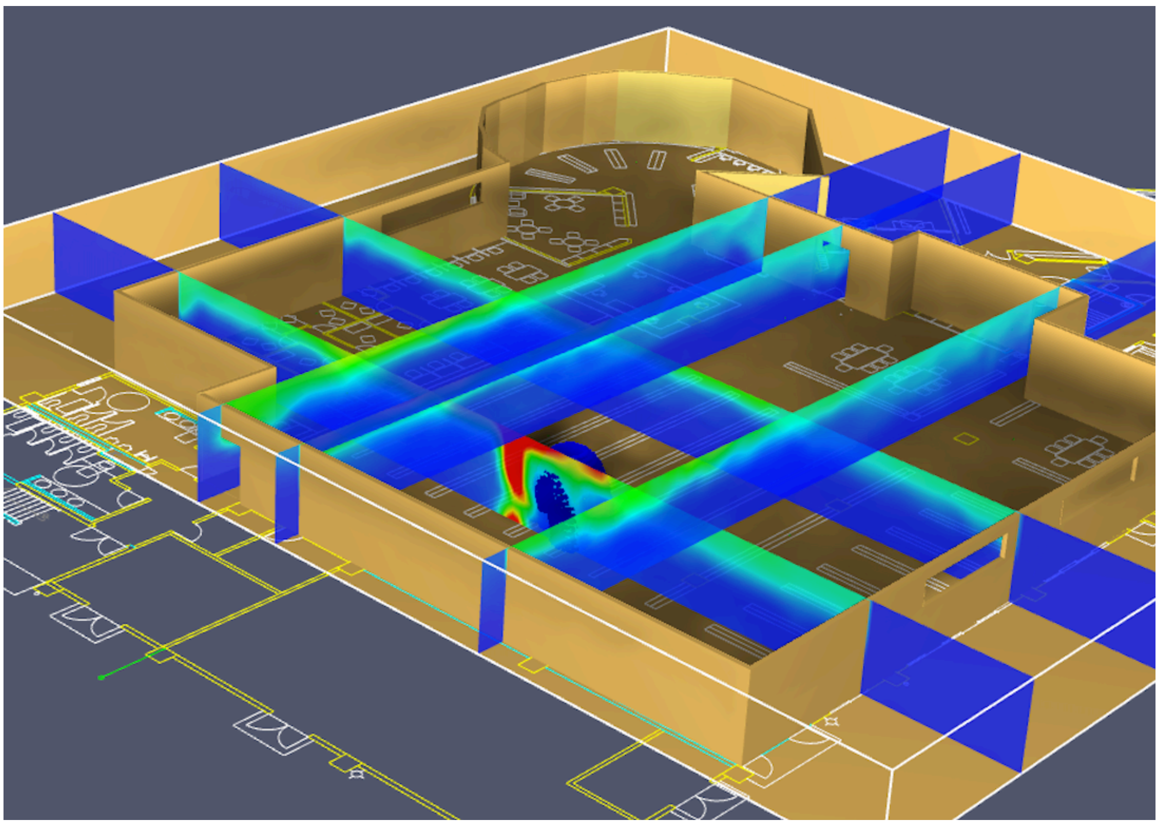


Figure 69: Fire Dynamics Simulation of Library Floor of NA893 Community Support Facility

The graphical results of the FDS simulation is shown in Figure 69 with slice files at 500 seconds. There is some smoke accumulated in the main library of the Community Support Facility. From the slice files, it seems that the temperature was high at the source of the fire, but the temperature did not rise significantly in the surrounding areas. Although there is smoke present in the room, it seems as if the smoke is accumulated more towards the top of the room. The results of the devices will follow.

Figure 70 shows the temperature readings from the thermocouple devices which were located throughout the main library floor during the FDS simulation. In this situation, the temperature in other parts of the room did not get above 28 degrees Celsius. The temperature is provided on the y axis in degrees Celsius and the time is given in the x-axis in seconds. Given that the RSET is 488 seconds, it would be reasonable to state that the occupants would not be burned while trying to egress the Community Support Facility within the RSET time.

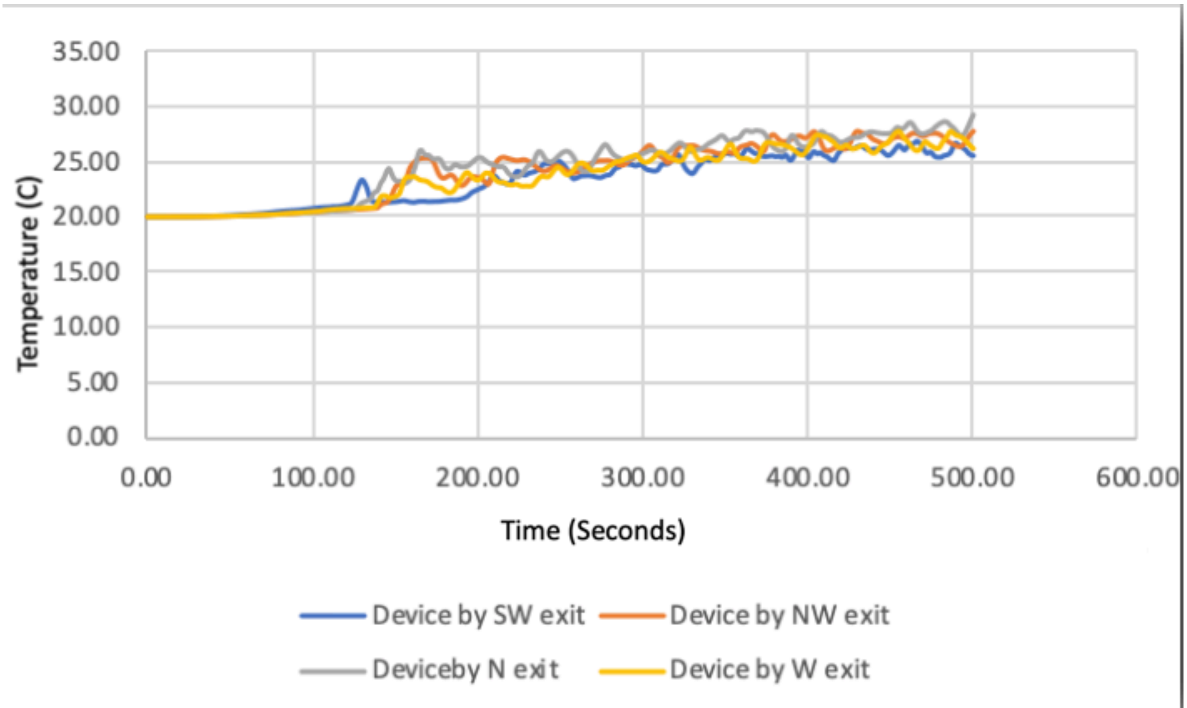


Figure 70: Temperature Profile of FDS Simulation of Library Floor of NA893 Community Support Facility

Figure 71 provides the readings from the FED monitors from the simulation of the subject facility. In this situation, it shows that occupants are not incapacitated since the levels never really approach the dosage where people cannot breathe. As shown in the graph, the FED dosage is significantly under a value of 1.0. The y-axis of the graph shows the dimensionless FED dosage and the x-axis is the time given in seconds. Given that the RSET is 488 seconds, it would be reasonable to state that the occupants would not be incapacitated by smoke inhalation while trying to egress the Community Support Facility within the RSET time.

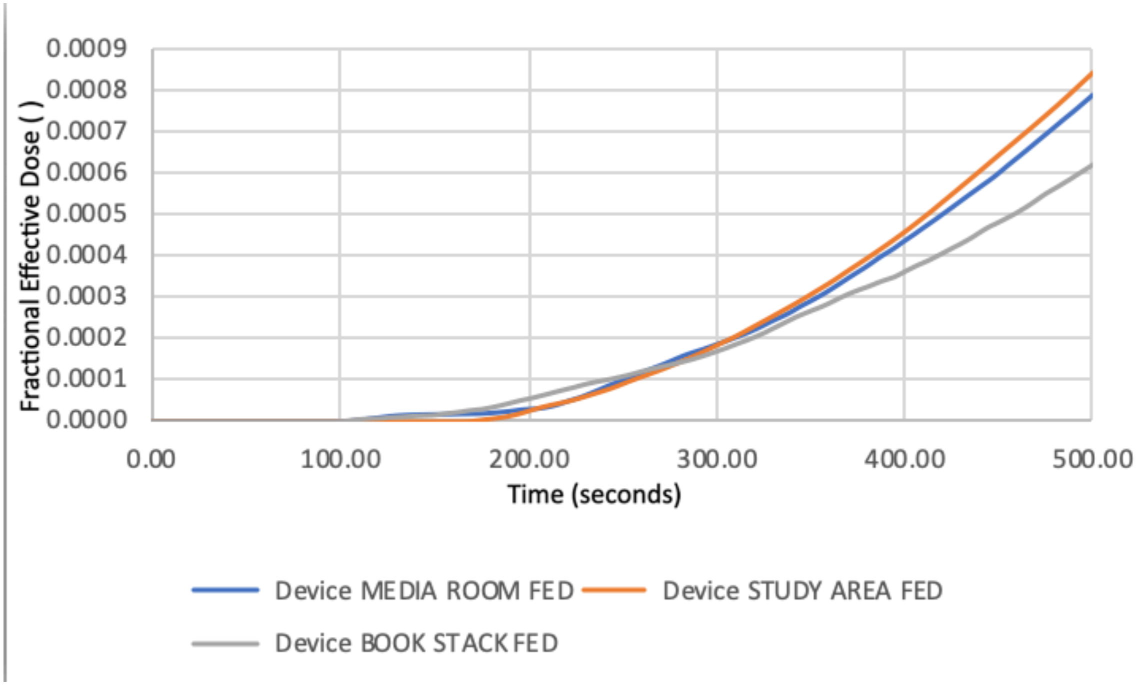


Figure 71: Fractional Effective Dose FDS Simulations for NA893 Community Support Facility

Figure 72 provides the readings from the visibility devices from the FDS simulation of the subject facility. In this situation, it shows that have 8 meters of visibility at various locations in Room 118B at 500 seconds, past the RSET time. As shown in the graph, the visibility is relatively good throughout the simulation. The y-axis of the graph shows the dimensions of visibility in meters and the x-axis is the time given in seconds. Given that the RSET is 488 seconds, it would be reasonable to state that the occupants do have good visibility while trying to egress the Community Support Facility within the RSET time.

