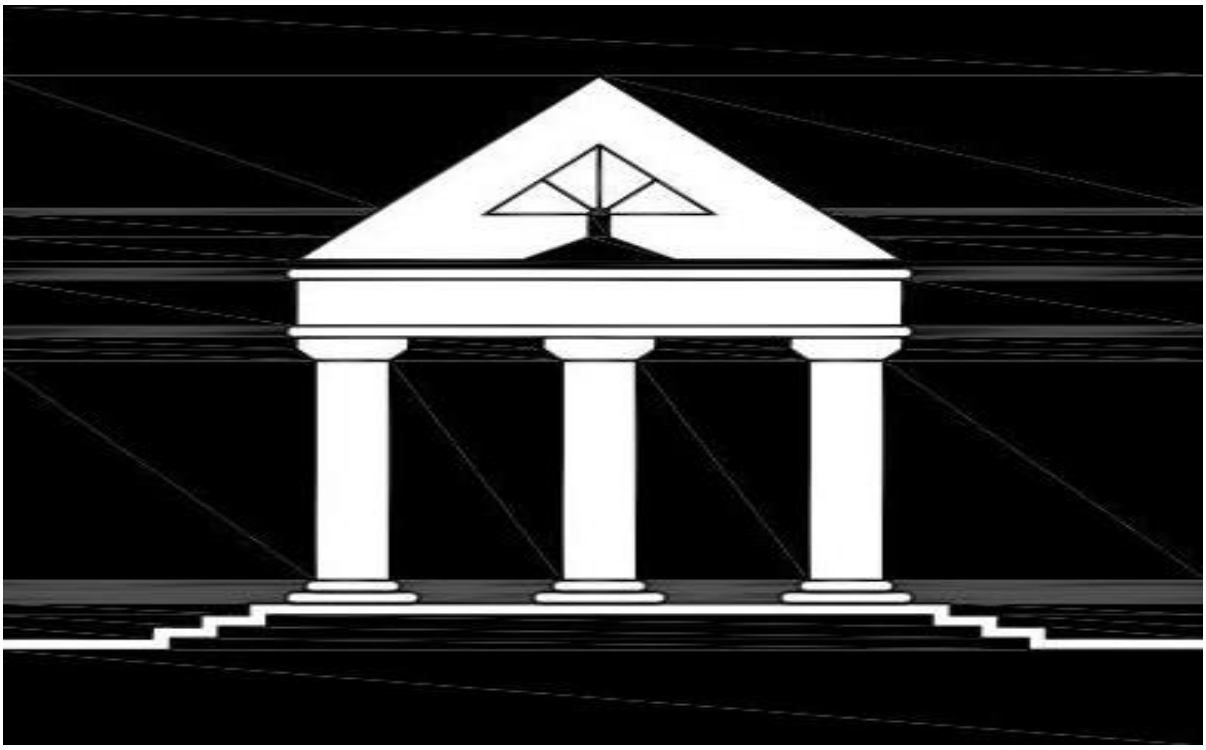
Fire Protection and Life Safety Evaluation



Houston Community College – San Jacinto Building

Houston, Texas

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DISCLAIMER

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KEYWORDS

International building code, Fire Dynamics Simulator, hydraulic flow model, existing, auditorium, egress

ABOUT THE AUTHOR

Will grew up in Dallas, TX and moved to Austin in 2006 to attend the University of Texas. During his time in Austin, he was involved in the Society of Fire Protection Engineers- UT Chapter. He eventually served as the vice president of the organization and in 2009 he turned his involvement in SFPE into an internship with Rolf Jensen & Associates in Houston, TX. In 2010, he graduated with a Bachelors of Science in Mechanical Engineering and moved to Houston to work with RJA full time, where he has worked since, excluding one month spent working in the RJA Macau office in 2012. In 2013, Will received the RJA Managers Award and was elected as the SFPE Houston Chapter President. In 2014 he received the Tom Brown President's Award for technical excellence given out by RJA, and was re-elected as SFPE Houston Chapter president.

Will is getting married in July of this year and will be sitting for the PE licensing exam this October

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EXECUTIVE SUMMARY

This report evaluates the life safety features of the HCC San Jacinto Building (SJB) both prescriptively and on a performance basis. The goal is to present the building code requirements for the HCC San Jacinto building and determine if the design is in compliance, as well as analyze the building on the basis of performance criteria to determine if there are any excessive threats to life safety.

The building is designed in compliance with the Houston Building Code, and takes advantage of lesser requirements for existing features. The performance section determines that based on fire and egress modeling, that while prescriptively the auditorium balcony is permitted to remain unchanged, the number of seats in the balcony should be reduced to comply with the requirements for new construction. Other alternatives are discussed, but this report recommends reducing the number of seats in the balcony.

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PROJECT DESCRIPTION

The San Jacinto Building was originally constructed in 1914 as a junior high school. In 1927, Houston Junior College (now the University of Houston) began using the facility at night, which prompted the first of many expansions to follow. Eventually the Houston Community College system acquired the building in 1988.

As it stands now, the SJB is 3 stories and approximately 155,000 sq. ft. in area with a first floor footprint of approximately 64,000 sq. ft. The building currently lies vacant for the renovations, but upon completion will be used for college classes and extracurricular activities. Notable architectural features include the original gym bleachers, classic green terrazzo flooring, the large auditorium balcony, and three unenclosed communicating stairs.

The project itself is a “gut and remodel” where as much of the existing structure will remain as possible, but the intent is to reprogram the building and change interior, nonbearing partitions. The intended interior layout is shown in Appendix A. The building’s fire alarm and sprinkler systems are aged and have not been maintained well, so as part of the design, the fire alarm and sprinkler systems will be completely replaced.

APPLICABLE CODES AND STANDARDS

The project lies within the city limits of Houston, TX. Therefore, the project is subject to the Houston Building Code (HBC), based on the 2006 International Building Code, including City of Houston Amendments, and the Houston Fire Code (HFC), based on the 2006 International Fire Code, including City of Houston Amendments. The construction/operation of the building is also subject to the Fire Department Life Safety Bureaus (LSBs). The LSBs have been adopted and enforced by the city fire marshal. They have not been voted on by elected officials, and they lie in a legal grey area, but they are still enforced. The LSBs cover the following topics:

1 - Fire Extinguishers

2 - Inspection and Testing of Fire Protection and Life Safety Equipment

3 - Fire Dept Access

4 - Access Gates

5 - Key Boxes/Electric Fence Registration

6 - Fire Depository Boxes

7 - High Rise Fire Safety Plans

8 - Fire Drills

9 - Marking of Fire Hydrants

10 - LP Gas and Open Flame Use

11 - Roofing Operations

12 - Fireworks Displays

13 - Outside Protected Aboveground Tanks for Generators and Fire Pumps

14 - Unattended Service Stations

15 - Mobile Refueling and Wet Hosing

16 - Open Burning and Recreational Fires

17 - Tire Chipping

18 - High-Rise Fire Safety Plan Approval

19 - Raw Wood Waste Processing

22 - Tents and Other Membrane Structures

23 -Mid-Rise Atrium Plan Approval

25 - Safety Inspections for Vehicles on Display Indoors effective

*LSBs 20 and 21 have been specifically rescinded by city council order.

The HBC has also modified the reference documents. The relevant NFPA reference documents are as follows:

2007 edition of NFPA 13: Installation of Sprinkler Systems

2007 edition of NFPA 14: Installation of Standpipe and Hose System

2007 edition of NFPA 72: National Fire Alarm and Signaling Code

Houston has also removed all references to accessibility requirements in the HBC, and defers to the Texas Accessibility Standards (TAS), thereby pushing responsibility for reviewing for accessibility to the Texas Department of Licensing and Regulation.

Texas (Title 28 §34.607) states that where NFPA 101 applies where a local jurisdiction has not adopted a building code. NFPA 101 is not applicable to this project as the city of Houston has adopted a building code.

PRESCRIPTIVE REQUIREMENTS

EXISTING vs NEW

The scope of the HBC reads as follows:

> *The provisions of this code shall apply to the construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, location, maintenance, removal and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures except work located primarily in a public way, public utility towers and poles, mechanical equipment not specifically regulated in this code, and hydraulic flood control structures.*

Wherever changes are made to a building, the HBC applies. Existing features are not required to be brought into compliance except in very specific situations.

To address existing, potentially dangerous features, Houston has added “Appendix L” to the HBC. Appendix L provides some base criteria that all buildings must meet unless they have historical designation, and this appendix covers items such as structural stability, guard rails, shaft enclosure, and sprinklers.

The City of Houston has not adopted an existing building code. They remedy this by heavily amending Ch. 34 of the base International Building Code. The charging language of Ch. 34 reads as follows:

> *When allowed. Additions, alterations or repairs may be made to any building or structure without requiring the existing building or structure to comply with all the requirements of this code, provided the addition, alteration or repair conforms to those required for a new building or structure.*
>
> *Additions or alterations shall not be made to an existing building or structure that will cause the existing building or structure to be in violation of any of the provisions of this code, and such additions or alterations shall not cause the existing building or structure to become unsafe. An unsafe condition shall be deemed to have been created if an addition or alteration will cause the existing building or structure to become structurally unsafe or overloaded, will not provide adequate egress in compliance with the provisions of this code or will obstruct existing exits, will create a fire hazard, will reduce required fire resistance, or will otherwise create conditions dangerous to human life. Any building so altered, which involves a change in use or occupancy, shall not exceed the height, number of stories and area permitted for new buildings. Any building plus new additions shall not exceed the height, number of stories and area specified for new buildings.*

Additions or alterations shall not be made to an existing building or structure when such existing building or structure is not in full compliance with the provisions of this code except when such addition or alteration will result in the existing building or structure being no more hazardous based on life safety, fire safety and sanitation, than before such additions or alterations are undertaken. (See also Section 415.8 for Group H-5 occupancies.)

The section is convoluted and verbose, but the intent is that existing features are permitted to remain (so long as they comply with Appendix L), new construction must meet the requirements for new construction, and new construction must not reduce the level of life safety in the existing building.

As permitted, the HCC San Jac. design takes advantage of some of the requirements for existing construction.

OCCUPANCIES/CONSTRUCTION

OCCUPANCIES PRESENT

Occupancies are the basis for many of the code requirements in the HBC.

SJB contains the typical functions one would expect in the community college. The uses of the space are shown in the left column of Table 1, and the corresponding occupancy groups are shown on the right.

TABLE 1: OCCUPANCIES

Use	Occupancy Group
Theater/Auditorium	Group A-1
Gymnasium	Group A-3
Indoor basketball court	Group A-4
Offices/Classrooms	Group B
Storage/MEP	S-2/F-2(Accessory)

An early concept for the occupancy of one of the spaces is shown below in Figure 1.

FIGURE 1: STUDY LOUNGE CONCEPT

CONSTRUCTION TYPE/AREA LIMITATIONS

HBC Section 503.1 Requires buildings to comply with the limits of Table 503.1 with respect to height, area, and number of stories.

HBC Section 508.3.2 permits multiple occupancies to not be separated from each other, provided that the most restrictive requirements from Section 403 (high rise) and Ch. 9 (fire protection systems) apply throughout the building. It also limits the maximum allowable area to that of the most restrictive of the non-separated occupancies. The floor areas of the building are shown below:

The floor areas for the building are as follows:

Level 1	64,000 sq. ft.
Level 2	44,000 sq. ft.
Level 3	46,500 sq. ft.
Total	154,500 sq. ft.

The maximum floor areas and number of stories for the building as permitted for Type IIA construction in HBC Table 503 are as follows:

A-1	15,500 sq. ft.	3 stories
A-3	15,500 sq. ft.	3 stories
A-4	15,500 sq. ft.	3 stories
B	37,500 sq. ft.	4 stories

Note: these values do not include increases for sprinklering or frontage

Group A-1 is the most restrictive occupancy type; therefore, the construction type must comply with the requirements for Group A-1.

HBC Section 506.3 permits an increase in the permissible floor area by 200% when the building is sprinklered throughout with a supervised, NFPA 13 sprinkler system. This increases the allowable floor area to 46,500 sq. ft. Even including the maximum increase based on having full frontage (75%), the maximum allowable floor area for Type IIA construction is 58,125 sq. ft. The first floor area exceeds this, so for new construction, the building must be Type IB construction.

Groups F, M, and S are not included in these calculations. HBC Section 508.3.1 permits accessory occupancies less than 10% of the floor area to be treated as part of the dominant occupancy with respect to height and area calculations.

However, the building is not new construction. As previously mentioned, as much of the structure is being maintained as possible. Based on the requirements of the HBC, the construction type is not required to be upgraded except when occupancies are changed or area/stories are added to the building – basically when the building is required to apply for a new Certificate of Occupancy or Life Safety Certificate. Since the building has an active Certificate of Life Safety, and the occupancy of the building is not changing, the structure is permitted to remain as Type IIB construction. Repairs to the structure do not require an upgrade in construction type.

CONSTRUCTION REQUIREMENTS

HBC Table 601 establishes the structural rating requirements for construction. The requirements for Type IIB construction (non-rated, noncombustible) are as follows:

Structural Frame	0-hr
Floor construction	0-hr
Roof construction	0-hr
Exterior bearing walls	0-hr
Interior bearing walls	0-hr

Building structural elements are not required to be provided with a fire protection rating in Type IIB construction.

Exterior walls have rating requirements also based on the fire separation distance from the building to an interior lot line. The exterior rating requirements (note: table is modified by Houston amendments) for a Type IIB, Group A-1 building from HBC Table 602 are as follows:

Less than 5 ft. to property line	1-hour
5 ft. or greater to property line	0-hour

At least 20 ft. of frontage is provided around the building, as is shown in Figure 2 below. Also, as the building's exterior/structure is to remain, the exterior walls are not required to be brought up, even if new construction required them to be upgraded.

FIGURE 2: "SATELLITE" VIEW OF SAN JACINTO BUILDING

Stairs used as exits and shafts are required to be rated 1-hours. This 1-hour rating is to be determined in accordance with ASTM E 119. The central stair is permitted to remain open because it is an existing condition, but also because it is a convenience stair (not used in the means of egress) and only connects three stories. Doors in 1-hour fire barriers (like hazardous rooms) are required to be rated for 45 minutes, but openings in shafts/stair ratings are required to be rated for 60 minutes.

CONCLUSION

The HBC permits SJB to remain as Type IIB construction, and the only fire barriers provided in this building are around shafts, stairs, and hazardous rooms. There are very few fire rated elements provided in the building design.

INTERIOR FINISHES

The interior finishes are mostly being replaced, and new finishes must meet the requirements for new construction. The wall and ceiling interior finish requirements for sprinklered occupancies are shown below in Table 2:

TABLE 2:INTERIOR FINISH REQUIREMENTS

Group	Exits	Corridors	Rooms
Group A	B	B	C
Group B/M	B	C	C
Group F/S	C	C	C

"B" and "C" correspond to interior finish testing criteria. A finish is considered Class B if it has a flame spread of 26-75, and Class C if the flame spread is 76-200. Both must have a smoke developed rating of less than 450. These ratings are determined in accordance with ASTM E 84 testing criteria.

Most of the interior finishes are lay-in panel ceiling and paint on the walls, so complying with these requirements is not difficult.

MEANS OF EGRESS

OCCUPANT LOAD, CAPACITIES, AND ARRANGEMENT

Occupant loads can be determined based on the function of the room. Table 3 below shows relevant occupant load factors taken from HBC Table 1004.1

TABLE 3: OCCUPANCY LOAD FACTORS

FUNCTION OF SPACE	FLOOR AREA IN SQ. FT. PER OCCUPANT
Accessory storage areas, mechanical equipment room	300 gross
Assembly with fixed seats	1 seat per occupant
Assembly without fixed seats	
Concentrated (chairs only-not fixed)	7 net
Standing space	5 net
Unconcentrated (tables and chairs)	15 net
Business areas	100 gross
Educational	

Classroom area	20 net
Shops and other vocational room areas	50 net
Exercise rooms	50 gross
Library	
Reading rooms	50 net
Stack area	100 gross
Locker rooms	50 gross
Mercantile	30 gross
Stages and platforms	15 net

By using the factors in Table 3, multiplied by the area of the room, this gives an estimated occupant load. Adequate egress is required to be provided based on the occupant load of the area. Note that this is based on the “function” of the space, not the occupancy.

HBC Table 1005.1 requires 0.2 in per occupant to be provided for egress components other than stairs, and 0.3in per occupant to be provided for stairs.

Based on the information above, Table 4 shows the occupant loads of each floor with associated egress capacity and exits. Specific exit locations and capacities are shown in the building layout in Appendix B.

TABLE 4: OCCUPANT LOAD, CAPACITY, AND NUMBER OF EXITS

	Floor Occupant Load	Egress Capacity	Number of exits
First floor	1997	3053	15
Second floor	1096	1040	6
Third floor	616	1040	6

Note that the second floor is over capacity. The balcony is located on the third floor, but is provided with exit access stairs which lead to required exits on the second floor, so the balcony is included in the 2nd floor numbers. The balcony contains 502 fixed seats and is provided with two 40 in. stairs with 36 in. doors. These exit access stairs limit the permitted occupant load on the balcony to 266 occupants. 236 seats would have to be

removed from the balcony if it were required to comply with the requirements for new construction. However, the seats are existing, so they are permitted to remain.

Arrangement and Features of the Means of Egress

The HBC defines the means of egress as follows:

> *A continuous and unobstructed path of vertical and horizontal egress travel from any occupied portion of a building or structure to a public way. A means of egress consists of three separate and distinct parts: the exit access, the exit and the exit discharge.*

Exit access is the portion of the means of egress which starts from any point in an area, and ends at an exit. Specific means of egress components (stair enclosures, horizontal exits, exit passageways) are specifically designated as exits, which affect many of the means of egress requirements. The exit discharge is the portion of egress once an occupant leaves an exit until the occupant reaches the public way.

Exit access is mostly regulated by two concepts: travel distance and redundancy. It sets the following limits on exit access based on occupancies as shown in Table 5:

TABLE 5: EXIT ACCESS TRAVEL DISTANCE

OCCUPANCY	WITH SPRINKLER SYSTEM (feet)
A, M, S-1	250
B	300
F-2, S-2, U	400

This is the maximum distance permitted from any point in an occupancy to an exit. As this building is predominantly a Group B occupancy, most places must be within 300 ft. of travel distance. Originally, the building contained three open stairs, but in order to meet travel distance limits, two stairs were designed to be enclosed in rated construction to be considered exit stairs.

The exit access must be designed to meet other requirements as well. The common path of travel must be limited to 75 ft. (100 ft. in sprinklered Group B/F/S). This is the maximum distance an occupant is permitted to travel before having a choice between two remote paths. Remote is defined as being 1/3 the diagonal of the space in a sprinklered facility.

Exit access must be arranged so that there are no dead end corridors which exceed 20 ft. (50 ft. for Group B/F occupancies). By definition corridors must lead to two exits, so where a corridor ends not at an exit, this distance must be limited so that an occupant does not waste time going in the wrong direction.

Exit access and exits are required to be marked by exit signs. Any place which requires two means of exit access, or where the arrangement might be confusing is required to have an exit sign. Corridors are required to have all points be within 100 ft. travel distance from an exit sign. This is an important distinction. The signs do not have to be visible down the entire length of the corridor, and if spaced perfectly, exit signs are permitted to have 200 ft. in-between installations.

SJB does not contain horizontal exits or exit passageways. It contains exit stairs and exit doors. The stairs are positioned strategically at the ends of the wings of the facility, with two located closer to the center as well. Below in Figure 3, the main central stair is shown. Note that this stair is not enclosed, and is therefore not considered an exit stair.

FIGURE 3: COMMUNICATING STAIR

All stairs in the means of egress (not just exit stairs) are required to have risers of between 7 in. and 4 in. high and treads no less than 11 in. All exit stairs are required to be at least 44 in. wide as they serve occupant loads of 50 or greater. If they served less than 50 occupants, then they would be permitted to be as narrow as 36” wide.

All of the exit stairs discharge directly to the exterior to paved surfaces which lead through parking lots/walkways to publicly deeded streets. Both interior and exterior means of egress must be lit under all conditions. During regular conditions, the means of egress must be lit to provide an average of 1 ft. candle across the path, with no spot

less than .1 ft.-candle. If normal power is interrupted, emergency power must be provided for a duration of not less than 90 minutes, where the light levels are permitted to be reduced to 0.6 and 0.06 ft.-candles respectively.

Auditorium Requirements

Auditoriums, specifically those with stages, have special requirements in Ch. 4 of the HBC. The stage is less than 50 ft. high, so a rated proscenium/fire curtain is not required. Set materials and scenery on the stage are required to comply with NFPA 701, but this is not very enforceable, unless the local AHJ is very involved. Where stages are greater than 1,000 sq. ft. in area, which this stage is, ventilation is required. Ventilation must be provided in the form of smoke control, or two smoke vents that comprise 5% of the stage area. No additional requirements, such as the activation time or mechanism, are stated for the vents. These vents are not required in the auditorium, as the auditorium and stage are an existing condition. If the stage/auditorium construction were new, these vents would be required. However, they would be ineffective as shown later in the report.

As the stage is greater than 1,000 sq. ft. in area, a 1½-inch hose connection must be installed in accordance with NFPA 13 or in accordance with NFPA 14 for Class II or III standpipes. This requirement is specifically addressed in the suppression section of this report. As the combined sprinkler/standpipe system is new, these hose connections are included in the building design.

Ch. 10 has additional requirements for egress spaces, such as for main entrances and aisle arrangements based on whether or not smoke-protected seating is provided, but as the seating arrangement is existing, the auditorium is not required to comply with these provisions.

Conclusion

The arrangement of the means of egress of the SJB complies with the HBC. The capacity of egress does not necessarily comply with the requirements for new construction, but the balcony is an existing condition that will be analyzed later in this report.

SPRINKLER/STANDPIPE SYSTEM

HBC Section 903.2.1.1 requires an automatic sprinkler system to be installed in Group A-1 occupancies with an occupant load of 300 or more. As this building is designed as mixed-use, non-separated, this requirement applies throughout the building and sprinklers must be installed in all accessible areas.

HBC Section 905.3.1 requires standpipes where an occupiable floor is more than 30 ft. above grade plane. Class I Standpipes must be provided in every required exit stair and

Class II standpipes must be provided for the stage as it exceeds 1,000 sq. ft. This section will document the requirements for the design of the combined sprinkler/standpipe system.

Building Water Supply Information

The first step in designing the sprinkler/standpipe system is to determine if the system has adequate pressure and flow. A flow test is the typical way to determine what water supplies a system can pull from a city line.

Attached in Appendix C is the flow test data from a nearby building, which is likely similar to the flow test for this building. The supply data is shown in blue in Figure 4 and is as follows:

Outlet diameter:	2.5 in.
Static Pressure:	64 psi
Residual Pressure:	58 psi.
Flow:	1,126 gpm

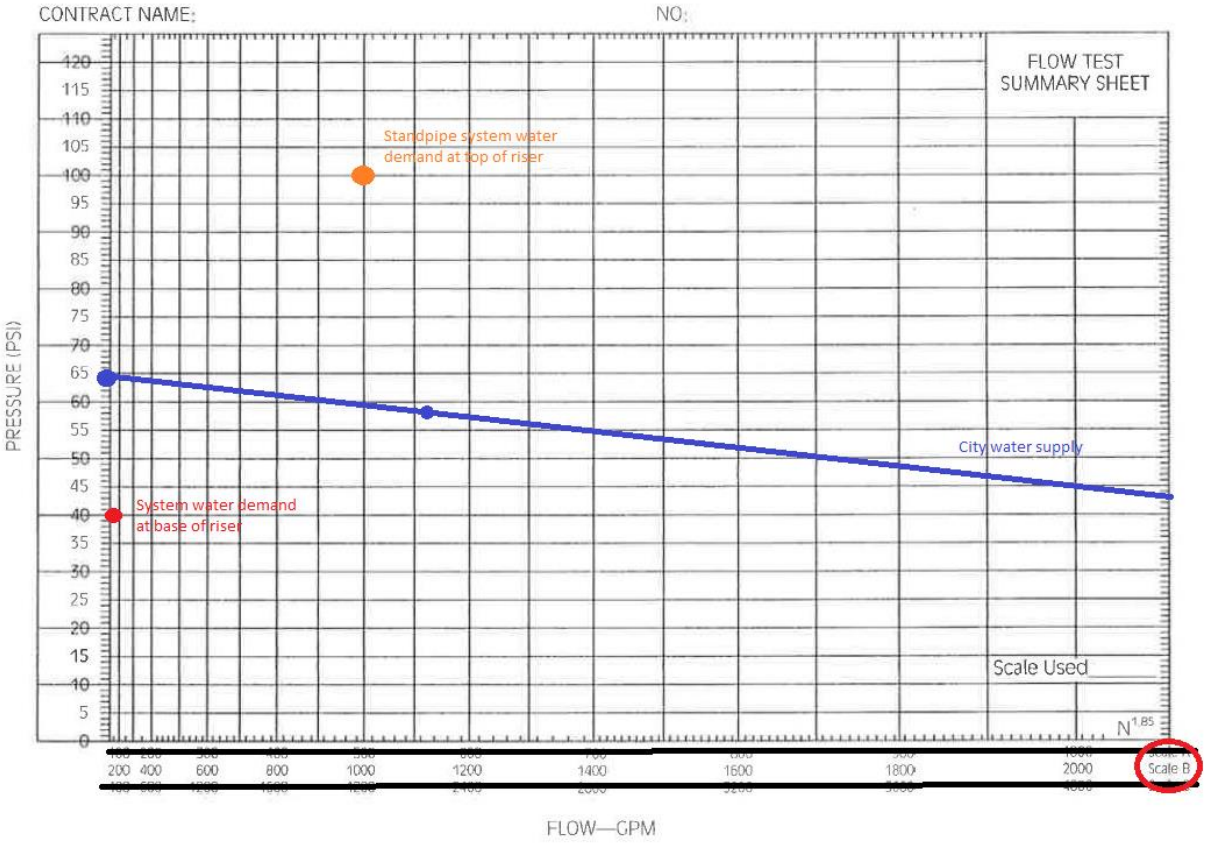


FIGURE 4: WATER SUPPL DATA

HBC Section 908.1 does not permit fire pumps to pull directly on city lines. When using a fire pump, a break tank must be installed. As the tank is usually installed at ground level, the system loses lose any potential pressure it might gain from the city supply if a pump is required. This ensures that whenever the city line does not provide adequate pressure/flow (such as when a standpipe system is installed) a break tank must be installed and the system requires an even larger pump.