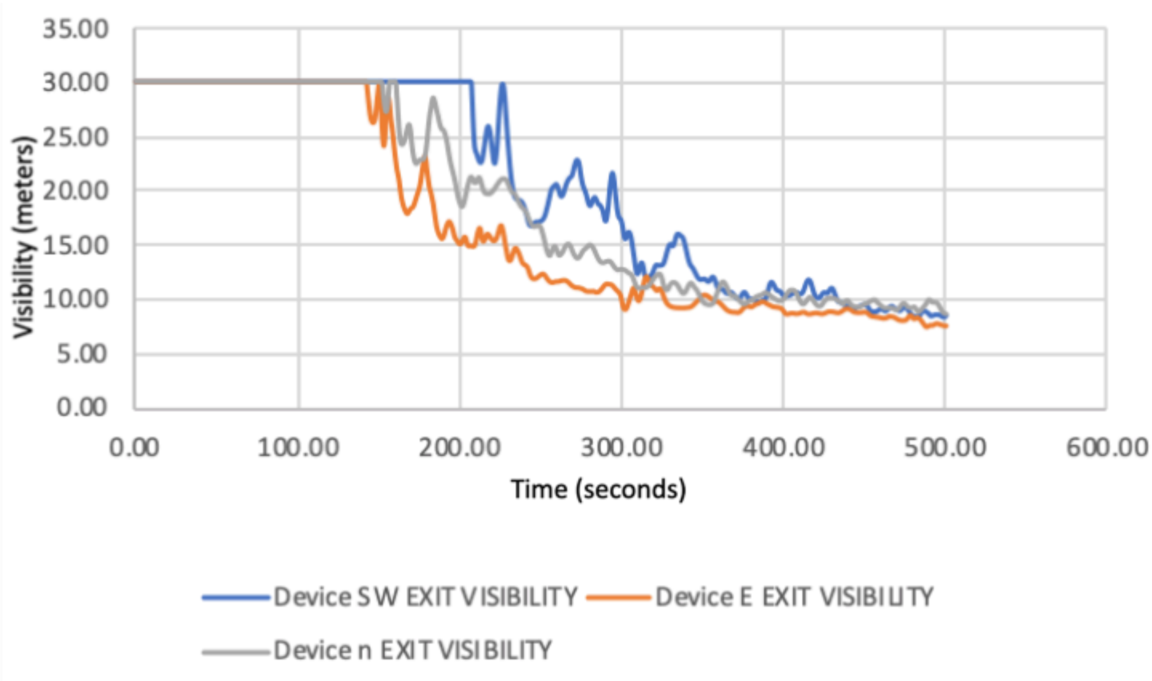


Figure 72: Visibility for FDS Simulations for NA893 Community Support Facility

Figure 73 provides the heat release rate from the FDS simulation of the subject facility. In this simulation, the heat release rate in Room 118B is very similar to the heat release rate given in the Zalok study on which Design Fire Scenario 1 is based on. As shown in the graph, heat release rate is a fast rate alpha T-square fire. The y-axis of the graph shows the heat release rate given in kilowatts and the x-axis is the time given in seconds.

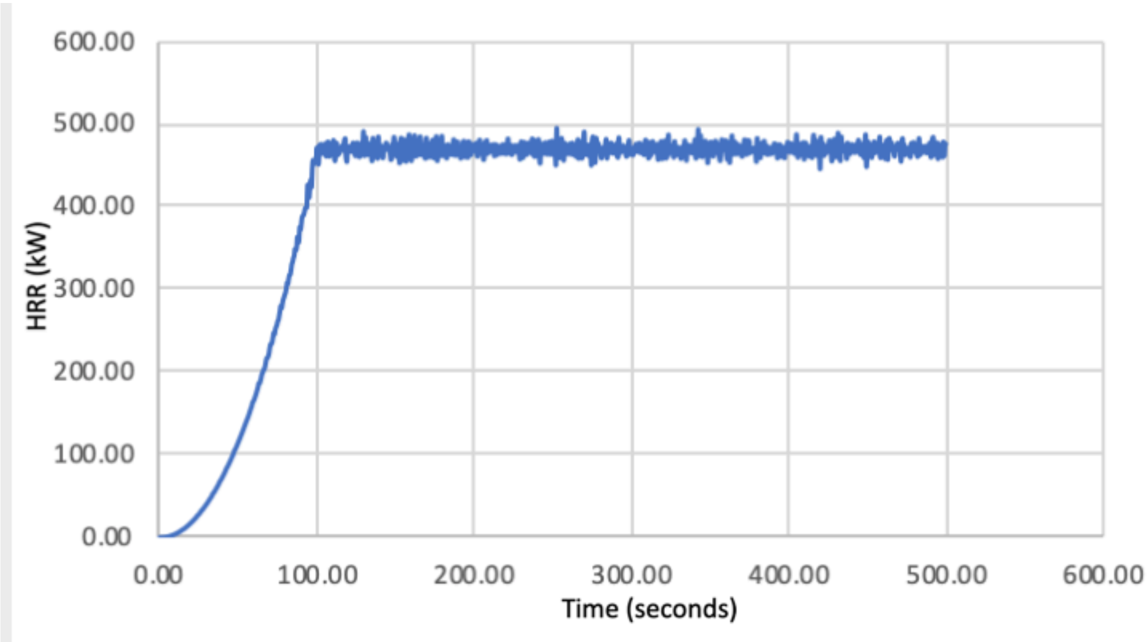


Figure 73: Heat Release Rate for FDS Simulations for NA893 Community Support Facility

CONCLUSION

For the performance-based analysis of the NA893 Community Support Facility, the required safe egress time (RSET), available safe egress time (ASET), and Fire Dynamics Simulation (FDS) and Pyrosim analysis were used to determine if the occupants of the subject facility can egress the building safely.

The required safe egress time was first calculated by analyzing its components. The required safe evacuation time (RSET) is composed of the time to notification, reaction time, pre-evacuation activity time, and travel time. The time to notification is calculated based on the fire alarm detector time and has been determined to be 47 seconds. The pre-movement activity time was taken from a study using a conservative estimate to be 75 seconds. The total evacuation time was determined during the prescriptive analysis to be 6 minutes and 5 seconds. Summing these values, the RSET is calculated to be 488 seconds or 8 minutes and 8 seconds. In order for the performance-based analysis for NA893 Community Support Facility to be successful, the ASET must be greater than the RSET.

There are many factors to be considered for the available safe egress time (ASET) of a facility. In order to do an ASET analysis, fire scenarios would need to be developed. Three fire scenarios are provided in this report. The first scenario would be a fire in the large book stack area in the main library. The second scenario would be a fire in a small compact space, the periodical room, with bookshelves that are more densely packed when compared to the large stack area. The third fire scenario is a workstation fire in the media rooms in the main library.

The ASET analysis would cover several factors to include the facility structure, heat effects to the occupants, smoke inhalation effects to the occupants, and visibility of the occupants while they egress the facility. Since the facility structure would have to withstand earthquakes in the highly seismic area of Japan as well as a 40-ton car bomb due to anti-terrorism and force protection requirements, it was no surprise that the facility structure can withstand the fire scenarios that were developed above. This was no surprise as well since there was a one-hour fire resistance requirement since the Community Support Facility was a Type IIA facility.

The Fire Dynamics Simulations (FDS) was also executed using Pyrosim to model the main library for the NA893 Community Support Facility. The FDS model was developed to model the fractional effective dose (FED), temperature effects, and ability to see during the fire scenario in Room 118B. Since some information was not available such as the mechanical smoke evacuation device, a conservative model was developed. Although there was no mechanical smoke evacuation system modeled, the smoke evacuation louvers were modeled and a fire sprinkler was located close to the bookshelf fire. Even if there were no mechanical smoke evacuation system, the FDS analysis support that all the occupants can safely egress the subject facility within the time provided by the RSET.

The fractional effective dose monitors are located in several locations within the main library floor where the occupant load is high. The fractional effective dose does not reach a value of 1.0, so the occupants can egress without smoke inhalation affecting them very much. Thermocouples have also been placed is several locations as well and the temperature did not rise above 33 degrees Celsius. Therefore, there are no significant heat effects against the exiting occupants. Finally, although there is some smoke accumulation in the library floor, by the RSET time, the exiting occupants still have a visibility of 8 meters. Thus, the occupants should be able to egress with relatively good visibility.

Given the ASET analysis, the occupants can safely egress the NA893 Community Support Facility based on the fire scenario give in the main library by the required safe egress time. Therefore, the performance-based analysis tends to support that NA893 Community Support Facility is a relatively safe facility from a fire protection perspective. Since there are competing requirements where the most stringent criteria need be used among US federal rules (NFPA), Department of Defense criteria (UFC 3-600-01), and Japanese laws (Building Standard Law of Japan and Fire Services Act), a much safer facility had been designed as a result.

RECOMMENDATIONS

Since the NA893 Community Support Facility is already designed and constructed, recommendations that would fundamentally change the design will not be possible. However, there are still very many operational things that can be done to decrease the potential fire threat to the subject facility. In this recommendation section, some suggestions to the design fires that were discussed in this project report will be provided to decrease the fire threat.

The first design fire considered in this cumulative paper is in Room 118B Main Library Book Stacks. The primary issue with the book stacks is that they are continuous lengths of book stacks for about 30-40 meters long. According to the Yuan study concerning bookshelves, the likelihood of a fire spreading is significantly decreased if the bookshelves are separated by 1.25 meters. Although the current layout of the bookshelves in the first floor separates the bookshelf rows by 1.25 meters, the bookshelves are continuous for 30-40 meters. Therefore, one row of library bookshelves may be one large fire load if it is to catch fire. However, if the long bookshelf row can be broken up into non-continuous rows of bookshelves, such as shown in Figure 74, the potential of one long row to burn will decrease considerably. If the bookshelf can have a break every 3-4 meters rather than having a continuous for 30-40 meters long bookshelf, a fire in the bookshelf can be contained to one bookshelf island rather than the entire length. Unfortunately, this does decrease the bookshelf area or volume by 10-20%.

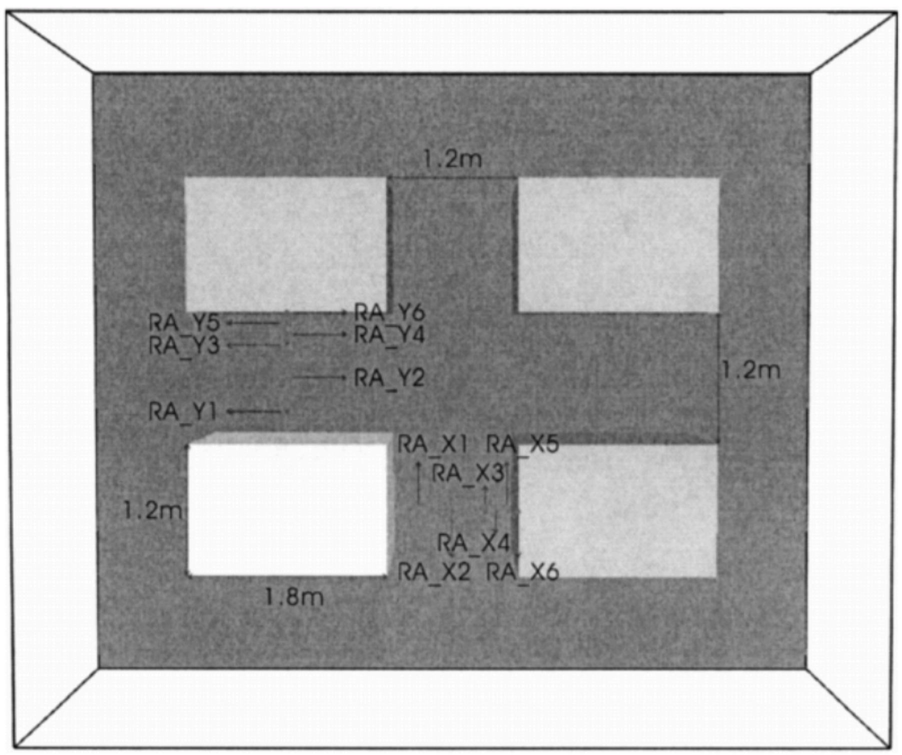


Figure 74: Bookshelf Spacing of 1.2 meters to Prevent Fire Spread

The second design fire considered in this cumulative paper is in Room 116 Periodical Room. The periodical room suffers the same issues as Room 118B with continuous bookshelves but is more severe. All the bookshelves in the periodical room are connected to each other without a fire break. Therefore, if a fire were to start in the bookshelf, all the bookshelves in the periodical room can be considered to be one large fire load. There are several recommendations in this room. First, the same mitigation method as Room 118B can be taken and the bookshelves can be separated from each other with spacing of 1.25 meters. However, this may drastically reduce the book or periodical holding capability of the periodical room.