Hazard Classifications

As a school, high hazard locations are not expected in this building. The building is comprised of light and ordinary hazard 1 compartments. The drawing showing hazard classifications is located in Appendix D. Classrooms, the auditorium, the gym, and similar rooms are classified as light hazard occupancies (pink). Storage, electrical, and mechanical rooms are designated ordinary hazard 1 occupancies (blue) as expected quantities of storage will remain below 8 ft. high and be primarily Class I and II commodities stored on shelves. The sprinkler system design criteria for these areas are as follows:

Light Hazard:

Design area – 900 sq. ft. (1500 base with 40% reduction from quick response sprinklers)

Density - .10 gpm/sq. ft.

Maximum coverage per sprinkler – 225 sq. ft.

Ordinary Hazard 1:

Design Area – 900 sq. ft. (1500 base with 40% reduction from quick response sprinklers)

Density - .15 gpm/sq. ft.

Maximum coverage per sprinkler – 130 sq. ft.

The standpipe demand criteria are as follows:

100 psi at the hose connections (NFPA 14 7.8.1) with a total flow of 1000 gpm (NFPA 14 Section 7.10.1.1.4 for 4 or more standpipes). Each standpipe must be capable of providing 250 gpm at the hose connection.

NFPA 14 Section 7.10.1.3.1.2 does not require a separate sprinkler demand so whichever is more demanding (the sprinkler system plus 250gpm from the hose or the standpipe system) is required.

Typically, the standpipe system is more demanding, but the next section will document this.

System Design

In Appendix E is a schematic layout of the sprinkler system. Branch lines, mains, and cross mains are shown in green; and standpipe risers and valves are shown in red. The design for this building was shelved after the schematic design phase and as such, professional sprinkler shop drawings were never created. In the appendix is a rough, schematic outline of a potential “tree” sprinkler system for the building. As this was created in AutoCAD and not Autosprink or HASS, the pipe measurements are not exact. Exact measurements are included for the specific components related to the calculation of demand in Appendix F. Generally, sprinkler branch lines will be 1 in. and will feed into 2 in. lines which will feed into large 4 in. main systems which are located the main corridors. These 4 in. mains will feed into 4 in. standpipes which are fed from the pump by 4 in. horizontal risers.

The blue line in Appendix E denotes the rough separation between the two sprinkler zones.

Sprinklers used throughout will be ordinary temperature, quick response, pendant/upright sprinklers, with a 5.6 k factor. An example is included in Appendix G.

Sprinkler piping is black steel schedule 40 and exact pipe sizes are shown in calculations table in Appendix F.

As Houston is not located in a seismic zone, pipe bracing is not required.

System Requirements

The sprinkler system is designed to meet the flow and pressure demands of the most hydraulically remote area. The calculations for the most remote design area are shown in Appendix F along with the design area.

As mentioned previously, the design area is a 900 sq. ft. rectangle located in the auditorium. The dimensions are 36 ft. along the branch line and 25 ft. across the branch line. This location was picked because is one of the most remote places from a connecting standpipe and that it is the highest location in the building. The remote design area is in a light hazard occupancy which may not seem like the most demanding area; however the .15gpm/sq. ft. OH1 design criteria is likely to be less demanding than having to push the water up an additional 12 or 24 feet, since the supply data shows there is plenty of flow.

Sprinklers are labeled as SPRINK in Appendix F, and where sprinkler branch lines connect to the main is labeled as RN. So RN1 to RN2 is the portion of the pipe from where one branch connects to where the next branch connects. The main in the corridor is labeled as MAIN, the top of the riser is labeled TOR, and the bottom of the riser is labeled BOR.

The calculated sprinkler system demand is only about 40 psi at 103 gpm. This is not unexpected. The building is not very tall, the most remote area (auditorium) is light hazard, and the sprinkler pipes were overdesigned to reduce pipe losses. The city supply would be able to provide ample pressure and flow for this system, were a standpipe system not required. The standpipe system requirements and sprinkler system requirements are separately shown on Figure 4 above. The sprinkler requirements at the base of the riser do not include the 250 gpm standpipe flow requirement. Houston does not permit a pump to be designed to use more than 100% of its rated flow capacity, therefore a 1000 gpm or 1,250 gpm pump capable of putting out 150 psi is required to meet the system demand.

INSPECTION TESTING AND MAINTENANCE

The following table is a list of the inspection, testing, and maintenance requirements for the fire suppression system components in the building:

TABLE 6: INSPECTIONS, TESTING, AND MAINTENANCE

Control valves	Controls valves must be inspected weekly where sealed or monthly where locked open or using a tamper switch. Position and operation valves must be tested annually, supervisory valve switches tested semiannually. Maintenance must be performed annually.
Waterflow alarm	Waterflow devices must be inspected quarterly. Mechanical devices must be tested quarterly, vane/pressure switches must be inspected semiannually
Supervisory devices	Supervisory devices(tamper switch) must be inspected quarterly
Fire department connections	Must be inspected quarterly
Main drains	Tested annually unless sole water supply is through a PV or backflow preventer, then tested quarterly
Standpipes and hose connections	See section after table

Pipe and fittings	Inspected annually
Sprinklers	Inspected annually, tested or replaced at 50 years and every ten years after (not fast response)
Gauges	Inspected monthly on wet systems, tested every 5 years
Hydraulic nameplate	Inspected annually
Buildings	Inspected annually, before the first freeze to determine that systems are not subject to freezing temperatures
Hangers/Bracing	Inspected annually
Spare sprinklers	Inspected annually
Information sign	Inspected annually
Pipe obstructions	Inspected every five years
Check valves	Must be tested every 5 years
Hose connections	Inspected annually, tested every 5 years
Hose racks	Inspected annually, tested every 5 years
Fire pumps	Inspected weekly
Backflow prevention assemblies	Inspected monthly when locked or supervised
Circulation relief	Tested annually
Fire pump	See below

Standpipes and hose connections have their own set of testing and maintenance requirements and are as follows:

The hose, hose nozzle, hose storage device, and piping must be inspected annually. The hose storage device must be tested every year, the hose every 5 years, and a hydrostatic and flow tests must be performed every 5 years. Hoses connections must have planned maintenance performed every year and valves must be serviced every year or as needed.

Fire pumps have their own set of testing and maintenance requirements, which are as follows:

Pumps system and housing are to be inspected weekly. Diesel engines are to have the no-flow condition tested weekly, and the flow condition and alarm signals tested annually. Hydraulic, transmission, and motor maintenance is to be on an annual basis.

The building owner is ultimately responsible for maintaining the systems, but likely the actual process will be delegated to a contract firm.

SPRINKLERS IN THE AUDITORIUM

HBC Section 404.3 permits atriums to not be sprinklered, where the height of the atrium is 55 ft. or greater. The building does not contain an atrium; however, this requirement is indicative of the height at which sprinklers become ineffective. This will be addressed in the performance portion of this report.

CONCLUSION:

Overall, the sprinkler system in this building is not very demanding. Were the sprinklers the only part of the system, the city supply would be able to provide ample flow and pressure. As is common in the city of Houston, it is the standpipes that drive the system increase. The city has very little confidence in the water system (based on the number of leaks during last year's drought, this concern may be well founded) and as such does not let fire pumps pull on the mains which means larger pumps are installed in Houston than in say, Austin or Dallas. The system in this building is a simple wet system and as such, the inspection and maintenance requirements are routine.

FIRE EXTINGUISHERS

Houston Fire Department LSB 01 requires fire extinguishers to be provided throughout all Group A and Group B occupancies. Extinguishers with minimum ratings of 2-A, 10-B:C must be provided for every 3,000 sq. ft. of area in Group A occupancies, and every 6,000 sq. ft. in Group B occupancies. The travel distance to any of these extinguishers must not exceed 75 ft.

Fire extinguishers are provided in this building design in compliance with the Houston Fire Code and LSB 01.

FIRE ALARM & MASS NOTIFICATION

Houston Building Code (HBC) Section 907.2.1.1 requires a manual fire alarm system to be installed in Group A occupancies with an occupant load over 300. Group A occupancies with occupant loads over 1000 are required to have an emergency voice/alarm communications system installed. Smoke detectors are not required in the

building (outside of large ductwork) and are not provided in the design. Manual pulls stations and waterflow devices are provided to initiate the alarm system and aubidle and visual notification appliances will be used to notify occupants. Visible notification devices (strobes) are provided in areas subject to the occupation by the hearing impaired (generally public or multi-person spaces).

The fire alarm system in the design is a Simplex® 4100U Fire Alarm Control Panel and will be installed in the electrical room in the East portion of the building as shown in Appendix J. The system initiates alarm based on input from manual pull stations located at required exits and from waterflow switches in the sprinkler system.

Fire Alarm Detection Devices and Locations

As previously mentioned the fire alarm initiating devices are manual pull stations and waterflow devices. Product data for the devices are included in Appendix I. The manual pull stations are SimplexGrinnell and the waterflow devices are manufactured by SystemSensor.

NFPA 72 Section 17.14.8.4 requires manual fire alarm boxes to be installed within 5 ft. of each exit doorway on each floor. Waterflow devices are installed as a part of each floor control valve system in order to monitor which sprinkler zone is flowing water.

The locations of the devices are shown in Appendix J. Pull stations are shown in blue and waterflow alarms are shown in purple.

Potential Fire Scenarios

The initiation of a general alarm will need to be by one of the following methods: occupant interaction or activation of a sprinkler. The time for an occupant to notice a fire is very unpredictable and is completely situational. This analysis is based on the conservative situation of the building or area being empty, and a sprinkler is activated by a non-arson fire.

There are a few non arson fires that could be expected. Trash, storage, minor amounts of combustible liquid spills, chairs and furniture (most notably in the auditorium), and set props. Any of these items could be ignited by a bad electrical connection, errant cigarette butt, or pyrotechnic/electrical stage prop.

A likely fire scenario is a trash can fire, which can be approximated by a t-squared growth fire. Two DETACT models approximating the fire growth and response time are included in Appendix K.

The first model assumes a ceiling height of 9 ft., standard 15 ft. sprinkler spacing, sprinkler activation temperature of 168°F, a starting ambient temperature 68°F, sprinkler RTI of 88.7, and that the fire is at-squared growth fire with a fast growth coefficient. The DETACT model projects a response time of the sprinkler to be approximately 3 minutes,

when the fire reaches an approximate output of 1400kW. Waterflow alarms are required to initiate within 90s of a flow of at least one sprinkler being achieved. A general alarm could be estimated to be reached within 4½ minutes.

The second DETACT model has the same characteristics, except that the ceiling height is 36 ft., as it would be in the auditorium. This time the sprinkler activates at approximately 6 minutes and the fire size is approximately 6600 kW. A general alarm could be estimated to be reached within 7½ minutes.

Even in the worst case scenario, the fire department can be expected to be notified in less than 10 minutes, and with control mode sprinklers, it is probable that damage would be mitigated in areas other than the auditorium. A fire in the auditorium is addressed in the performance section of the report.

Fire Alarm System Requirements

NFPA 72 Section 10.12.1 requires alarm activation of notification appliances to occur within 10 seconds after an initiation device (pull station or waterflow alarm) signal is sent. Section 10.13 stipulates the conditions upon which the fire alarm can be deactivated.

NFPA 72 Section 10.14 requires supervisory notifications to be automatically indicated within 90s of their activation at the fire alarm panel or supervising station and also stipulates the conditions upon which the supervisory notification can be removed.

NFA 72 Section 10.15 requires trouble signals to be indicated within 200s. A trouble signal can be indicated by a primary power failure, ground fault conditions, or any abnormal condition in a system due to a fault. The section also states the requirements for trouble notification.

Fire Alarm Notification Devices and Locations

Visible notification device spacing is every 100 ft. in the corridors. Strobes not located in corridors are spaced based on spacing criteria from NFPA 72, shown below in Figures 5 and 6.

Maximum Room Size		Maximum Lens Height		Minimum Required Light Output (Effective Intensity); One Light (cd)
ft	m	ft	m	
20 × 20	6.1 × 6.1	10	3.0	15
30 × 30	9.1 × 9.1	10	3.0	30
40 × 40	12.2 × 12.2	10	3.0	60
44 × 44	13.4 × 13.4	10	3.0	75
50 × 50	15.2 × 15.2	10	3.0	95
53 × 53	16.2 × 16.2	10	3.0	110
55 × 55	16.8 × 16.8	10	3.0	115
59 × 59	18.0 × 18.0	10	3.0	135
63 × 63	19.2 × 19.2	10	3.0	150
68 × 68	20.7 × 20.7	10	3.0	177
70 × 70	21.3 × 21.3	10	3.0	185
20 × 20	6.1 × 6.1	20	6.1	30
30 × 30	9.1 × 9.1	20	6.1	45
44 × 44	13.4 × 13.4	20	6.1	75
46 × 46	14.0 × 14.0	20	6.1	80
50 × 50	15.2 × 15.2	20	6.1	95
53 × 53	16.2 × 16.2	20	6.1	110
55 × 55	16.8 × 16.8	20	6.1	115
59 × 59	18.0 × 18.0	20	6.1	135
63 × 63	19.2 × 19.2	20	6.1	150
68 × 68	20.7 × 20.7	20	6.1	177
70 × 70	21.3 × 21.3	20	6.1	185
20 × 20	6.1 × 6.1	30	9.1	55
30 × 30	9.1 × 9.1	30	9.1	75
50 × 50	15.2 × 15.2	30	9.1	95
53 × 53	16.2 × 16.2	30	9.1	110
55 × 55	16.8 × 16.8	30	9.1	115
59 × 59	18.0 × 18.0	30	9.1	135
63 × 63	19.2 × 19.2	30	9.1	150
68 × 68	20.7 × 20.7	30	9.1	177
70 × 70	21.3 × 21.3	30	9.1	185

FIGURE 5: WALL STROBE SPACING

Maximum Room Size		Minimum Required Light Output [Effective Intensity (cd)]		
ft	m	One Light per Room	Two Lights per Room (Located on Opposite Walls)	Four Lights per Room (One Light per Wall)
20 × 20	6.10 × 6.10	15	NA	NA
28 × 28	8.53 × 8.53	30	Unknown	NA
30 × 30	9.14 × 9.14	34	15	NA
40 × 40	12.2 × 12.2	60	30	15
45 × 45	13.7 × 13.7	75	Unknown	19
50 × 50	15.2 × 15.2	94	60	30
54 × 54	16.5 × 16.5	110	Unknown	30
55 × 55	16.8 × 16.8	115	Unknown	28
60 × 60	18.3 × 18.3	135	95	30
63 × 63	19.2 × 19.2	150	Unknown	37
68 × 68	20.7 × 20.7	177	Unknown	43
70 × 70	21.3 × 21.3	184	95	60
80 × 80	24.4 × 24.4	240	135	60
90 × 90	27.4 × 27.4	304	185	95
100 × 100	30.5 × 30.5	375	240	95
110 × 110	33.5 × 33.5	455	240	135
120 × 120	36.6 × 36.6	540	305	135
130 × 130	39.6 × 39.6	635	375	185

NA: Not allowable.

FIGURE 6: CEILING STROBE SPACING

Low dB audible notification devices are capable of providing 65 dB (approximately 15 dB above ambient) at approximately 45 ft. away (Based on the equation $L_2 = L_1 - 20\log_{10}\frac{r_2}{r_1}$, where L represents the sound level in dBs and r is the distance from the device). Locations of notification devices are shown in Appendix J. Strobes are shown in red, and horns are shown in green.

Notification devices include 15cd TrueAlert addressable strobes, 30 cd TrueAlert addressable strobes, and low dB TrueAlert addressable horns and product data is included in Appendix L.

15cd strobes are used for corridor notification, every 100 ft. in the corridor, and provided within 15 ft. of each turn in the corridor, 30cd strobes are spaced to provide no more than 30 ft. by 30 ft. of coverage, and horns are used to provide coverage up to 45 ft. away in order to comply with NFPA 72. Strobes are provided in multi-person and public spaces in order to comply with the Texas Accessibility Standards and the strobes are required to be synchronized, where two can be viewed from one spot.

EMERGENCY VOICE/ALARM NOTIFICATION

The HBC requires this building to have an emergency/voice alarm notification system because of the size of the assembly occupancy. The system is capable of overriding the fire alarm with a pre-recorded message or a live message and is remotely monitored/initiated by campus security. The system has separate notification devices capable of providing a message, not just a blaring horn sound, and visible notification devices are equipped with amber, instead of white, lenses. Being that this is on a college campus in Houston, pre-recorded messages would include, but not be limited to: shooter on campus, hurricane warnings, specific zone evacuations for a fire, and flood warnings.

POWER REQUIREMENTS

The power requirements of the system can be determined by adding up the power draws of each device. The first floor, west zone has the most devices so we will assume that it is the most demanding zone. The Table 7 shows the type circuit with the number and types of devices on the circuit, the wire size, the wire resistance and the length of wire, and uses this to calculate the total current, the voltage drop, and the % of voltage drop.

TABLE 7: FIRE ALARM POWER REQUIREMENTS

Circuit Number	Horn .022mA	Strobe (30cd) .128mA	Strobe (15cd) .076mA	Wire size	Wire resistance	Wire Length	Total Current (A)	Voltage Drop (V)	Voltage Drop (%)
S1	32	34	14	12	1.98	1600	5.07	32.1	133

As we can see, having the entire zone on one NAC not only exceeds the power limits of the NAC, but also exceed permissible voltage drop. Multiple NACs are required to be provided in the design.

The secondary power supply is required to be capable of operating the system in a non-alarm condition for at least 24 hours followed by 5 minutes of operating in alarm condition with a 20 percent safety margin. Even on one NAC, which as previously stated is insufficient, the power draw of the system for 5 minutes in alarm would be .507 amp-

hours. The notification devices do not draw power during a non-alarm condition. The power draw in normal condition would be from the fire alarm panel and modules installed in the panel. The alarm system design was not to the point at which specific numbers of modules and remote annunciators were specified. The design will need to account that the entire system will need to be on standby for 24 hours before going into alarm for 5 minutes. The standby power is typically the dominant factor, but it is very likely that the battery backups will be able to provide the needed amp-hours.

Inspection, Testing, and Maintenance Requirements.

NFPA 72 also stipulates the required inspection maintenance and testing of fire alarm devices.

NFPA 72 Table 14.3.1 requires yearly visual inspections for components, and weekly visual inspections for fuses, LEDs, trouble signals, and the power supply. Battery visual inspections are monthly or semiannually based on the type of battery. Notification appliances require visual inspections semiannually. Table 14.3.1 is included in Appendix M for reference.

NFPA 72 Table 14.4.3.2 establishes the testing requirements for fire alarm systems and components. There are too many requirements to list here, however the highlights are as follows:

Annual testing of control equipment, trouble, and supervisory functions.

Monthly generator and annual UPS and secondary power tests

Annual testing of initiating devices

Table 14.4.3.2, which stipulates the inspections, testing, and maintenance requirements, is included in entirety in Appendix N.

Maintenance is required to be performed in compliance with the manufacturer's instructions and the records are required to be kept until the next test and one year after by NFPA 72 Section 14.6.

Conclusion

Overall, the fire alarm system in this building is fairly simple. It only includes the bare minimum pull stations and waterflow alarms to initiate the fire alarm system as required by the Houston Building Code. As this report has shown, the fire alarm design is compliant with the Houston Building Code and the 2013 edition of NFPA 72.

PERFORMANCE

GOALS/OBJECTIVES

The objective of this section is to document characteristics associated with the building and potential fire scenario. The overall goal is to determine if an adequate level of life safety is provided in the building, specifically with regards to the balcony which this report assumes is the worst case scenario in the building.

TENABILITY CRITERIA

Tenability can be determined by a number of factors: toxic gases, heat, and visibility. Typically the first criterion to fail is visibility, so visibility will be used to evaluate the room tenability.

Both the International Code Council and National Fire Protection Association codes base performance requirements on maintaining tenability at or above 6ft. of the highest walking surface. This report will use the same height, and this 6 ft. must be maintained above the balcony walkway. This is a reasonable justification as occupants will egress down to the balcony and are expected to pool on the balcony walkway, not at the top of the seats.

From SFPE Table 3-11.34, the average person without a seeing disability can see an LED exit sign from 14.7 meters away, with a standard deviation of 1.2. Based on the assumption that the human sight is represented by a bell curve, two standard deviations (2.4) higher than the average will encompass approximately 95% of the population. Maintaining tenability for 95% of the population is a reasonable degree of safety, so as long as the visibility is maintained at or above 17.1m (56 ft.), at least above 6ft. above the walkway, the balcony will be deemed as providing an acceptable level of life safety.

EGRESS ANALYSIS

OCCUPANT CHARACTERISTICS

Occupants in this facility are likely to be a cross-section of average American adults. While not the majority, significant portions of the population are likely to be elderly, infirm, disabled, and in less than stellar physical shape. Many occupants are likely to be familiar with the buildings, but this is a community college. Many occupants will only attend the university once or twice a week and will most likely commute to class, attend class, and leave, seldom deviating from their normal paths. Few will have participated in evacuation drills. This will slow evacuation time. It is likely that during testing, occupants will be reluctant to evacuate during an alarm situation, if they leave at all. This coupled with evening classes where people are less active and alert are likely to increase recognition and response times.

The assembly occupancies pose an even greater risk. Due to high unfamiliarity, high population density, and narrow fixed seating or bench rows, egress time is delayed further. Occupants will most likely try to exit via the door they entered and a situation

could arise where crowd crush occurs in the auditorium. While there is the opportunity for crowd crush to occur, it will not be analyzed in this report because the occupant densities in the building are compliant with the HBC requirements.

Calculating Egress Times

The evacuation time can be predicted using the equations from Ch. 3 of the SFPE Handbook and some assumptions. The following equations calculate evacuation time based on hydraulic analysis. The main limitations associated with this method are geometrical and situational. This does not account for out of the ordinary scenarios such as crowd crush nor does it account for confusing egress layouts or long travel times. It focuses on egress points (balcony stairs) being the limiting factor in egress. It does not work well for non-uniform egress arrangements. Like in this building, there are large areas that dump into the same stair enclosure. It is easy enough to figure that the two stairs entering are the limiting factor, but then the egress door is wider. If the doors for each floor are the limiting factor, but the exit discharge doors are more restrictive, based on when and where occupants enter the stair, the egress time could be greatly affected. Also, it assumes an even distribution of people which is not the case in this building where occupants are focused in the gym and auditorium. To fully analyze a building properly, an iterative method must be performed like determining the hydraulic mean of multiple-loop sprinkler systems, finding the hydraulic choke points in the means of egress on floors where the egress routes converge to really determine what the limiting factors are. This is an extremely inefficient way to calculate exit time, so assumptions have to be made.

The following calculations are performed assuming an even population distribution, and that portions of exits (stair doors, exit doors, stairways) will be the limiting factors, not corridors such as those leading from the gymnasium or the auditorium, nor travel times down the stair. Queuing time will be the limiting factor, as is confirmed by the computer egress model shown in the Pathfinder section.

Premovement Time:
SFPE Handbook 3-12 discusses the results from evacuation drills. The results contained significant variations, some of which are obviously situationally biased. For this project we will assume that the building premovement time will be approximately 30s based on likely occupant confusion and attempts to gather up belongings.

General Evacuation Time:

$$First\ floor\ effective\ egress\ widths: (68-12)*6+(56-12)*2+(136-24)*2*2 + (42-12)+(96-12)+(36-12)+(32-12)=918\ in.$$
$$Second\ floor\ effective\ egress\ widths: (36-12)\cdot 4+(56-12)\cdot 2=184\ in.$$
$$Third\ floor\ effective\ egress\ widths: (36-12)\cdot 4+(56-12)\cdot 2=184\ in.$$

Note that 6 inches are taken from the inside of each door for a boundary layer as covered in SFPE Handbook Table 3-13.1. Only door widths are included as all doors to stairs are more restrictive than stairs themselves.

From SFPE Table 3-13.5, doors and corridors are capable of discharging a maximum of 24 persons per minute per foot of effective width.

$$First\ floor\ maximum\ flows: 918in \cdot 24\ persons\ per\ minute\ per\ ft = 1836\ persons\ per\ minute$$

$$Second\ floor\ maximum\ flows: 184 \cdot 24\ persons\ per\ minute\ per\ ft = 368\ persons\ per\ minute$$

$$Third\ floor\ maximum\ flows: 184 \cdot 24\ persons\ per\ minute\ per\ ft = 368\ persons\ per\ minute$$

Using these flow rates and the occupant loads of each floor (1997, 1096, 616) we get an egress time of 1.1 minutes for the first floor, 3.0 minutes for the second floor, and 2.1 minutes for the third floor. Coupled with the premovement time of 30s, we get a total building evacuation time of less than 4 minutes.

This method is useful for gaining an approximate idea of how long it will take occupants to exit a building. This report will address he egress times from a specific dense area in a later section

PATHFINDER MODEL

The Pathfinder model has two modes: SFPE and Steering. Both are based on the SFPE hydraulic flow model, but Steering does not limit the maximum flow limit for doors and it does not account for velocity decreasing as density increases. For these reasons, this report uses SFPE mode to simulate building egress.

Pathfinder screenshots of input files are shown in Appendix O. Pathfinder shows that it takes approximately 315 seconds for all the occupants to egress using SFPE mode, and 190s in steering mode. The file shows that there are certain problem areas, particularly the auditorium balcony, which dramatically increase the egress time. As previously stated, the egress balcony is not provided with sufficient exit access and chokes its occupants down the two corridors., and the last occupants to egress are balcony occupants.