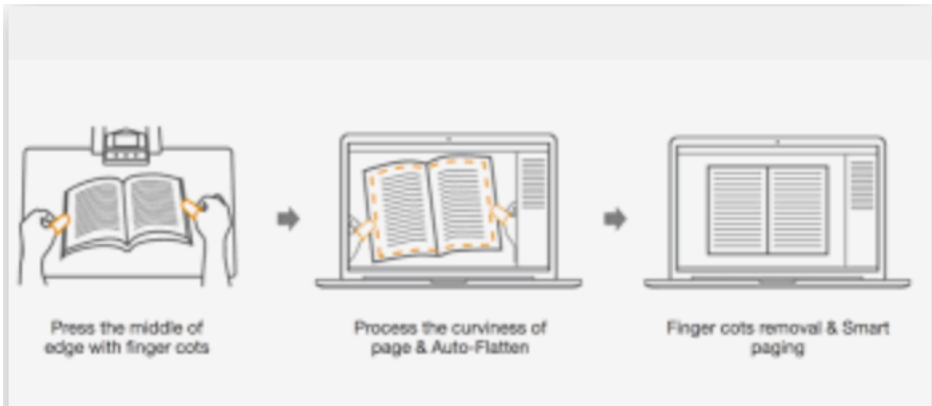


Figure 75: Process of Digitizing Paper Based Books and Periodicals into Digital Versions

Another option is to turn Room 116 Periodical Room from a large storage room for periodicals into a reading room for current periodicals and with some computer stations to view older periodicals. Older periodicals can be digital copies and stored on a server somewhere, as shown in Figure 75. This change will require much more information technology infrastructure. Otherwise, the Main Library can invest in online periodical services such as ProQuest.

The third design fire considered in this project report is in Room 111A-J Media Rooms. Currently, each media room is an enclosed space with that are about 3m x 2.5 m x 2.4 m in dimension. There is a computer workstation with a desk and a chair or two per room. These media rooms can be likened to cubicle workstations and the heat release rates are modeled after them. There are several fire safety issues with these media rooms. They are enclosed spaces with combustible furniture such as computers, desks, and chairs. The walls of the media rooms may have acoustic tiles which may be flammable as well. These media rooms are located adjacent to each other in a confined space. If one media room were to catch fire, all the media rooms can be considered to be one large fire load since they are all connected with each other without a fire break. In order to mitigate this issue, I would propose that the Main Library move away from the enclosed room media room concept and move to an open arrangement or open desk computer area concept. The computers should be equipped with headphones so the user can watch their media without bothering the surrounding patrons. Furthermore, the computer desks should be separated by about 1.25 meters like the bookshelves so that it may serve as a fire break.

Figure 76: Concept of Open Desk Media Room

The Main Library at the NA893 Community Support Facility is based on the traditional library model. The traditional library is characterized by an emphasis on storage and preservation of physical items, particularly books and periodicals cataloging at a high level rather than one of detail. For instance, author and subject indexes as opposed to full text browsing based on physical proximity of related materials. In the traditional library model, the users must travel to the library to learn what is there and make use of it.

Rapid advances information technologies have revolutionized the role of libraries. As a result, libraries face new challenges, competitors, demands, and expectations. Libraries are redesigning services and information products to add value to their services and to satisfy the changing information needs of the user community. Traditional libraries are still handling largely printed materials that are expensive and bulky. Information seekers are no longer satisfied with only printed materials. They want to supplement the printed information with more dynamic electronic resources. Demands for digital information are increasing.

Digital libraries have changed the way that library users access information. They are heading toward an environment in which digital information may substitute for much print- based information. A library's existence does not depend on the physical form of documents. Its mission is to link the past and the present, and help shape the future by preserving the records of human culture, as well as integrating emerging information technologies. This mission is unlikely to change in the near future. Digital libraries come in many forms. They attempt to provide instant access to digitized information and consist of a variety of information, including multimedia.

The modern digital library differs from the traditional library in several ways. There is more emphasis on access to digitized materials wherever they may be located, with digitization eliminating the need to own or store a physical item. Rather, the digital library will catalog media down to individual words or glyphs, browsing based on hyperlinks, keyword, or any defined measure of relatedness. Library materials on the same subject do not need to be near one another in any physical sense sue to broadcast technology. Library users need not visit a digital library except electronically.

As the current NA893 Main Library transitions from the typical analog library to the new modern digital library, many of the recommendations given above can be instituted. The Main Library will still serve as a place of learning and accessing information but the physical setting can be made much more safe in terms of fire safety will physical distancing of bookshelves and media centers.

REPORT CONCLUSION

This is the culminating project report for the Fire Project Engineering Program at California Polytechnic at San Luis Obispo. This project reviewed the fire protection systems for a project for the US military in Japan, JFY893 Community Support Facility, Yokosuka Naval Base. The subject facility consists of the base main library, education center, family services, and other community services. The first floor of the subject facility is the Main Base Library for the active duty population, their dependents, and other US Federal and Japanese National employees. The Education Center provides services for advancing of the academic, technical, and vocational education of military personnel of all grades and ranks in order to enhance their potential to the military services. The Education Center also provides educational opportunities for the adult civilian population on base. The Family Service shall provide information and referral services, education and training services, and counseling service for active duty population with services usable to dependents and retirees. The fourth floor of the subject project will provide psychological clinical support services to the servicemen and their families.

This paper is composed of three major components. First, the NA893 Community Support Facility has been introduced so that its function is understood to the reader. Based on the International Building Code, the required construction classification has been identified. Then, the materials used to construct the columns, beams, floor assemblies, roof assembly, exterior walls, interior walls, door openings, joints, penetrations, and partitions have been distinguished. The floor plan of the subject facility has been provided and its function have been explained with room details.

The prescriptive and performance-based analysis of the subject facility has been performed on the subject facility from a fire protection and safety perspective. The second portion of this report has concentrated on the prescriptive-based analysis for NA893 Community Support Facility. The prescriptive-based analysis was based on the analysis provided in the core Fire Protection Engineering Courses at CalPoly. The occupancy classification and means of egress has been analyzed and described as per FPE521 Egress Analysis and Design. The electrical and communications system has been studied and presented as per FPE522 Fire Detection and Alarm Systems. The mechanical engineering systems have been covered through the FPE523 Fire Suppression

System class. The fire safety strategy of the fire resistance in the building has been investigated and shown through the FPE 524 Structural Fire Protection course coverage.

Fully loaded, the NA893 Community Support Facility can have up to 1,447 occupants. Since there are more than 500 people on the second floor, three stairwells are required by the Life Safety Code. There are several double doors providing exits from the main library including the main exit to the North and side exits to the South-West and East. The stairwells from the second through fourth floors exit through an external stairwell to the South-West, internal stairwell to the South-East, and the central internal stairwell, which will exit through the main exit to the North. The total evacuation time is calculated to be 6.05 minutes.

The Fire Detection and Alarm Systems have been designed in coordination with the Japanese Fire Services Act, NFPA, and UFC 3-600-01. The requirements were generally complimentary of each other but the spacing of the smoke detectors and fire alarms were spaced more closely together in the Japanese requirement. This would mean that the US requirements for the fire detectors and alarms were exceeded. The personnel announcement system requirements were exceeded by the Department of Defense Mass Notification Systems rules which were developed right after the 9/11 terror attacks. The intelligibility commissioning and testing requirements were much stricter than presented in the NFPA72.

The fire demand for the subject facility was designed based on the UFC 3-600-01 since it was more stringent than the NFPA and Japanese laws. The library has been classified as an Ordinary Hazard 2 while the second through fourth floors were classified as Light Hazard. The sprinkler design requires a design density of 0.20 gpm/ft^2 and a design area of 3,000 ft^2. The hose stream allowance is 500 gpm and the duration of supply is 90 minutes. The water supply came from the base potable water distribution system and the nearest hydrant was G-28 and the connection to the facility was made at the fire pump room located at the South-Eastern portion of the building. The water supply would provide 69 psi static pressure, 60 psi residual pressure, and available flow of 890 gpm. Although the water supply did meet the demand of the facility, the Japanese Building Standard Law requires that all high occupancy building have a fire pump, emergency generator, and fire cistern. The Japanese law requires a fire pump since Japan is a high seismic zone and the potential of water main breakage and power loss can occur after an earthquake. Therefore, the fire pump, emergency generator, and fire cistern are redundant systems.

According to Table 506.1 of the IBC, the NA893 Community Support Facility is Construction Type IIA since it is a 4-story building at a height of 63.8 ft, fully sprinklered as an Ordinary Hazard 2 facility, and includes Occupancy Group A3 (15,069 ft^2 and Occupancy Group B (28,868 ft^2). This requires the exterior and interior bearing walls as well as the floor and ceilings to have a fire resistance rating of one-hour in accordance to the IBC Table 601. However, the Department of Defense as well as the Japanese laws has much stricter structural requirement due to various reasons which would as a result, reinforce fire safety requirements. The Japanese Structural Law, which was revised in

2004, required higher levels of structural support since it was classified as a high population density building and since it was designated as an emergency evacuation area. Furthermore, Yokosuka has been zoned as a high seismic activity zone. Furthermore, after the 9/11 terror attacks, the UFC 4-010-01 required a special progressive collapse analysis since it was labeled a high-security target, high-density inhabited facility, and a mission critical facility.

The last portion of the culminating report is the performance-based analysis for NA893 Community Support Facility. The performance-based analysis has been analyzed in several sections. First, the Required Safe Egress Time (RSET) has been analyzed and calculated. An analysis of the time taken by occupants to safely escape from the effects of fire has also been done in a quantitative and methodical way. Next, the Available Safe Egress Time (ASET) has been evaluated. The time the effects of fire reach the tenability limits prescribed in the acceptance criteria have been determined. There are several factors which have been considered. The subject facility's structural integrity and its ability to survive the fire will has been evaluated. The ability of the occupants to egress the facility when subjected to intense heat and smoke have also been considered as well. through computer modeling programs such as Fire Dynamics Simulator (FDS) and Pyrosim.

The required safe evacuation time (RSET) is composed of the time to notification, reaction time, pre-evacuation activity time, and travel time and have been determined to be 488 seconds. The time to notification is calculated from the fire alarm detector time to be 47 seconds. The pre-movement activity time was taken from a study using a conservative estimate to be 75 seconds. The total evacuation time was calculated in the prescriptive-based analysis to be 6.05 minutes. In order for the performance-based analysis for NA893 Community Support Facility to be successful, the ASET will need to be greater than the RSET.

Three fire scenarios are provided in this report in order to evaluate the subject facility from a performance-based analysis. The first scenario would be a fire in the large book stack area in the main library, Room 118B. The second scenario would be a fire in a small compact space, the periodical room (Room 116), with bookshelves that are more densely packed when compared to the large stack area. The third fire scenario is a workstation fire in the media rooms, Rooms 111A-J, in the main library. Specifics on the fire scenarios are provided with realistic heat release rates from documented sources.