BALCONY ANALYSIS

As previously mentioned, the balcony contains more seats than would be prescriptively permitted in new construction. In order to evaluate the threat to life safety this represents, the egress time from the balcony must be determined.

Using hydraulic hand calculations shown in Appendix P, the calculated egress times for the balcony with 502 seats is 265s. With the prescriptively permitted amount of 266 seats, the egress time is 140s.

Using the Pathfinder model on SFPE mode, the egress times are shown to be 315s and 195s, respectively. Both of these values are close to the hand calculation models and will be used in the next section to evaluate the balcony.

One item not addressed in this analysis is crowd crush. Section 3-13 in the SFPE handbook indicates that crowd crush conditions can exist at densities of 0.09 persons/sq.ft. (11 sq. ft. per occupant). The occupant density in this area exceeds 11 sq. ft. per occupant so crowd crush may be a concern. The density of the balcony could would reduced below 11 sq. ft. per occupant where only 266 chairs are provided.

CONCLUSION

The overall building egress analysis shows that it does not take an unreasonable amount of time to exit the building. Without an analysis of how much time occupants have to egress the building, this information is more or less useless. The balcony egress analysis will be used in the next section to determine the threat to life safety posed to the auditorium balcony occupants.

FIRE MODELING

The second part of the evaluation is determining the RSET. This is a combination of the egress and tenability evaluations. To determine, how long an environment is tenable, we can use an FDS model.

The required safe escape time (RSET) is the amount of time occupants need to egress an area. The available safe escape time (ASET) is the amount of time provided for the occupants to escape. Fire modeling can be used to determine if the ASET exceeds the RSET. The component of ASET and RSET are shown below in Figure 6.

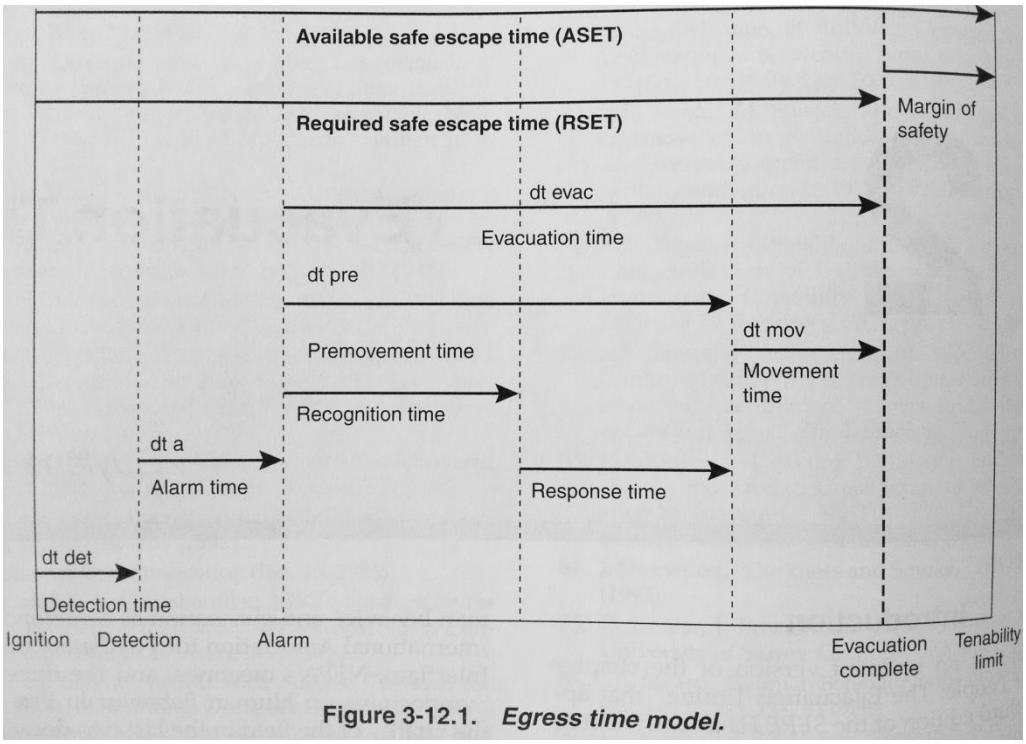


FIGURE 7: ASET-RSET

FDS can be used to simulate the environment and provide more accurate answers, when compared to hand calculations. It uses the Navier-Stokes equation and finite volume techniques to approximate a fluid system and this report uses the Pyrosim program to generate an FDS file.

The evaluation of the fire model includes data from the means of egress performance evaluation, in order to determine how long a tenable environment must be provided. As hydraulic model and Pathfinder (SFPE) model produced similar results, the slightly more conservative Pathfinder results (315s, 195s) will be used.

SCENARIO

The scenario evaluated in this section is based on a fire on the stage scenery, where there is no human involvement with the fire.

FDS MODEL

The FDS file used for the fire model is attached in Appendix Q.

Figure 8 shows the base model in Pyrosim. The walls and general obstructions are shown in light yellow, whereas floor surfaces are shown in grey. The approximate seat locations are shown as brown and the balcony walkway is shown in green. The balcony is an unusual color to standout, because this is where the tenability will be analyzed

A visibility slice file is provided at 9.75m, which is 2m (approximately 6 ft.) above the balcony walking surface. While this is not the highest surface in the auditorium, it is reasonable to assume that as occupants exit, the occupants on the higher rows will make their way down. Rather than provide a walking surface height as a function of time, this model makes the assumption that occupants will make their way down to the balcony floor before tenability at the seating level becomes an issue.

The fire in the scenario is based averages from an Arup report, created at the request of an NFPA Committee. This report documents that the average soot yield is 0.0356 kg/kg for fuel sources on stages, and this value is used as the soot yield for the reaction in the model. The heat release rate was based on a DETACT model shown in Appendix R. Based on having quick response sprinklers, 12 ft. spacing, and a height of 36 ft., the model shows that the sprinklers will activate at approximately 376s and 6600 kW. The fire in the model is set to grow to 6600kW as a t-squared rate until 375s, where it levels off. Sprinklers are not included in the model for two reasons: the fire is assumed to stay at a constant heat rate and be controlled by the sprinklers, and the sprinklers activate after the occupants have left the balcony. Including sprinklers in the model adds nothing to the analysis.

Figure 8 below shows the base FDS model created in Pyrosim.

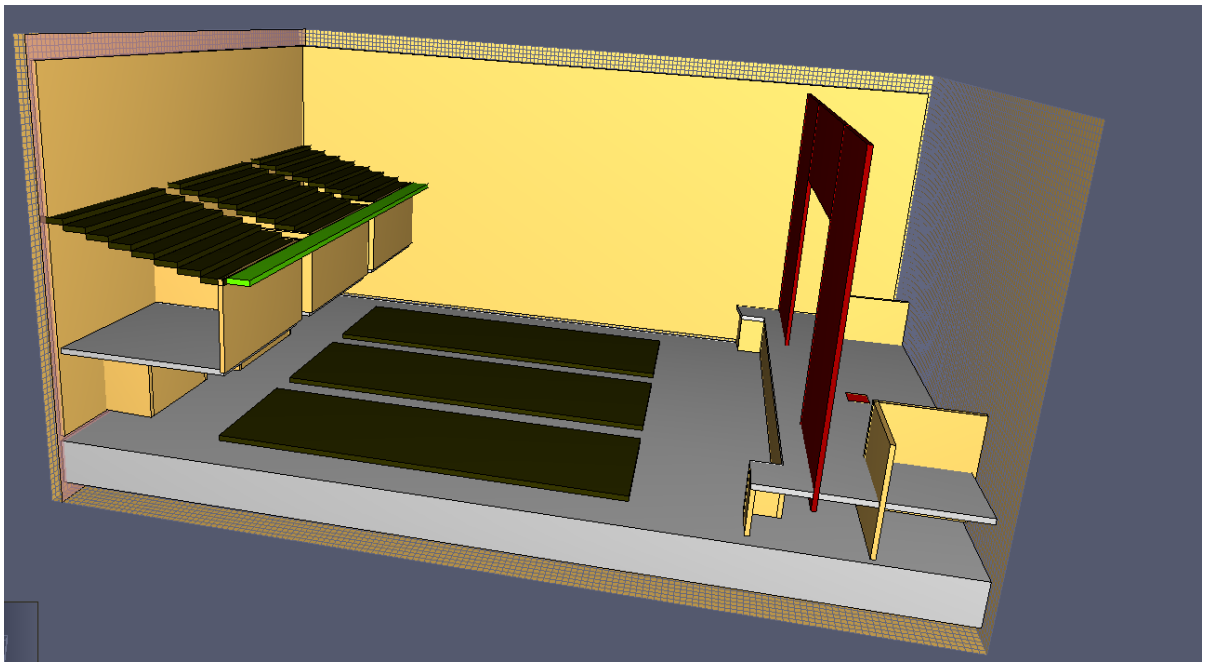


FIGURE 8: PYROSIM MODEL

The mesh for the model is set at 58x70x40, which gives cell sizes of $1m^3$. This may seem like a large number, but based on the characteristic fire diameter using the equation shown in Figure 9. NUREG 1824 states that the effective diameter of a fire can

exceed the cell size by a factor of between 4 and 16 to give accurate results. This equation estimates that the mesh size will output reasonably accurate data with a "coarse" mesh size.

$$D^* = \left(\frac{\dot{Q}}{\rho_\infty c_p T_\infty \sqrt{g}} \right)^{\frac{2}{5}}$$

FIGURE 9: MESH SIZE EQUATION

As the building is provided with smoke detection in certain ductwork, as required by the HBC, the model assumes that HVAC shutdown occurs instantaneously, and does not account for return air vents removing smoke from the space. The main doors to the corridors on the 1st and 2nd floors are shown open. Additional doors around the exterior are not included as the inclusion of additional doors did not significantly affect the results.

The heat release rate for the model is shown below in Figure 10. Based on the DETACT models shown in Appendix R, the sprinklers activate at 375s, which is where the graph in Figure 9 levels off.

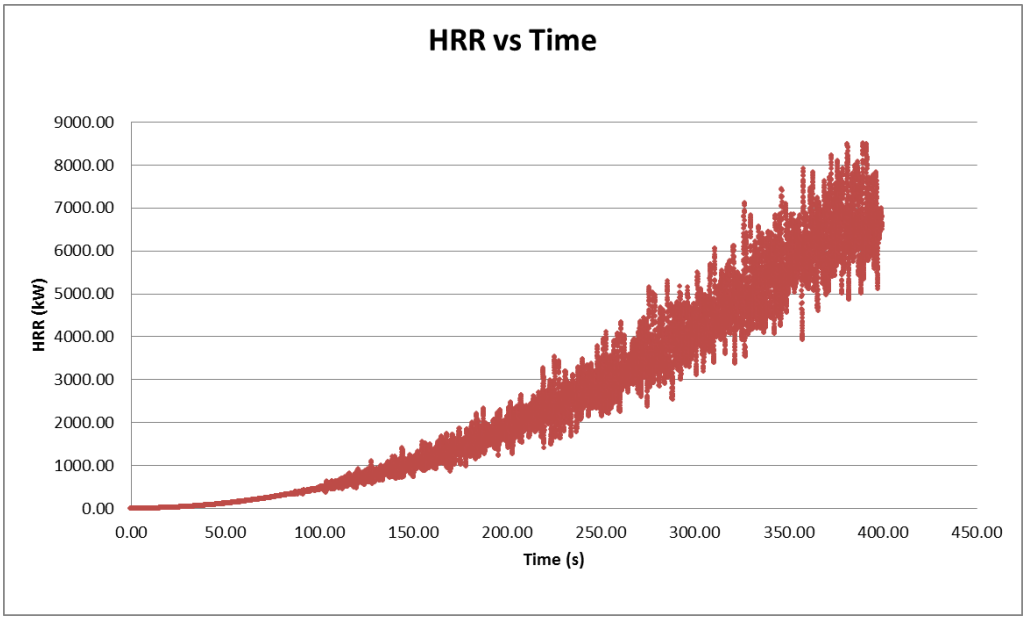


FIGURE 10: FIRE GROWTH AS A FUNCTION OF TIME

Figure 11 shows an example of the space filling with smoke with the HRR from the fire shown.

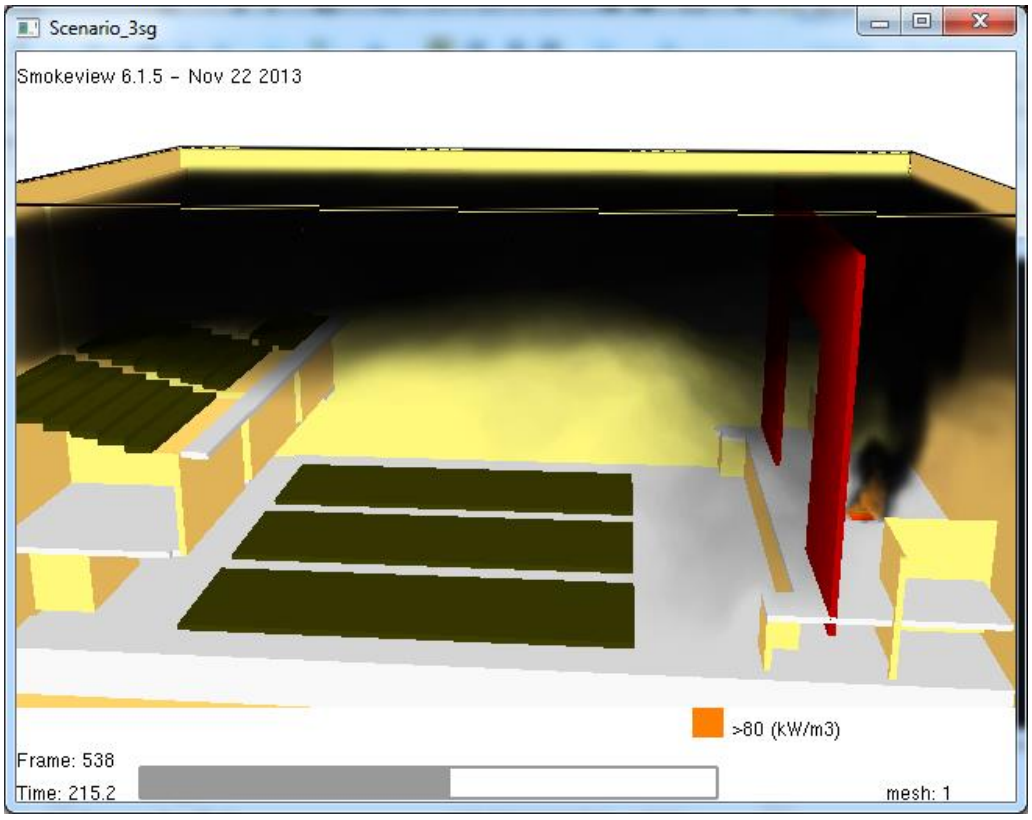


FIGURE 11: FDS MODEL FILLING WITH SMOKE

ANALYSIS

The fire model shows that at a time of 195s, the balcony walkway is still tenable, as are the majority of the seats. This condition is shown in Figure 6 below.

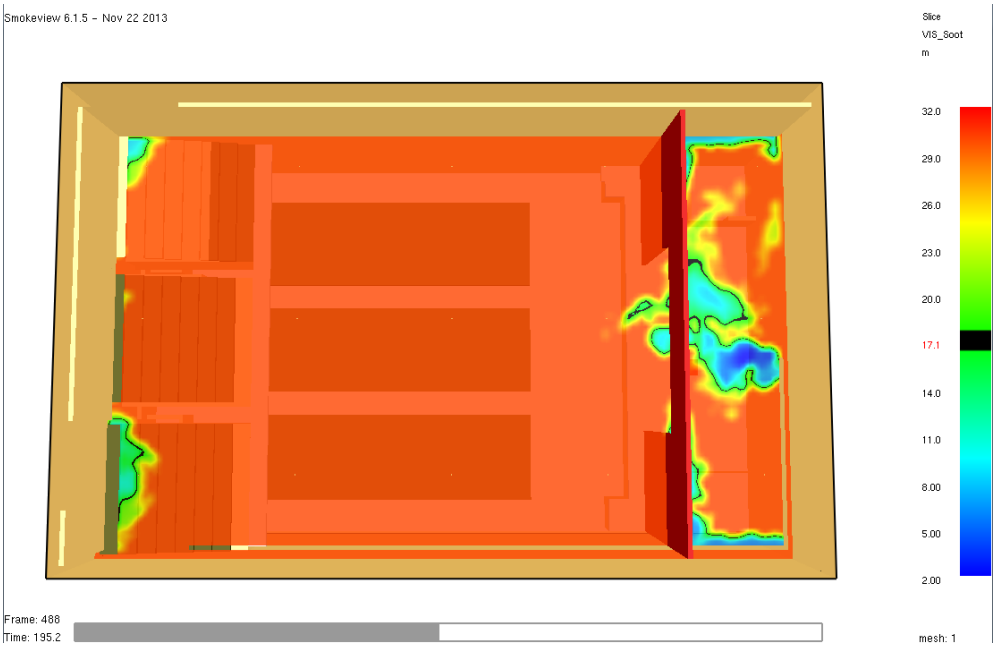


FIGURE 12: TENABILTY AT 195 SECONDS

Portions of the balcony become untenable at approximately 220s, and by 315s, the balcony is completely engulfed by the smoke layer and is no longer tenable. This condition is shown below in Figure 13.

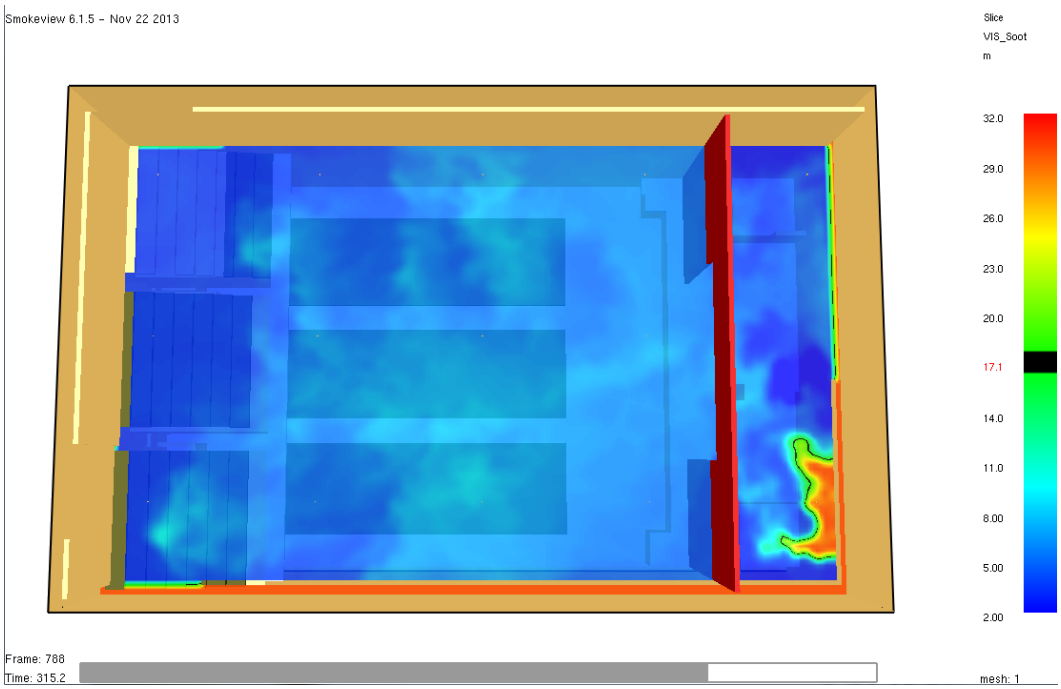


FIGURE 13: TENABILITY AT 315 SECONDS

Figure 14 shows that the balcony becomes untenable at approximately 250s, between the two calculated required egress times.

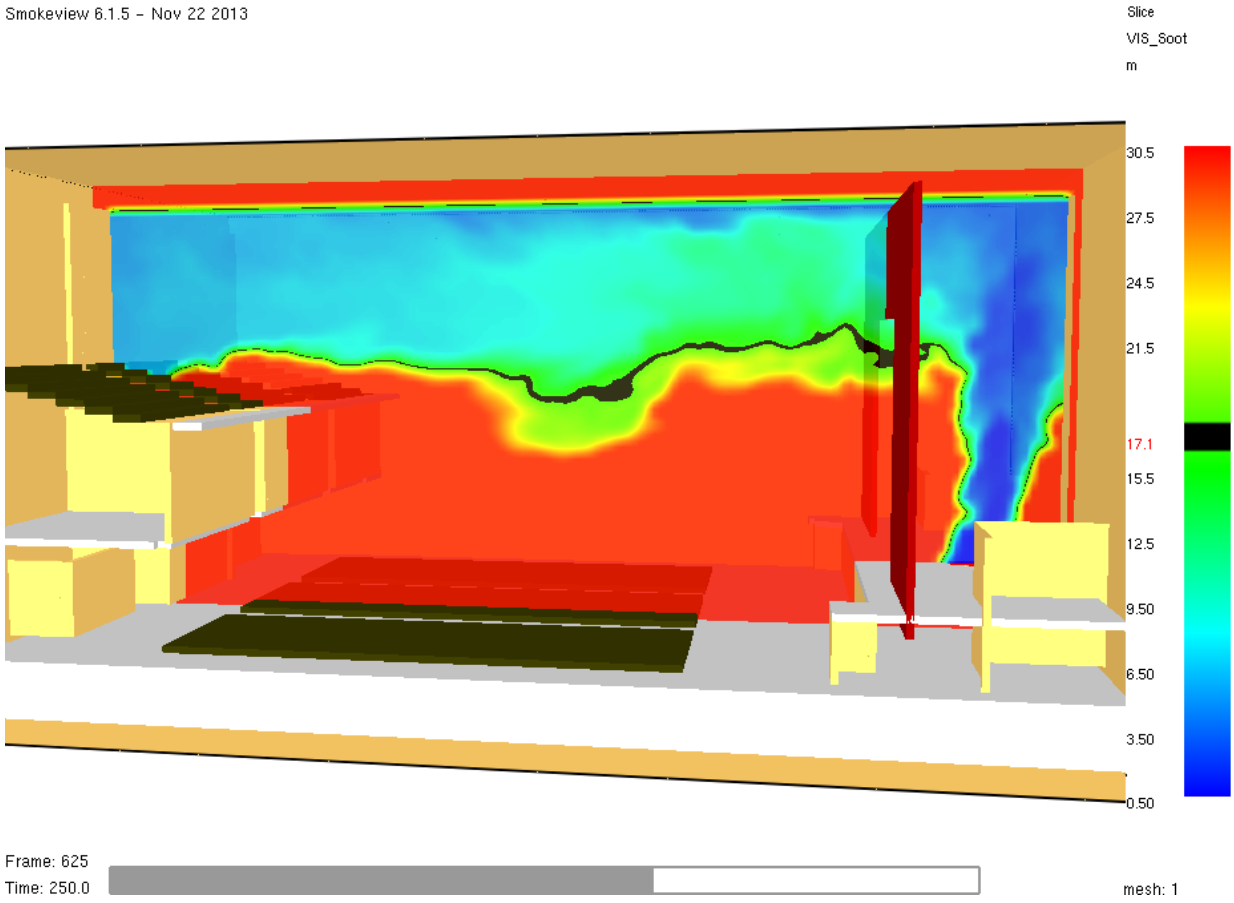


FIGURE 14: TENABILITY BREAING POINT

Heat vents are not required, as this is an existing stage, but even if they were required they would be ineffective. Attached in Appendix S is the DETACT model for the smoke vents. Based on the egress times, DETACT calculations, and FDS model, sprinklers (375s), smoke vents (520s), and fire curtains (520s) would activate well after occupants have egress from the balcony. Sprinklers are required, but smoke vents are not and would represent a reduction in property damage, not an increase in life safety. None of these features are included in the model.

SUMMARY

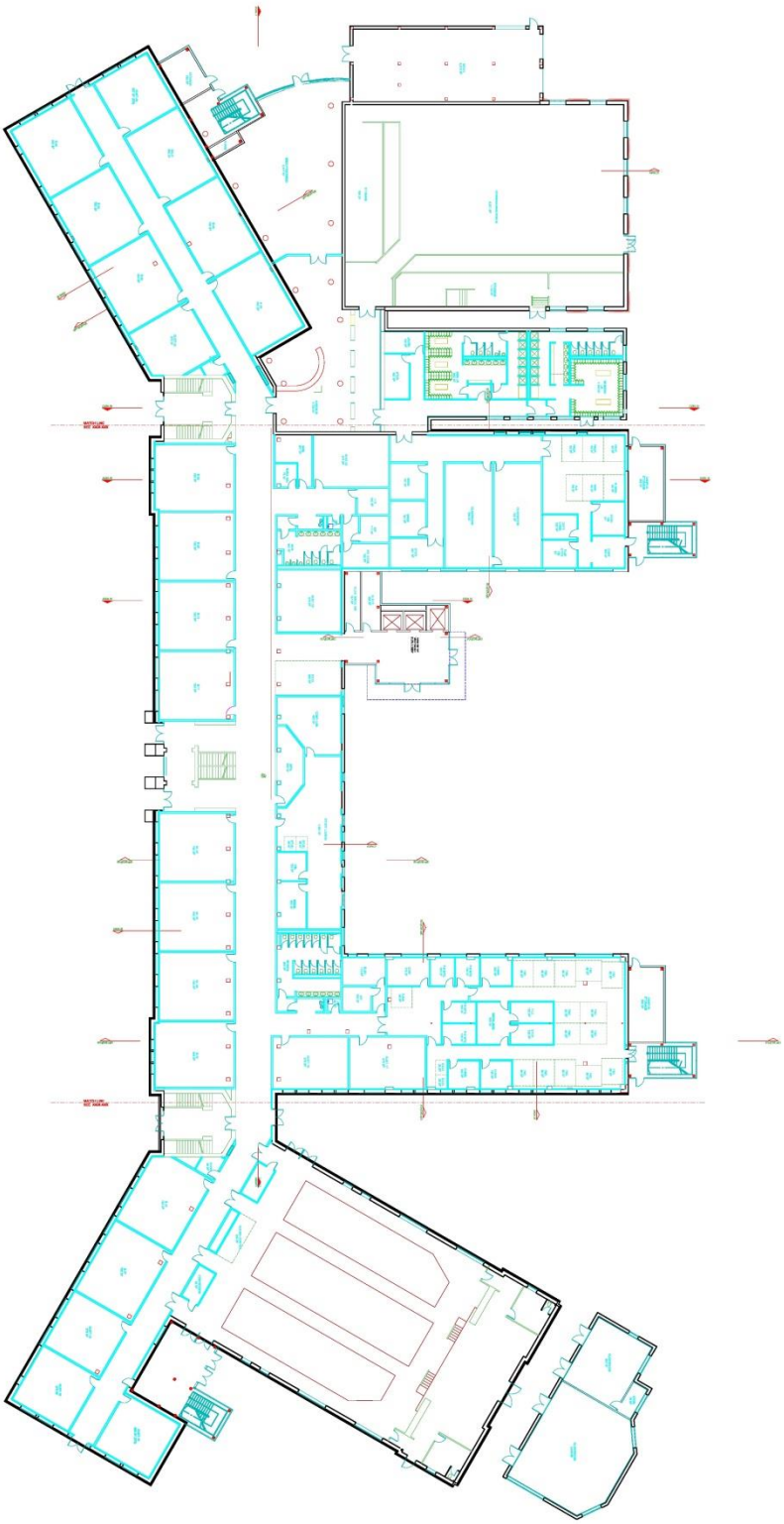
The Pyrosim model shows that the existing numbers of seats represent a threat to life safety, and based on performance criteria, should be removed. While it could be argued that more seats than are permitted by the HBC for new construction could remain, this report recommends that the number of seats be reduced, as this would be a much cheaper option than installing a smoke control system, would be much more effective