From the prescriptive-based analysis portion of the report, it was already determined that the subject facility would be able to withstand one-hour of fire since the internal support beams require this fire rating since it is a Type IIA facility. The performance-based analysis considered the effect of the design fire scenarios on the support beams on the first floor of the subject facility. Since Room 118B is very large, the Traveling Fire Methodology (TFM) was used to model ceiling jet temperature effects to the reinforced concrete beams. For Rooms 116 and 111, the Margaret Law Theorem was used to calculate the strength of steel in the concrete as temperature from the fire was applied. It was determined that the structural members do not fail under the conditions provided in this report. The performance-based analysis is consistent with the prescriptive-based analysis since the structural members have a one-hour fire rating and should not fail during the RSET time of 488 seconds.

The Fire Dynamics Simulations (FDS) and Pyrosim were used to model the main library for the NA893 Community Support Facility. The FDS model was developed to model the fractional effective dose (FED), temperature effects, and ability to see during the fire scenario in the library. The fractional effective dose monitors were located in several locations within the main library during the fire and did not reach a value of 1.0. Thermocouples have also been placed is several locations as well and the temperature did not rise above 33 degrees Celsius during the simulation. The visibility remained above 8 meters during the duration of the simulation. Therefore, according to the FDS simulation, the occupants of NA893 Community Support Facility are able to egress the building safely within the required safe egress time.

This culminating report concludes with an overall evaluation of the facility from a prescriptive and performance-based analysis that this facility is safe from a fire protection and safety perspective. Although there were challenges of planning and designing a US military facility in Japan, the fact that the most stringent rules for fire protection rules among competing requirements such as the US federal codes (NFPA), Department of Defense criteria (UFC 3-600-01), and Japanese laws (Building Standard Law of Japan and Fire Services Act) needed to be utilized, resulted in a much safer facility.

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NFPA 70: *National Electrical Code*, 2018 Edition.

NFPA 72: *National Fire Alarm and Signaling Code*, 2018 Edition.

NFPA 101: *Life Safety Code*, 2018 Edition.

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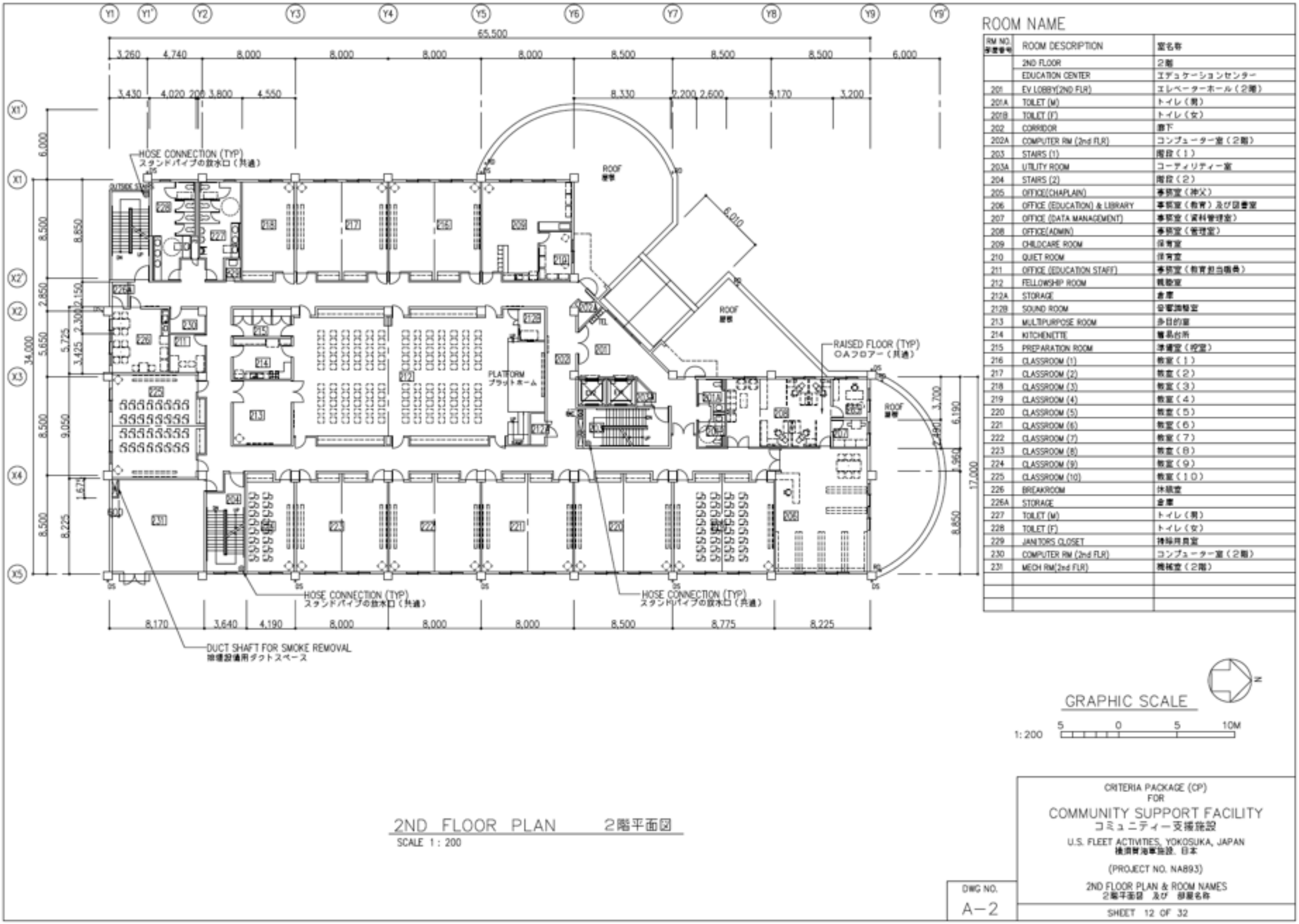
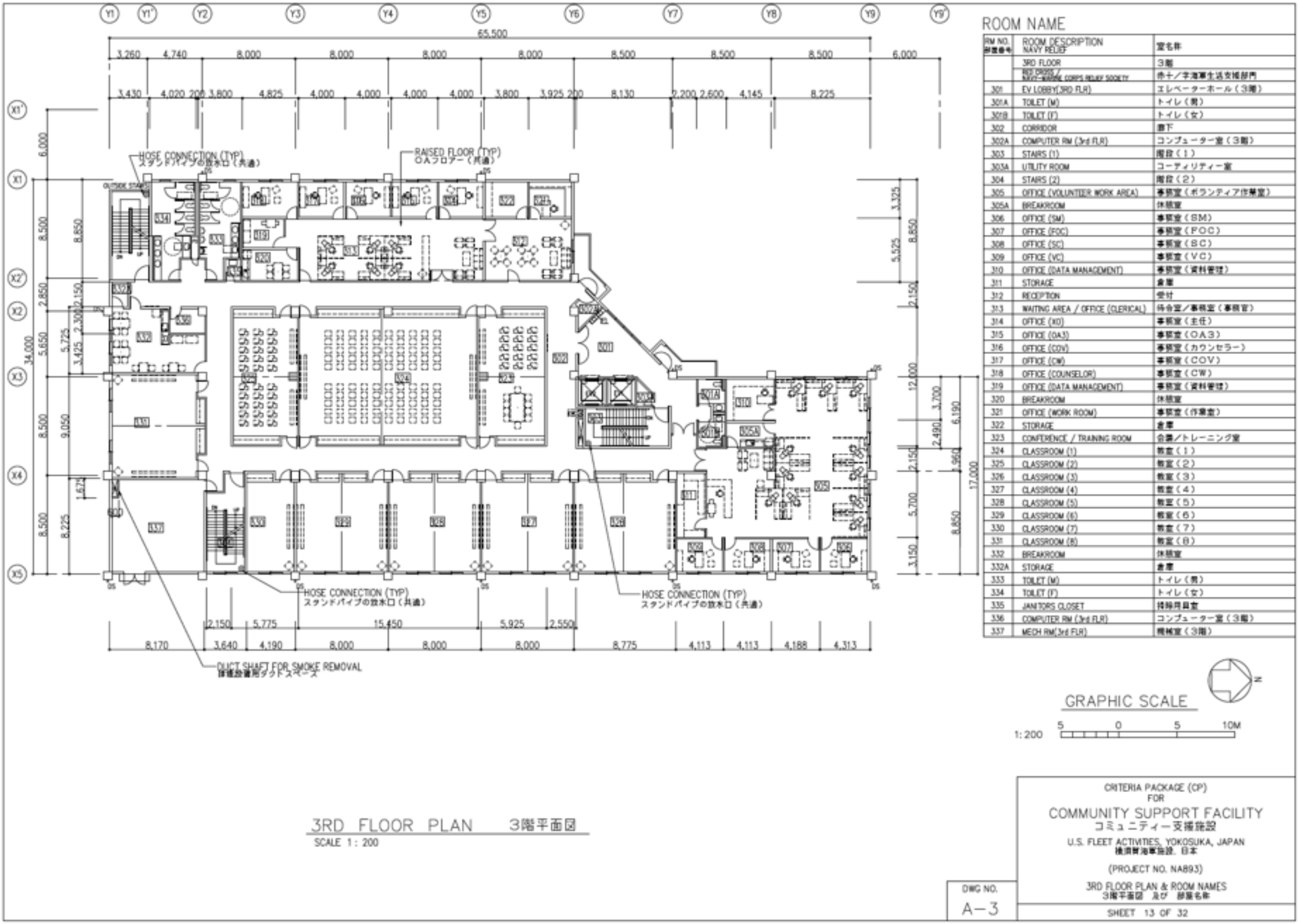
UFC 4-021-01, *Mass Notification Systems*, original dated 21 August 2002