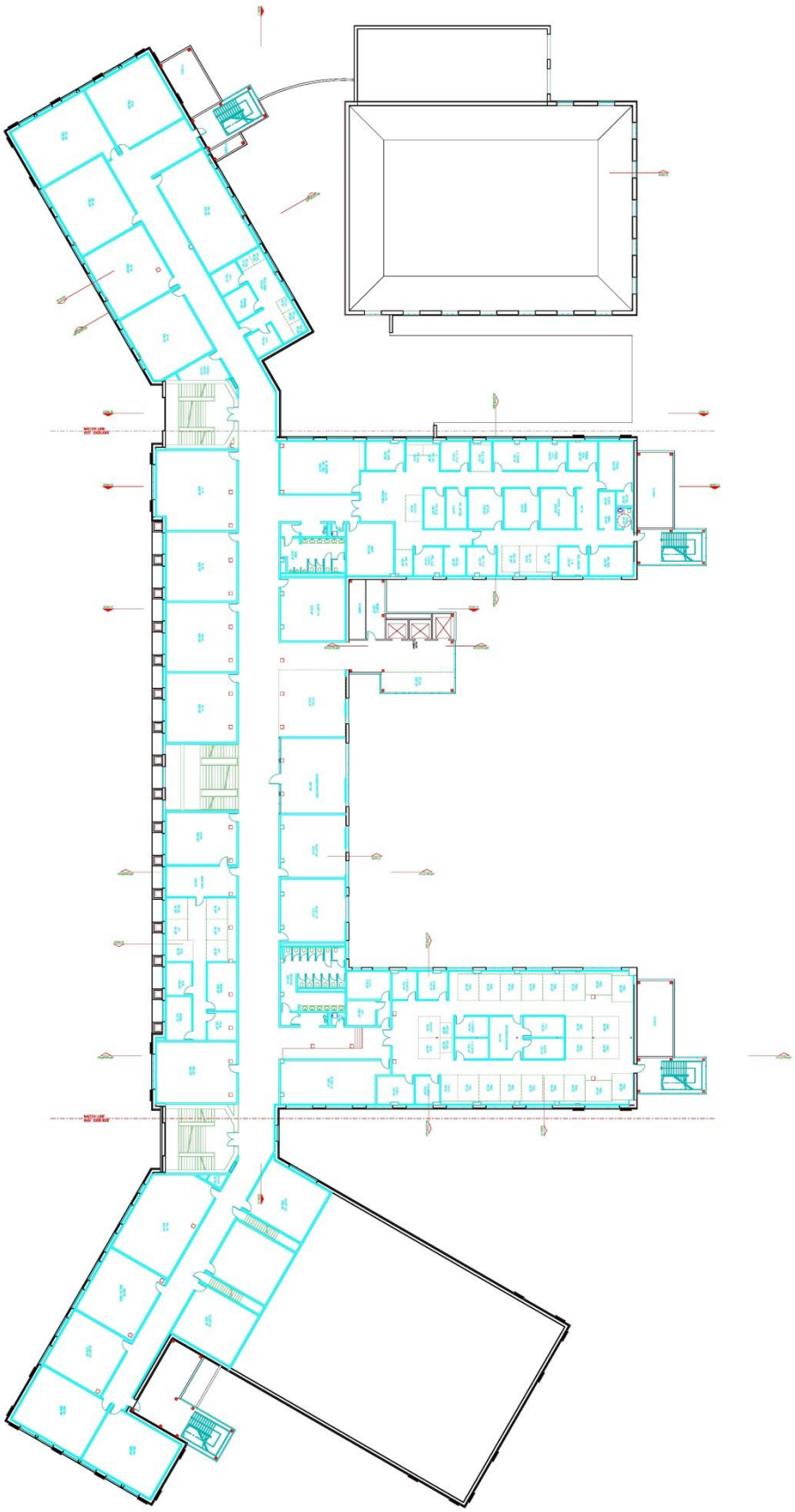
than the installation of heat vents, and would reduce the concerns about occupant density leading to crowd crush.

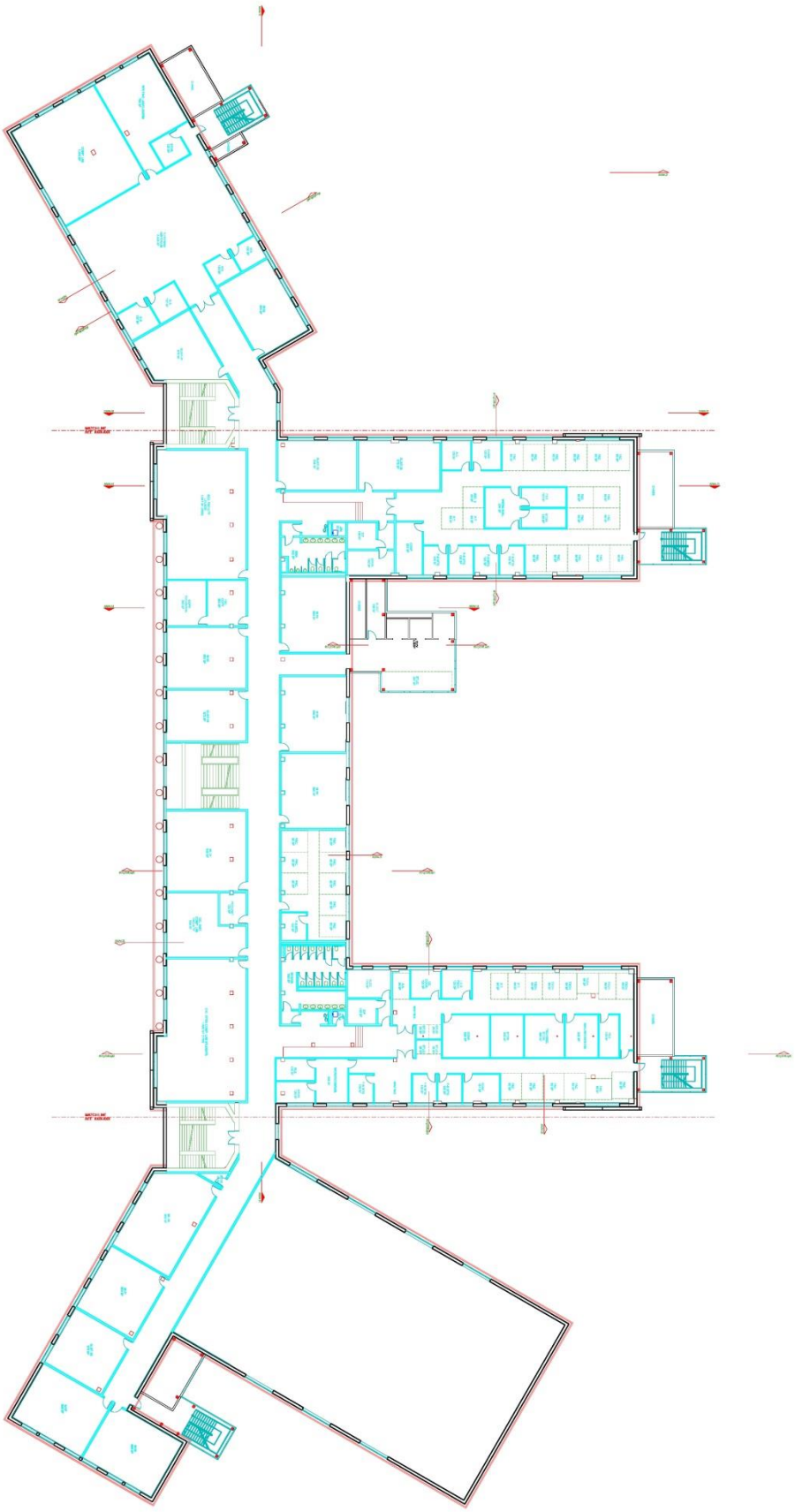
CONCLUSIONS/RECOMMENDATIONS

The design for the Houston Community College San Jacinto Building complies with the requirements of the Houston Building Code. The performance analysis of the building determined that the number of seats in the balcony represents a threat to the life safety of the occupants, and this report recommends that seats be removed until the amount matches the amount permitted by code.