APPENDIX A: Floor Plan

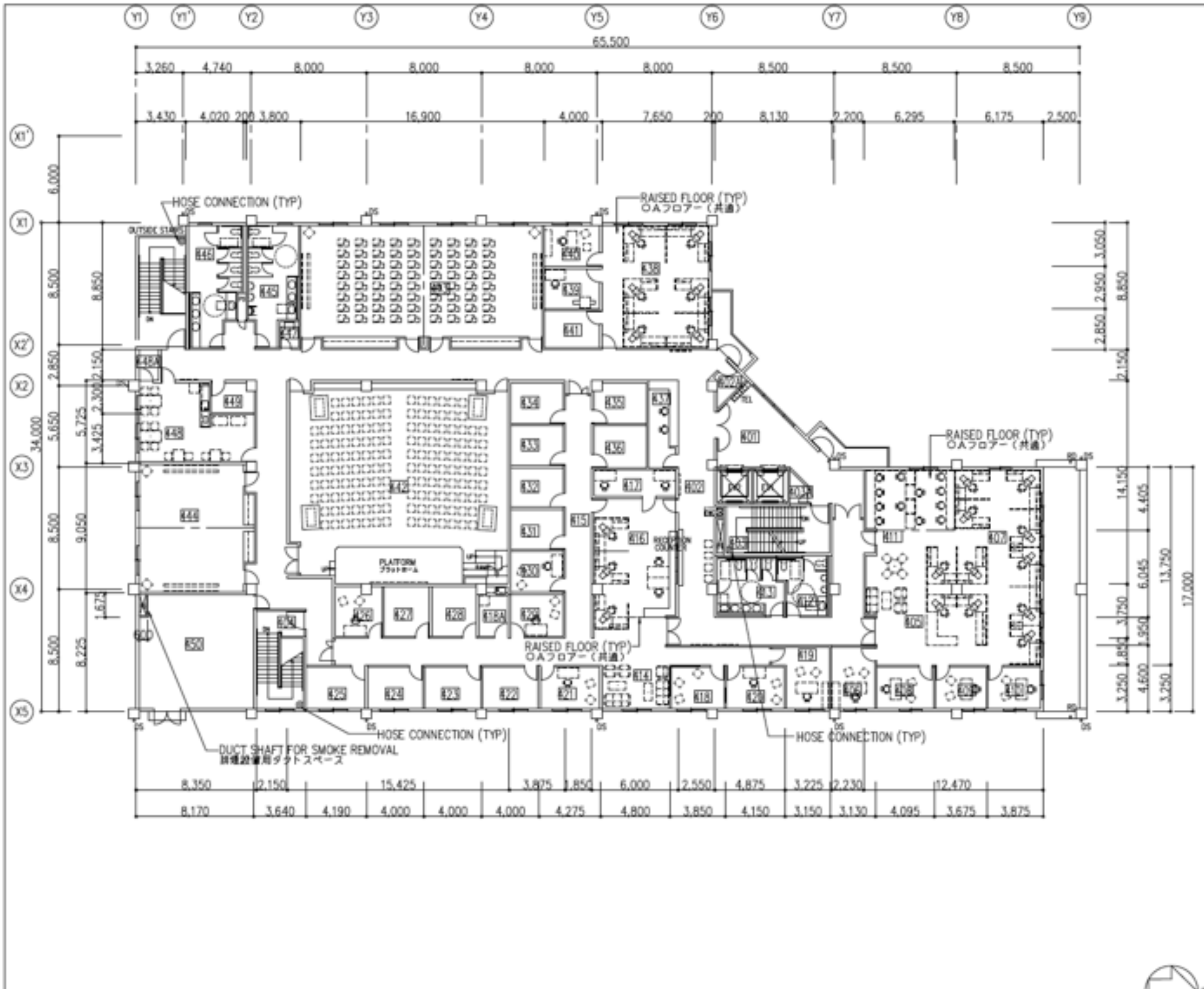

ROOM NAME
RM NO. | ROOM DESCRIPTION
1ST FLOOR
LIBRARY
101 EV LOBBY(1ST FLR)
101A VESTIBULE
101B COMPUTER RM (1st FLR)
102 CORRIDOR
102A STORAGE
102B JANITORS CLOSET(1)
103 STAIRS (1)
103A UTILITY ROOM
104 STAIRS (2)
104A STORAGE
105 OFFICE (DIRECTOR)
106 OFFICE (ASST.DIR./ADMIN CLERK)
107 BREAKROOM(STAFF)
108 OFFICE (DATA MANAGEMENT)
109 TOILET(M)
109A TOILET(F)
110 MULTIPURPOSE ROOM
111A~J MEDIA ROOM
112 CHILDRENS READING ROOM
113 STUDY ROOM (CHILDREN GROUP)
114 OFFICE/WORK RM (CHILDREN GROUP)
115 OFFICE(TECHNICAL SERVICE)
116 PERIODICAL / COMPACT STORAGE
117 STUDY AREA (PRIVATE BOOTH)
118 LIBRARY OPEN AREA
118A CIRCULATION DESK
118B BOOK STACK AREA
118C DISPLAY AREA
118D REFERENCE AREA
118E READING AREA
118F A/V & SPECIAL COLLECTIONS
118G PATRON ACCESS COMPUTERS
118H PERIODICAL
119 TOILET (M)
120 TOILET (F)
121 JANITORS CLOSET(1)
122 COMPUTER RM (1st FLR)
122A STORAGE
123 MECH RM(1st FLR)
124 EMERGENCY GENERATOR ROOM
125 FIRE PUMP ROOM
LEGEND:
HOSE BIB
HOSE CONNECTION
DOWN SPOUT
ROOF DRAIN
HOSE CONNECTION (TYP)
RAISED FLOOR (TYP)
MAIN ENTRANCE
OUTSIDE STAIRS
FIRE EXIT
1ST FLOOR PLAN 1階平面図
SCALE 1 : 200
GRAPHIC SCALE
1:200
CRITERIA PACKAGE (CP)
FOR
COMMUNITY SUPPORT FACILITY
U.S. FLEET ACTIVITIES, YOKOSUKA, JAPAN
(PROJECT NO. NA893)
1ST FLOOR PLAN & ROOM NAMES
DWG NO.
A-1
SHEET 11 OF 32


ROOM NAME
RM NO. 部屋番号 | ROOM DESCRIPTION | 室名称
2ND FLOOR | 2階
EDUCATION CENTER | エデュケーションセンター
201 | EV LOBBY(2ND FLR) | エレベーターホール（2階）
201A | TOILET (M) | トイレ（男）
201B | TOILET (F) | トイレ（女）
202 | CORRIDOR | 廊下
202A | COMPUTER RM (2nd FLR) | コンピューター室（2階）
203 | STAIRS (1) | 階段（1）
203A | UTILITY ROOM | ユーティリティー室
204 | STAIRS (2) | 階段（2）
205 | OFFICE(CHAPLAIN) | 事務室（神父）
206 | OFFICE (EDUCATION) & LIBRARY | 事務室（教育）及び図書室
207 | OFFICE (DATA MANAGEMENT) | 事務室（資料管理室）
208 | OFFICE(ADMIN) | 事務室（管理室）
209 | CHILDCARE ROOM | 保育室
210 | QUIET ROOM | 保育室
211 | OFFICE (EDUCATION STAFF) | 事務室（教育担当職員）
212 | FELLOWSHIP ROOM | 親睦室
212A | STORAGE | 倉庫
212B | SOUND ROOM | 音響調整室
213 | MULTIPURPOSE ROOM | 多目的室
214 | KITCHENETTE | 簡易台所
215 | PREPARATION ROOM | 準備室（控室）
216 | CLASSROOM (1) | 教室（1）
217 | CLASSROOM (2) | 教室（2）
218 | CLASSROOM (3) | 教室（3）
219 | CLASSROOM (4) | 教室（4）
220 | CLASSROOM (5) | 教室（5）
221 | CLASSROOM (6) | 教室（6）
222 | CLASSROOM (7) | 教室（7）
223 | CLASSROOM (8) | 教室（8）
224 | CLASSROOM (9) | 教室（9）
225 | CLASSROOM (10) | 教室（10）
226 | BREAKROOM | 休憩室
226A | STORAGE | 倉庫
227 | TOILET (M) | トイレ（男）
228 | TOILET (F) | トイレ（女）
229 | JANITORS CLOSET | 掃除用具室
230 | COMPUTER RM (2nd FLR) | コンピューター室（2階）
231 | MECH RM(2nd FLR) | 機械室（2階）
HOSE CONNECTION (TYP)
スタンドパイプの放水口（共通）
RAISED FLOOR (TYP)
OAフロアー（共通）
DUCT SHAFT FOR SMOKE REMOVAL
排煙設備用ダクトスペース
PLATFORM
プラットホーム
ROOF
OUTSIDE STAIR
65,500
34,000
17,000
GRAPHIC SCALE
1:200
5 0 5 10M
2ND FLOOR PLAN 2階平面図
SCALE 1 : 200
CRITERIA PACKAGE (CP)
FOR
COMMUNITY SUPPORT FACILITY
コミュニティー支援施設
U.S. FLEET ACTIVITIES, YOKOSUKA, JAPAN
横須賀海軍施設、日本
(PROJECT NO. NA893)
2ND FLOOR PLAN & ROOM NAMES
2階平面図 及び 部屋名称
DWG NO.
A−2
SHEET 12 OF 32



ROOM NAME

RM NO. 部屋番号	ROOM DESCRIPTION NAVY RELIEF	室名称
	3RD FLOOR	3階
	RED CROSS / NAVY-MARINE CORPS RELIEF SOCIETY	赤十字／海軍生活支援部門
301	EV LOBBY(3RD FLR)	エレベーターホール（3階）
301A	TOILET (M)	トイレ（男）
301B	TOILET (F)	トイレ（女）
302	CORRIDOR	廊下
302A	COMPUTER RM (3rd FLR)	コンピューター室（3階）
303	STAIRS (1)	階段（1）
303A	UTILITY ROOM	ユーティリティー室
304	STAIRS (2)	階段（2）
305	OFFICE (VOLUNTEER WORK AREA)	事務室（ボランティア作業室）
305A	BREAKROOM	休憩室
306	OFFICE (SM)	事務室（SM）
307	OFFICE (FOC)	事務室（FOC）
308	OFFICE (SC)	事務室（SC）
309	OFFICE (VC)	事務室（VC）
310	OFFICE (DATA MANAGEMENT)	事務室（資料管理）
311	STORAGE	倉庫
312	RECEPTION	受付
313	WAITING AREA / OFFICE (CLERICAL)	待合室／事務室（事務官）
314	OFFICE (XO)	事務室（主任）
315	OFFICE (OA3)	事務室（OA3）
316	OFFICE (COV)	事務室（カウンセラー）
317	OFFICE (CW)	事務室（COV）
318	OFFICE (COUNSELOR)	事務室（CW）
319	OFFICE (DATA MANAGEMENT)	事務室（資料管理）
320	BREAKROOM	休憩室
321	OFFICE (WORK ROOM)	事務室（作業室）
322	STORAGE	倉庫
323	CONFERENCE / TRAINING ROOM	会議／トレーニング室
324	CLASSROOM (1)	教室（1）
325	CLASSROOM (2)	教室（2）
326	CLASSROOM (3)	教室（3）
327	CLASSROOM (4)	教室（4）
328	CLASSROOM (5)	教室（5）
329	CLASSROOM (6)	教室（6）
330	CLASSROOM (7)	教室（7）
331	CLASSROOM (8)	教室（8）
332	BREAKROOM	休憩室
332A	STORAGE	倉庫
333	TOILET (M)	トイレ（男）
334	TOILET (F)	トイレ（女）
335	JANITORS CLOSET	清掃用具室
336	COMPUTER RM (3rd FLR)	コンピューター室（3階）
337	MECH RM(3rd FLR)	機械室（3階）



4TH FLOOR PLAN 4階平面図
SCALE 1 : 200

GRAPHIC SCALE
1: 200 5 0 5 10M

ROOM NAME

RM NO. 部屋番号	ROOM DESCRIPTION	室名称
	4TH FLOOR	4階
	FAMILY SERVICE CENTER	ファミリーサービスセンター
401	EV LOBBY(4TH FLR)	エレベーターホール（４階）
402	CORRIDOR	廊下
402A	COMPUTER RM (4th FLR)	コンプューター室（４階）
403	STAIRS (1)	階段（１）
403A	UTILITY ROOM	ユーティリティー室
404	STAIRS (2)	階段（２）
405	WAITING AREA	待合室
406	OFFICE (DIRECTOR)	事務室（所長）
407	ADMIN WORK AREA	管理作業室
408	OFFICE (TAMP MGR)	事務室（移籍補助官）
409	OFFICE (RAP MGR)	事務室（同上副官）
410	OFFICE (SOCIAL SERVICE REP.)	事務室（福祉事業担当官室）
411	COMPUTER AREA	コンピューター室
412	TOILET(M)	トイレ（男）
413	TOILET(F)	トイレ（女）
414	WAITING AREA (PRIVATE)	待合室
415	CORRIDOR (CLINICAL)	廊下
416	RECEPTION / OFFICE(ADMIN)	受付／事務室（管理）
417	OFFICE(DATA MANAGEMENT)	事務室（資料管理）
418	CHILDREN'S PLAYROOM	プレイルーム
418A	BREAK/ROOM	休憩室
419	OFFICE (CLINICAL/FAP DIV.HEAD)	事務室（診療部長）
420	OFFICE (CB/LSW)	事務室（ＣＢ／ＬＳＷ）
421	OFFICE (CB/SW)	事務室（ＣＢ／ＳＷ）
422	OFFICE (CB/SSS)	事務室（ＣＢ／ＳＳＳ）
423	OFFICE (CB/I & T)	事務室（ＣＢ／Ｉ　＆　Ｔ）
424	OFFICE (CB/SSS)	事務室（ＣＢ／ＳＳＳ）
425	OFFICE (FAP/SAB LSW)	事務室 (FAP/SAB LSW)
426	OFFICE (FAP/SAB SIW)	事務室 (FAP/SAB SIW)
427	OFFICE (FAP/SAB SSA)	事務室 (FAP/SAB SSA)
428	OFFICE (FAP/SAB SSA)	事務室 (FAP/SAB SSA)
429	OFFICE (FAP/SAB SSA)	事務室 (FAP/SAB SSA)
430	OFFICE (FAP/SAB SSA)	事務室 (FAP/SAB SSA)
431	OFFICE (FAP/SAB SSA)	事務室 (FAP/SAB SSA)
432	OFFICE (FAP/CAB LSW)	事務室 (FAP/CAB LSW)
433	OFFICE (FAP/CAB SSA)	事務室 (FAP/CAB SSA)
434	OFFICE (FAP/CAB SSA)	事務室 (FAP/CAB SSA)
435	OFFICE (FAP/CAB NPS NURSE)	事務室 (FAP/CAB NPS NURSE)
436	OFFICE (FAP/CAB SSA)	事務室 (FAP/CAB SSA)
437	RECEPTION / WAITING AREA	受付／待合室
438	OFFICE (ADMIN)	事務室（管理）
439	OFFICE(DATA MANAGEMENT)	事務室（資料管理）
440	OFFICE (I & R DIV/SSA)	事務室 (I & R DIV/SSA)
441	STORAGE	倉庫
442	CLASSROOM (AOB / ICR)	教室（ＡＯＢ／ＩＣＲ）
443	CLASSROOM(1)	教室（１）
444	CLASSROOM(2)	教室（２）
445	TOILET (M)	トイレ（男）
446	TOILET (F)	トイレ（女）
447	JANITORS CLOSET	清掃用具室
448	BREAK/ROOM	休憩室
448A	STORAGE	倉庫
449	COMPUTER RM (4th FLR)	コンプューター室（４階）
450	MECH RM(4th FLR)	機械室（４階）

CRITERIA PACKAGE (CP)
FOR
COMMUNITY SUPPORT FACILITY
コミュニティー支援施設
U.S. FLEET ACTIVITIES, YOKOSUKA, JAPAN
横須賀海軍施設，日本
(PROJECT NO. NA893)

DWG NO. A—4

4TH FLOOR PLAN & ROOM NAMES
４階平面図 及び 部屋名称

SHEET 14 OF 32

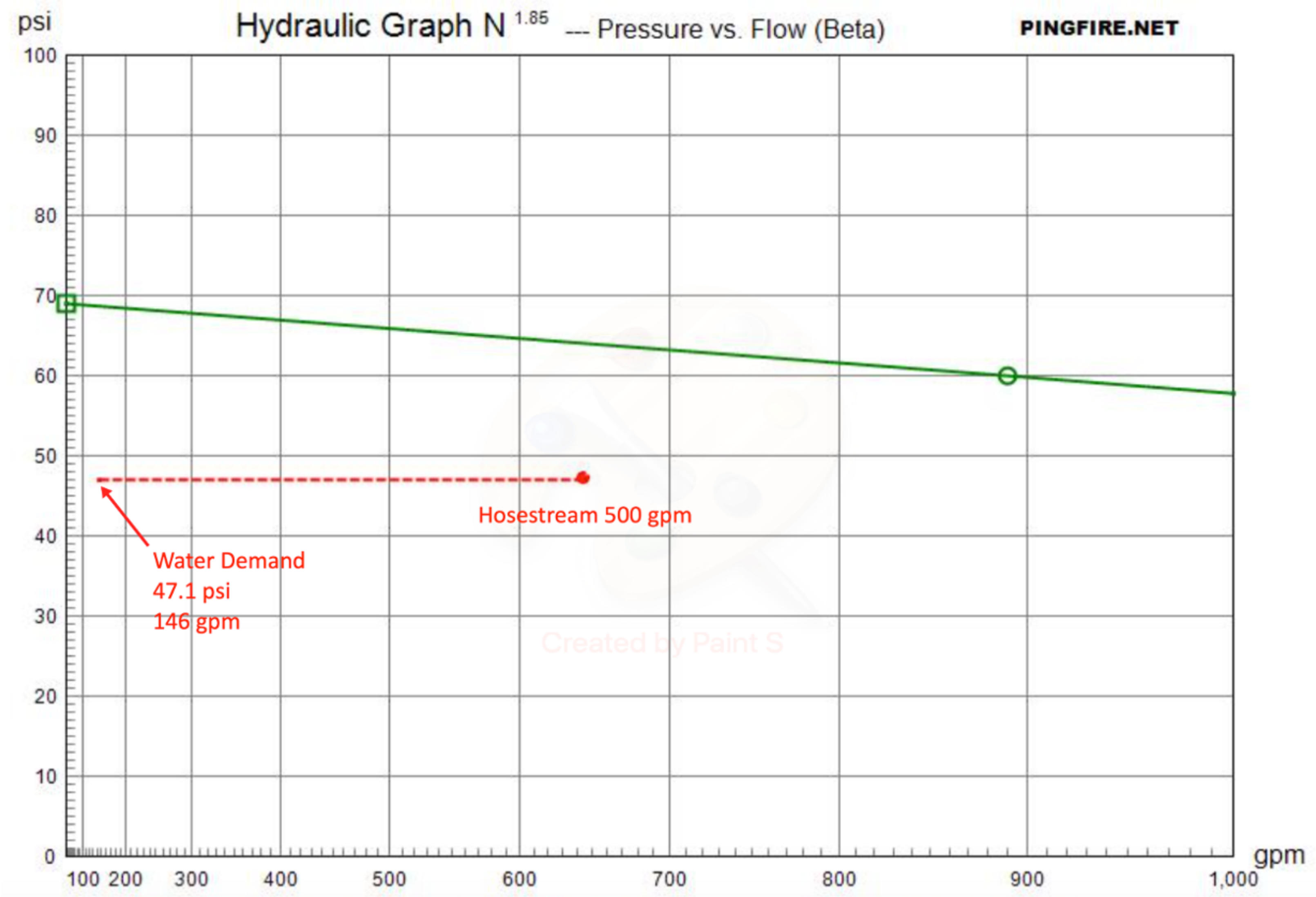
APPENDIX B: Hydraulic Calculations for Room 118B (Main Library)

Project name: NA893 Community Support Facility - Room 118 **B** Date: 20-Mar-18

Step No.	Nozzle Ident and Location	Flow in gpm		Pipe size	Pipe Fittings and Devices	Equivalent Pipe Length		Friction loss (psi/ft)		Pressure Summary		Normal Pressure		Notes	
	1	q				L	12	C=	120	Pt	18.4	Pt		k=	Q = D*A = 120 x 0.20
	BL11			1.25		F	0			Pe		Pv			
		Q	24.0	1.38		T	12	pf	0.048	Pf	0.6	Pn		Pt=	Pt = (Q/K)^2
	2	q	24.4			L	12	C=	120	Pt	18.9	Pt		k=	q = k * (Pt)^1/2
	BL11			1.5		F	0			Pe		Pv			q = 5.6*(5.2)^.5
		Q	48.4	1.61		T	12	pf	0.083	Pf	1.0	Pn			
	3	q	25.0			L	12	C=	120	Pt	19.9	Pt		k=	q = k * (Pt)^1/2
	BL11			1.5		F	0			Pe		Pv			q = 5.6*(7.5)^.5
		Q	73.4	1.61		T	12	pf	0.179	Pf	2.1	Pn			
	4	q	26.3			L	12	C=	120	Pt	22.1	Pt		k=	q = k * (Pt)^1/2
	BL11			2		F	0			Pe		Pv			q = 5.6*(7.5)^.5
		Q	99.7	2.067		T	12	pf	0.093	Pf	1.1	Pn			
		q			2T-20	L	1	C=	120	Pt	23.2	Pt		k=	Pe = 1 * 0.4333
	DN			2		F	20			Pe	0.4	Pv			
	RN	Q	73.4	2.067		T	21	pf	0.053	Pf	1.1	Pn			
	CM	q	73.4			L	10	C=	120	Pt	24.8	Pt		k=	K = 73.4/(23.6)^0.5
	to			2.5		F				Pe		Pv			14.74911542
	BL10	Q	146.8	2.469		T	10	pf	0.080	Pf	0.8	Pn			
	BL9	q				L	104	C=	120	Pt	25.6	Pt			
	to			2.5		F	0			Pe		Pv			
	CM2	Q	146.8	2.469		T	104	pf	0.080	Pf	8.4	Pn			
	DN	q			2T-24	L	6	C=	120	Pt	33.9	Pt			Pe = 6 x 0.43333
	RN			2.5		F	24			Pe	2.6	Pv			2.598
		Q	146.8	2.469		T	30	pf	0.080	Pf	2.4	Pn			
	DN	q				L	107	C=	120	Pt	33.9	Pt			
	to			3		F				Pe		Pv			
	CM2	Q	146.8	3.068		T	107	pf	0.028	Pf	3.0	Pn			
	CM2	q			2T-30	L	51	C=	120	Pt	38.9	Pt			2.598
	to			3		F	30			Pe		Pv			
	CM3	Q	146.8	3.068		T	81	pf	0.028	Pf	2.3	Pn			
		q			1T-30	L	4	C=	120	Pt	41.2	Pt			Pe = 4 x 0.43333
	BOR			3	AV-16	F	46			Pe	1.7	Pv			1.732
		Q	146.8	3.068		T	50	pf	0.028	Pf	1.4	Pn			

	BOR	q			2T-40	L	4	C=	120	Pt	44.3	Pt			Pe = 4 x 0.43333
	to			4		F	80			Pe	1.7	Pv			1.732
	Main	Q	146.8	4.026		T	94	pf	0.007	Pf	0.7	Pn			
		q			PIS-60	L	230	C=	120	Pt	46.7	Pt			
	POC			4	CCV-6	F	66			Pe		Pv			
		Q	**146.8**	4.026		T	50	pf	0.007	Pf	0.4	Pn			
										Pt	**47.1**				

APPENDIX C: Hydraulic Supply and Demand Curve for NA893 Community Support Facility


psi
Hydraulic Graph N 1.85 --- Pressure vs. Flow (Beta)
PINGFIRE.NET
100
90
80
70
60
50
40
30
20
10
0
100 200 300 400 500 600 700 800 900 1,000
gpm
Hosestream 500 gpm
Water Demand
47.1 psi
146 gpm

APPENDIX D: Calculation of estimate of the response time of ceiling mounted fire detectors (DETACT) for Room 118B, Main Library

DETACT.XLS: Estimate of the response time of ceiling mounted fire detectors

INPUT PARAMETERS			CALC. PARAMETERS	
Ceiling height (H)	3.5	m	R/H	0.924
Radial distance (R)	3.2	m	dT(cj)/dT(pl)	0.316
Ambient temperature (To)	20	C	u(cj)/u(pl)	0.214
Actuation temperature (Td)	33.9	C	Rep. t2 coeff.	k
Response time index (RTI)	2	(m-s)1/2	Slow	0.003
Fire growth power (n)	2	-	Medium	0.012
Fire growth coefficient (k)	0.047	kW/s^n	Fast	0.047
Time step (dt)	1	s	Ultrafast	0.400

Calculation time (s)	HRR	Gas temp	Gas velocity	Det temp	dT/dt
0	0.0	20.0	0.00	20.00	0.0000
1	0.0	20.1	0.05	20.00	0.0097
2	0.2	20.2	0.08	20.01	0.0295
3	0.4	20.4	0.11	20.04	0.0543
4	0.8	20.5	0.13	20.09	0.0813
5	1.2	20.7	0.15	20.17	0.1085
6	1.7	20.9	0.17	20.28	0.1346
7	2.3	21.2	0.19	20.42	0.1590
8	3.0	21.4	0.20	20.58	0.1812
9	3.8	21.6	0.22	20.76	0.2010
10	4.7	21.9	0.24	20.96	0.2185
11	5.7	22.1	0.25	21.18	0.2340
12	6.8	22.4	0.27	21.41	0.2475
13	7.9	22.6	0.28	21.66	0.2593
14	9.2	22.9	0.30	21.92	0.2698
15	10.6	23.2	0.31	22.19	0.2791
16	12.0	23.5	0.32	22.47	0.2874
17	13.6	23.8	0.34	22.75	0.2948
18	15.2	24.1	0.35	23.05	0.3016
19	17.0	24.4	0.36	23.35	0.3079
20	18.8	24.7	0.37	23.66	0.3138
21	20.7	25.0	0.39	23.97	0.3193
22	22.7	25.3	0.40	24.29	0.3245
23	24.9	25.6	0.41	24.62	0.3294
24	27.1	26.0	0.42	24.95	0.3342
25	29.4	26.3	0.43	25.28	0.3388
26	31.8	26.6	0.45	25.62	0.3432
27	34.3	27.0	0.46	25.96	0.3475
28	36.8	27.3	0.47	26.31	0.3517
29	39.5	27.7	0.48	26.66	0.3557
30	42.3	28.0	0.49	27.02	0.3597
31	45.2	28.4	0.50	27.38	0.3636
32	48.1	28.8	0.51	27.74	0.3674
33	51.2	29.1	0.52	28.11	0.3711
34	54.3	29.5	0.53	28.48	0.3747

35	57.6	29.9	0.54	28.85	0.3783
36	60.9	30.3	0.55	29.23	0.3818
37	64.3	30.6	0.56	29.61	0.3853
38	67.9	31.0	0.57	30.00	0.3887
39	71.5	31.4	0.58	30.39	0.3920
40	75.2	31.8	0.59	30.78	0.3953
41	79.0	32.2	0.60	31.17	0.3985
42	82.9	32.6	0.61	31.57	0.4016
43	86.9	33.0	0.62	31.97	0.4048
44	91.0	33.4	0.63	32.38	0.4078
45	95.2	33.8	0.64	32.79	0.4109
46	99.5	34.2	0.65	33.20	0.4138
47	103.8	34.6	0.66	33.61	0.4168
48	108.3	35.1	0.67	34.03	0.4197
49	112.8	35.5	0.68	34.45	0.4225
50	117.5	35.9	0.69	34.87	0.4254
51	122.2	36.3	0.70	35.30	0.4282
52	127.1	36.7	0.71	35.72	0.4309
53	132.0	37.2	0.72	36.16	0.4336
54	137.1	37.6	0.73	36.59	0.4363
55	142.2	38.0	0.73	37.03	0.4390
56	147.4	38.5	0.74	37.46	0.4416
57	152.7	38.9	0.75	37.91	0.4442
58	158.1	39.4	0.76	38.35	0.4467
59	163.6	39.8	0.77	38.80	0.4492
60	169.2	40.3	0.78	39.25	0.4517
61	174.9	40.7	0.79	39.70	0.4542
62	180.7	41.2	0.80	40.15	0.4567
63	186.5	41.6	0.80	40.61	0.4591
64	192.5	42.1	0.81	41.07	0.4615
65	198.6	42.6	0.82	41.53	0.4639
66	204.7	43.0	0.83	41.99	0.4662
67	211.0	43.5	0.84	42.46	0.4685
68	217.3	44.0	0.85	42.93	0.4708
69	223.8	44.4	0.85	43.40	0.4731
70	230.3	44.9	0.86	43.87	0.4754
71	236.9	45.4	0.87	44.35	0.4776
72	243.6	45.8	0.88	44.82	0.4798
73	250.5	46.3	0.89	45.30	0.4820
74	257.4	46.8	0.90	45.79	0.4842
75	264.4	47.3	0.90	46.27	0.4863
76	271.5	47.8	0.91	46.76	0.4885
77	278.7	48.3	0.92	47.25	0.4906
78	285.9	48.8	0.93	47.74	0.4927

79	293.3	49.3	0.94	48.23	0.4948
80	300.8	49.7	0.94	48.72	0.4968
81	308.4	50.2	0.95	49.22	0.4989
82	316.0	50.7	0.96	49.72	0.5009
83	323.8	51.2	0.97	50.22	0.5029
84	331.6	51.7	0.97	50.72	0.5049
85	339.6	52.3	0.98	51.23	0.5069
86	347.6	52.8	0.99	51.74	0.5089
87	355.7	53.3	1.00	52.24	0.5108
88	364.0	53.8	1.00	52.75	0.5128
89	372.3	54.3	1.01	53.27	0.5147
90	380.7	54.8	1.02	53.78	0.5166
91	389.2	55.3	1.03	54.30	0.5185
92	397.8	55.8	1.04	54.82	0.5204
93	406.5	56.4	1.04	55.34	0.5223
94	415.3	56.9	1.05	55.86	0.5241
95	424.2	57.4	1.06	56.38	0.5259
96	433.2	57.9	1.06	56.91	0.5278
97	442.2	58.5	1.07	57.44	0.5296
98	451.4	59.0	1.08	57.97	0.5314
99	460.6	59.5	1.09	58.50	0.5332

APPENDIX E: Backup Calculations for Heat Transfer to Structural Members in Main Library, Room 118B, NA893 Community Support Facility

NA893 Community Support Facility, Main Library, Room 118B

								at x = 0	at x = 8.0
Constants								TFM	TFM
			Time (hrs)	Time (min)	Time (sec)	x (m)	Lt*	Temp (K)	Temp (K)
k	0.8	W/mk	0	0	0	0	0	2.93E+02	2.93E+02
rho	2100	kg/m3	0.00277778	0.16666667	10	0.01	0.00041667	1.49E+03	3.05E+02
cp	880	J/kgK	0.00555556	0.33333333	20	0.02	0.00083333	1.49E+03	3.12E+02
delta x	0.01	meters	0.00833333	0.5	30	0.03	0.00125	1.49E+03	3.18E+02
delta t	10	seconds	0.01111111	0.66666667	40	0.04	0.00166667	1.49E+03	3.24E+02
S.B	5.67E-08	W/m2K4	0.01388889	0.83333333	50	0.05	0.00208333	1.49E+03	3.29E+02
hc	20	W/m2K	0.01666667	1	60	0.06	0.0025	1.49E+03	3.33E+02
e	1		0.01944444	1.16666667	70	0.07	0.00291667	1.49E+03	3.38E+02
Fo	0.04329004	< 0.5	0.02222222	1.33333333	80	0.08	0.00333333	1.49E+03	3.42E+02
			0.025	1.5	90	0.09	0.00375	1.49E+03	3.46E+02
TA	293	K	0.02777778	1.66666667	100	0.1	0.00416667	1.49E+03	3.50E+02
%	0.1		0.03055556	1.83333333	110	0.11	0.00458333	1.49E+03	3.54E+02
Qdot"	900	kW/m2	0.03333333	2	120	0.12	0.005	1.49E+03	3.57E+02
qf	3000	MJ/m2	0.03611111	2.16666667	130	0.13	0.00541667	1.49E+03	3.61E+02
H	3.5	m	0.03888889	2.33333333	140	0.14	0.00583333	1.49E+03	3.64E+02
L	24	m	0.04166667	2.5	150	0.15	0.00625	1.49E+03	3.68E+02
W	22.7	m	0.04444444	2.66666667	160	0.16	0.00666667	1.49E+03	3.71E+02
			0.04722222	2.83333333	170	0.17	0.00708333	1.49E+03	3.74E+02
Lf		m	0.05	3	180	0.18	0.0075	1.49E+03	3.77E+02
tb		sec	0.05277778	3.16666667	190	0.19	0.00791667	1.49E+03	3.80E+02
s	0.001	m/s	0.05555556	3.33333333	200	0.2	0.00833333	1.49E+03	3.84E+02
			0.05833333	3.5	210	0.21	0.00875	1.49E+03	3.87E+02
L beam	27.89	feet	0.06111111	3.66666667	220	0.22	0.00916667	1.49E+03	3.90E+02
Dead Load	4.4624	klf	0.06388889	3.83333333	230	0.23	0.00958333	1.49E+03	3.92E+02
Live Load	2.2312	klf	0.06666667	4	240	0.24	0.01	1.49E+03	3.95E+02
b	24	in	0.06944444	4.16666667	250	0.25	0.01041667	1.49E+03	3.98E+02
d	31	in	0.07222222	4.33333333	260	0.26	0.01083333	1.49E+03	4.01E+02

Fb	3.6	ksi	0.075	4.5	270	0.27	0.01125	1.49E+03	4.04E+02
			0.07777778	4.66666667	280	0.28	0.01166667	1.49E+03	4.07E+02
Wt	6.47048	klf	0.08055556	4.83333333	290	0.29	0.01208333	1.49E+03	4.09E+02
Mv	629.134557	k-ft	0.08333333	5	300	0.3	0.0125	1.49E+03	4.12E+02
			0.08611111	5.16666667	310	0.31	0.01291667	1.49E+03	4.15E+02
			0.08888889	5.33333333	320	0.32	0.01333333	1.49E+03	4.17E+02
			0.09166667	5.5	330	0.33	0.01375	1.49E+03	4.20E+02
			0.09444444	5.66666667	340	0.34	0.01416667	1.49E+03	4.23E+02
			0.09722222	5.83333333	350	0.35	0.01458333	1.49E+03	4.25E+02
			0.1	6	360	0.36	0.015	1.49E+03	4.28E+02
			0.10277778	6.16666667	370	0.37	0.01541667	1.49E+03	4.30E+02
			0.10555556	6.33333333	380	0.38	0.01583333	1.49E+03	4.33E+02
			0.10833333	6.5	390	0.39	0.01625	1.49E+03	4.35E+02
			0.11111111	6.66666667	400	0.4	0.01666667	1.49E+03	4.38E+02
			0.11388889	6.83333333	410	0.41	0.01708333	1.49E+03	4.40E+02
			0.11666667	7	420	0.42	0.0175	1.49E+03	4.43E+02
			0.11944444	7.16666667	430	0.43	0.01791667	1.49E+03	4.45E+02
			0.12222222	7.33333333	440	0.44	0.01833333	1.49E+03	4.47E+02
			0.125	7.5	450	0.45	0.01875	1.49E+03	4.50E+02
			0.12777778	7.66666667	460	0.46	0.01916667	1.49E+03	4.52E+02
			0.13055556	7.83333333	470	0.47	0.01958333	1.49E+03	4.55E+02
			0.13333333	8	480	0.48	0.02	1.49E+03	4.57E+02
			0.13611111	8.16666667	490	0.49	0.02041667	1.49E+03	4.59E+02
			0.13888889	8.33333333	500	0.5	0.02083333	1.49E+03	4.62E+02
			0.14166667	8.5	510	0.51	0.02125	1.49E+03	4.64E+02
			0.14444444	8.66666667	520	0.52	0.02166667	1.49E+03	4.66E+02
			0.14722222	8.83333333	530	0.53	0.02208333	1.49E+03	4.68E+02
			0.15	9	540	0.54	0.0225	1.49E+03	4.71E+02
			0.15277778	9.16666667	550	0.55	0.02291667	1.49E+03	4.73E+02
			0.15555556	9.33333333	560	0.56	0.02333333	1.49E+03	4.75E+02
			0.15833333	9.5	570	0.57	0.02375	1.49E+03	4.77E+02

0.16111111	9.66666667	580	0.58	0.02416667	1.49E+03	4.80E+02
0.16388889	9.83333333	590	0.59	0.02458333	1.49E+03	4.82E+02
0.16666667	10	600	0.6	0.025	1.49E+03	4.84E+02
0.16944444	10.1666667	610	0.61	0.02541667	1.49E+03	4.86E+02
0.17222222	10.3333333	620	0.62	0.02583333	1.49E+03	4.88E+02
0.175	10.5	630	0.63	0.02625	1.49E+03	4.91E+02
0.17777778	10.6666667	640	0.64	0.02666667	1.49E+03	4.93E+02
0.18055556	10.8333333	650	0.65	0.02708333	1.49E+03	4.95E+02
0.18333333	11	660	0.66	0.0275	1.49E+03	4.97E+02
0.18611111	11.1666667	670	0.67	0.02791667	1.49E+03	4.99E+02
0.18888889	11.3333333	680	0.68	0.02833333	1.49E+03	5.01E+02
0.19166667	11.5	690	0.69	0.02875	1.49E+03	5.03E+02
0.19444444	11.6666667	700	0.7	0.02916667	1.49E+03	5.06E+02
0.19722222	11.8333333	710	0.71	0.02958333	1.49E+03	5.08E+02
0.2	12	720	0.72	0.03	1.49E+03	5.10E+02
0.20277778	12.1666667	730	0.73	0.03041667	1.49E+03	5.12E+02
0.20555556	12.3333333	740	0.74	0.03083333	1.49E+03	5.14E+02
0.20833333	12.5	750	0.75	0.03125	1.49E+03	5.16E+02
0.21111111	12.6666667	760	0.76	0.03166667	1.49E+03	5.18E+02
0.21388889	12.8333333	770	0.77	0.03208333	1.49E+03	5.20E+02
0.21666667	13	780	0.78	0.0325	1.49E+03	5.22E+02
0.21944444	13.1666667	790	0.79	0.03291667	1.49E+03	5.24E+02
0.22222222	13.3333333	800	0.8	0.03333333	1.49E+03	5.26E+02
0.225	13.5	810	0.81	0.03375	1.49E+03	5.28E+02
0.22777778	13.6666667	820	0.82	0.03416667	1.49E+03	5.30E+02
0.23055556	13.8333333	830	0.83	0.03458333	1.49E+03	5.32E+02
0.23333333	14	840	0.84	0.035	1.49E+03	5.34E+02
0.23611111	14.1666667	850	0.85	0.03541667	1.49E+03	5.36E+02
0.23888889	14.3333333	860	0.86	0.03583333	1.49E+03	5.38E+02
0.24166667	14.5	870	0.87	0.03625	1.49E+03	5.40E+02
0.24444444	14.6666667	880	0.88	0.03666667	1.49E+03	5.42E+02

0.24722222	14.8333333	890	0.89	0.03708333	1.49E+03	5.44E+02
0.25	15	900	0.9	0.0375	1.49E+03	5.46E+02
0.25277778	15.1666667	910	0.91	0.03791667	1.49E+03	5.48E+02
0.25555556	15.3333333	920	0.92	0.03833333	1.49E+03	5.50E+02
0.25833333	15.5	930	0.93	0.03875	1.49E+03	5.52E+02
0.26111111	15.6666667	940	0.94	0.03916667	1.49E+03	5.54E+02
0.26388889	15.8333333	950	0.95	0.03958333	1.49E+03	5.56E+02
0.26666667	16	960	0.96	0.04	1.49E+03	5.58E+02
0.26944444	16.1666667	970	0.97	0.04041667	1.49E+03	5.60E+02
0.27222222	16.3333333	980	0.98	0.04083333	1.49E+03	5.62E+02
0.275	16.5	990	0.99	0.04125	1.49E+03	5.64E+02
0.27777778	16.6666667	1000	1	0.04166667	1.49E+03	5.66E+02
0.28055556	16.8333333	1010	1.01	0.04208333	1.49E+03	5.68E+02
0.28333333	17	1020	1.02	0.0425	1.49E+03	5.70E+02
0.28611111	17.1666667	1030	1.03	0.04291667	1.49E+03	5.71E+02
0.28888889	17.3333333	1040	1.04	0.04333333	1.49E+03	5.73E+02
0.29166667	17.5	1050	1.05	0.04375	1.49E+03	5.75E+02
0.29444444	17.6666667	1060	1.06	0.04416667	1.49E+03	5.77E+02
0.29722222	17.8333333	1070	1.07	0.04458333	1.49E+03	5.79E+02
0.3	18	1080	1.08	0.045	1.49E+03	5.81E+02
0.30277778	18.1666667	1090	1.09	0.04541667	1.49E+03	5.83E+02
0.30555556	18.3333333	1100	1.1	0.04583333	1.49E+03	5.85E+02
0.30833333	18.5	1110	1.11	0.04625	1.49E+03	5.87E+02
0.31111111	18.6666667	1120	1.12	0.04666667	1.49E+03	5.89E+02
0.31388889	18.8333333	1130	1.13	0.04708333	1.49E+03	5.90E+02
0.31666667	19	1140	1.14	0.0475	1.49E+03	5.92E+02
0.31944444	19.1666667	1150	1.15	0.04791667	1.49E+03	5.94E+02
0.32222222	19.3333333	1160	1.16	0.04833333	1.49E+03	5.96E+02
0.325	19.5	1170	1.17	0.04875	1.49E+03	5.98E+02
0.32777778	19.6666667	1180	1.18	0.04916667	1.49E+03	6.00E+02
0.33055556	19.8333333	1190	1.19	0.04958333	1.49E+03	6.02E+02

0.33333333	20	1200	1.2	0.05	1.49E+03	6.03E+02
0.33611111	20.1666667	1210	1.21	0.05041667	1.49E+03	6.05E+02
0.33888889	20.3333333	1220	1.22	0.05083333	1.49E+03	6.07E+02
0.34166667	20.5	1230	1.23	0.05125	1.49E+03	6.09E+02
0.34444444	20.6666667	1240	1.24	0.05166667	1.49E+03	6.11E+02
0.34722222	20.8333333	1250	1.25	0.05208333	1.49E+03	6.13E+02
0.35	21	1260	1.26	0.0525	1.49E+03	6.14E+02
0.35277778	21.1666667	1270	1.27	0.05291667	1.49E+03	6.16E+02
0.35555556	21.3333333	1280	1.28	0.05333333	1.49E+03	6.18E+02
0.35833333	21.5	1290	1.29	0.05375	1.49E+03	6.20E+02
0.36111111	21.6666667	1300	1.3	0.05416667	1.49E+03	6.22E+02
0.36388889	21.8333333	1310	1.31	0.05458333	1.49E+03	6.23E+02
0.36666667	22	1320	1.32	0.055	1.49E+03	6.25E+02
0.36944444	22.1666667	1330	1.33	0.05541667	1.49E+03	6.27E+02
0.37222222	22.3333333	1340	1.34	0.05583333	1.49E+03	6.29E+02
0.375	22.5	1350	1.35	0.05625	1.49E+03	6.31E+02
0.37777778	22.6666667	1360	1.36	0.05666667	1.49E+03	6.33E+02
0.38055556	22.8333333	1370	1.37	0.05708333	1.49E+03	6.34E+02
0.38333333	23	1380	1.38	0.0575	1.49E+03	6.36E+02
0.38611111	23.1666667	1390	1.39	0.05791667	1.49E+03	6.38E+02
0.38888889	23.3333333	1400	1.4	0.05833333	1.49E+03	6.40E+02
0.39166667	23.5	1410	1.41	0.05875	1.49E+03	6.41E+02
0.39444444	23.6666667	1420	1.42	0.05916667	1.49E+03	6.43E+02
0.39722222	23.8333333	1430	1.43	0.05958333	1.49E+03	6.45E+02
0.4	24	1440	1.44	0.06	1.49E+03	6.47E+02
0.40277778	24.1666667	1450	1.45	0.06041667	1.49E+03	6.49E+02
0.40555556	24.3333333	1460	1.46	0.06083333	1.49E+03	6.50E+02
0.40833333	24.5	1470	1.47	0.06125	1.49E+03	6.52E+02
0.41111111	24.6666667	1480	1.48	0.06166667	1.49E+03	6.54E+02
0.41388889	24.8333333	1490	1.49	0.06208333	1.49E+03	6.56E+02
0.41666667	25	1500	1.5	0.0625	1.49E+03	6.57E+02

0.41944444	25.1666667	1510	1.51	0.06291667	1.49E+03	6.59E+02
0.42222222	25.3333333	1520	1.52	0.06333333	1.49E+03	6.61E+02
0.425	25.5	1530	1.53	0.06375	1.49E+03	6.63E+02
0.42777778	25.6666667	1540	1.54	0.06416667	1.49E+03	6.64E+02
0.43055556	25.8333333	1550	1.55	0.06458333	1.49E+03	6.66E+02
0.43333333	26	1560	1.56	0.065	1.49E+03	6.68E+02
0.43611111	26.1666667	1570	1.57	0.06541667	1.49E+03	6.70E+02
0.43888889	26.3333333	1580	1.58	0.06583333	1.49E+03	6.72E+02
0.44166667	26.5	1590	1.59	0.06625	1.49E+03	6.73E+02
0.44444444	26.6666667	1600	1.6	0.06666667	1.49E+03	6.75E+02
0.44722222	26.8333333	1610	1.61	0.06708333	1.49E+03	6.77E+02
0.45	27	1620	1.62	0.0675	1.49E+03	6.78E+02
0.45277778	27.1666667	1630	1.63	0.06791667	1.49E+03	6.80E+02
0.45555556	27.3333333	1640	1.64	0.06833333	1.49E+03	6.82E+02
0.45833333	27.5	1650	1.65	0.06875	1.49E+03	6.84E+02
0.46111111	27.6666667	1660	1.66	0.06916667	1.49E+03	6.85E+02
0.46388889	27.8333333	1670	1.67	0.06958333	1.49E+03	6.87E+02
0.46666667	28	1680	1.68	0.07	1.49E+03	6.89E+02
0.46944444	28.1666667	1690	1.69	0.07041667	1.49E+03	6.91E+02
0.47222222	28.3333333	1700	1.7	0.07083333	1.49E+03	6.92E+02
0.475	28.5	1710	1.71	0.07125	1.49E+03	6.94E+02
0.47777778	28.6666667	1720	1.72	0.07166667	1.49E+03	6.96E+02