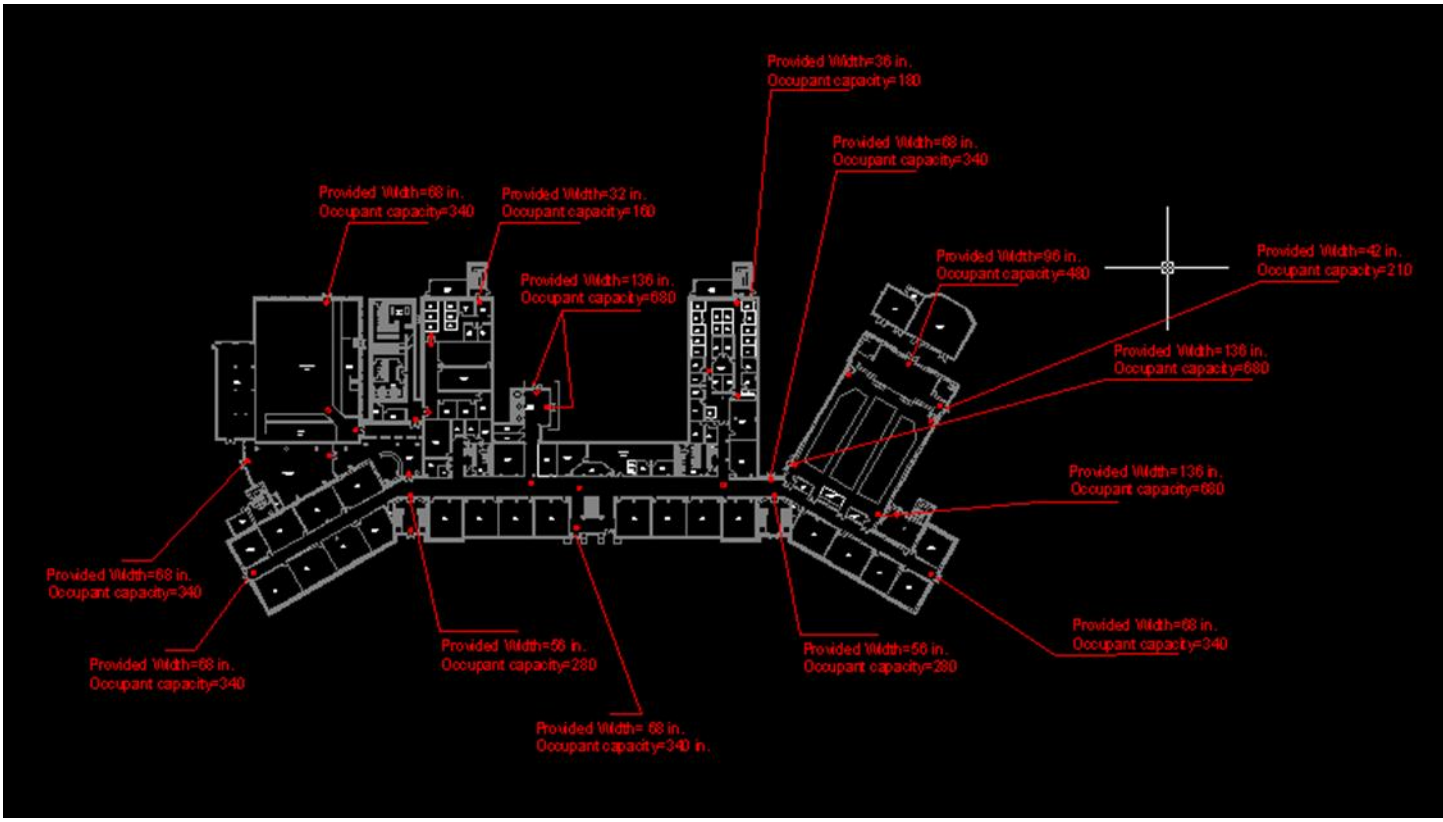
Appendix A: Floor Layout

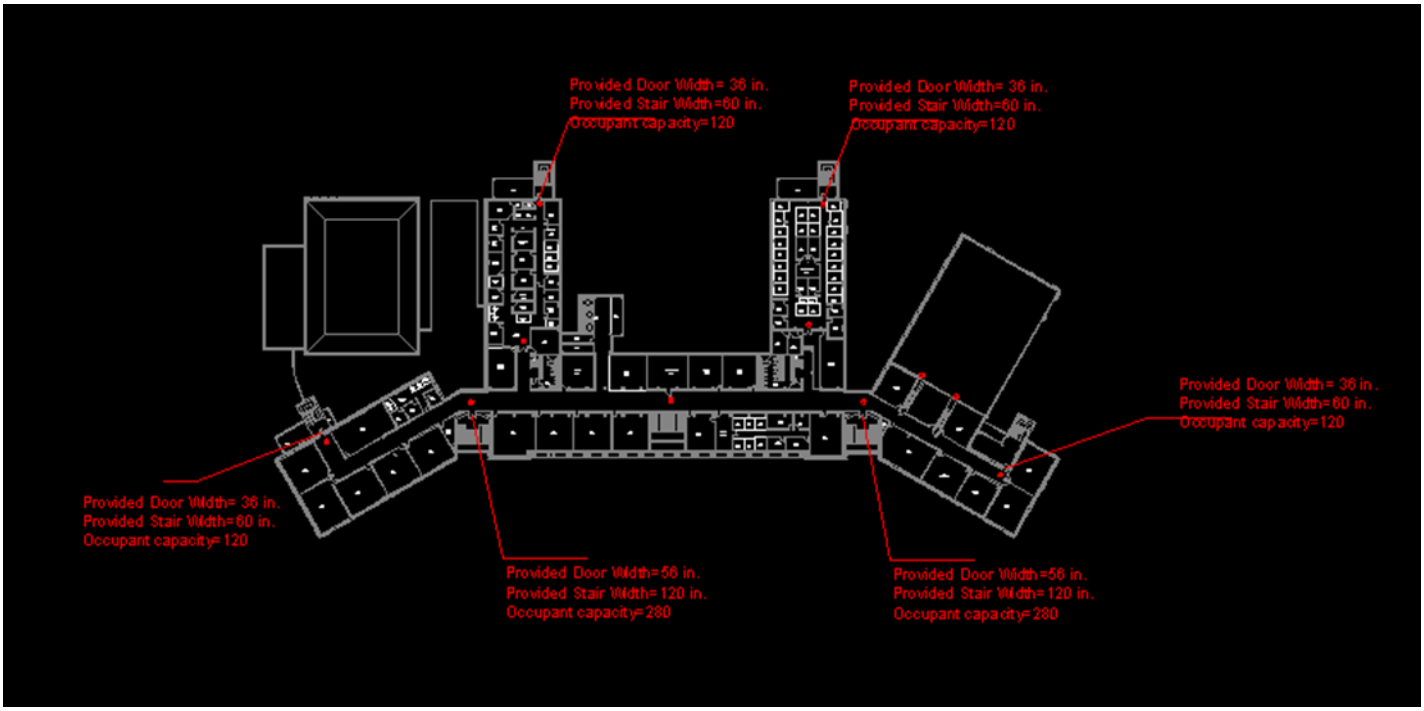


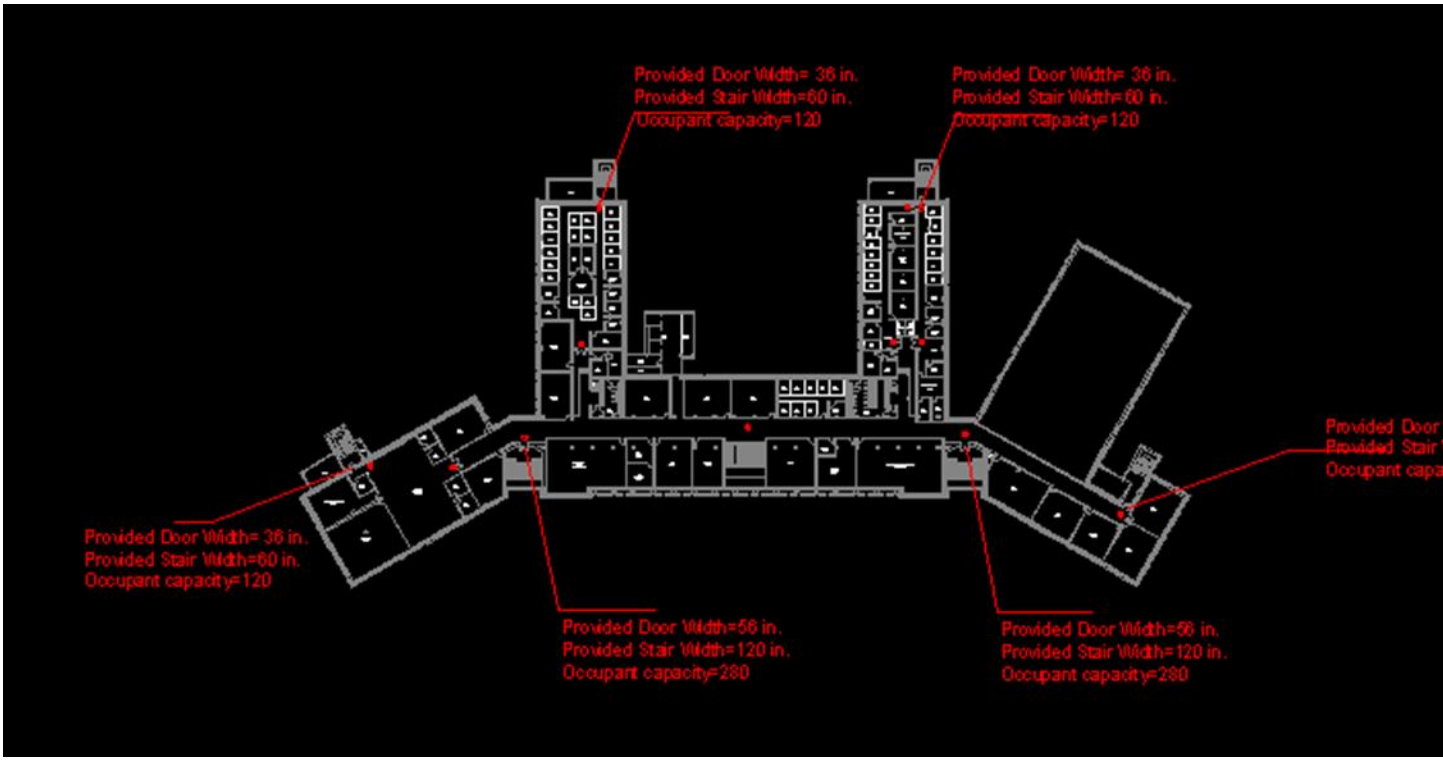




Appendix B: Egress Drawings




Provided Door Width= 36 in.
Provided Stair Width=60 in.
Occupant capacity=120
Provided Door Width= 36 in.
Provided Stair Width=60 in.
Occupant capacity=120
Provided Door Width= 36 in.
Provided Stair Width=60 in.
Occupant capacity=120
Provided Door Width= 36 in.
Provided Stair Width=60 in.
Occupant capacity=120
Provided Door Width=56 in.
Provided Stair Width=120 in.
Occupant capacity=280
Provided Door Width=56 in.
Provided Stair Width=120 in.
Occupant capacity=280


Provided Door Width= 36 in.
Provided Stair Width=60 in.
Occupant capacity=120
Provided Door Width= 36 in.
Provided Stair Width=60 in.
Occupant capacity=120
Provided Door Width= 36 in.
Provided Stair Width=60 in.
Occupant capacity=120
Provided Door Width=56 in.
Provided Stair Width=120 in.
Occupant capacity=280
Provided Door Width=56 in.
Provided Stair Width=120 in.
Occupant capacity=280

Appendix C: Hydraulic Flow Test Data

Dear Ms. Lucas:

On April 27, 2011, Rolf Jensen and Associates, Inc. (RJA) performed a water flow test, with City of Houston (COH) personnel, on the water service line that provides fire water for the above referenced facility. The following data are the results from the test:

Time:	10:45 am
Outlet Diameter:	2.5 inches
Static Pressure:	64 psi
Residual Pressure:	58 psi
Pitot:	45 psi
Flow:	1,126 gpm
Flow at 20 psi:	3,302 gpm

The water and pressure available is at the effective point (Static and Residual Hydrant - #1; see attachment #1). Please feel free to contact me with any questions you may have.

Attachment #1

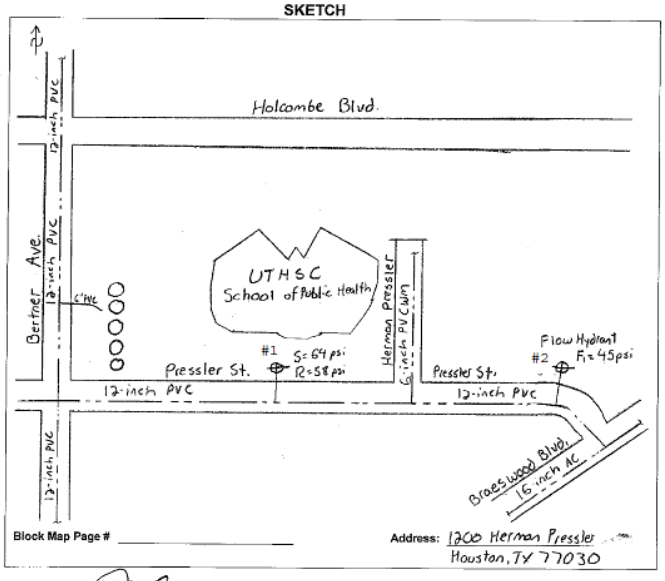
CITY OF HOUSTON
Part III Flow Test Completion Status Report

Time: 10:45 AM Weather: Sunny & Clear Date: 4-27-2011

☑ Completed ☐ No Show ☐ Cancelled ☐ Re-scheduled On _____ AM
☐ Not Completed [Reason(s)]
Area Served ☐ Residential ☐ Commercial ☐ Industrial

No	FIRE HYDRANTS		PRESSURES		FLOW @ RESIDUAL PRESSURE		
	LOCATION	MAKE	Static (psi)	Residual (psi)	Orifice Dia. (in)	Pitot PSI	Flow GPM
1	Pressler St. west of Herman Pressler	Mueller	64	58	2½"		
2	Pressler st. east of Herman Pressler	Mueller			2½"	45	1126
3							
4							

SKETCH

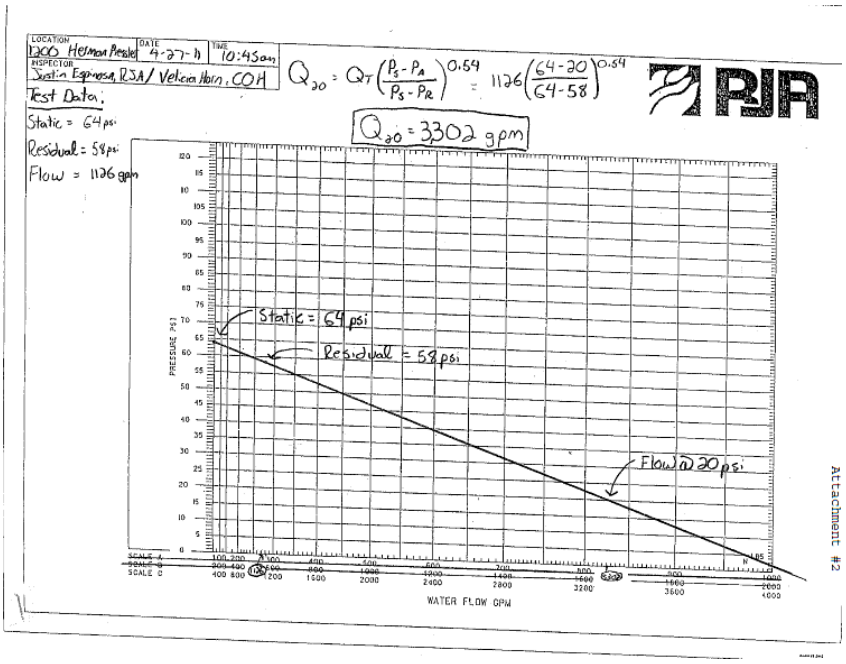


Block Map Page # _____

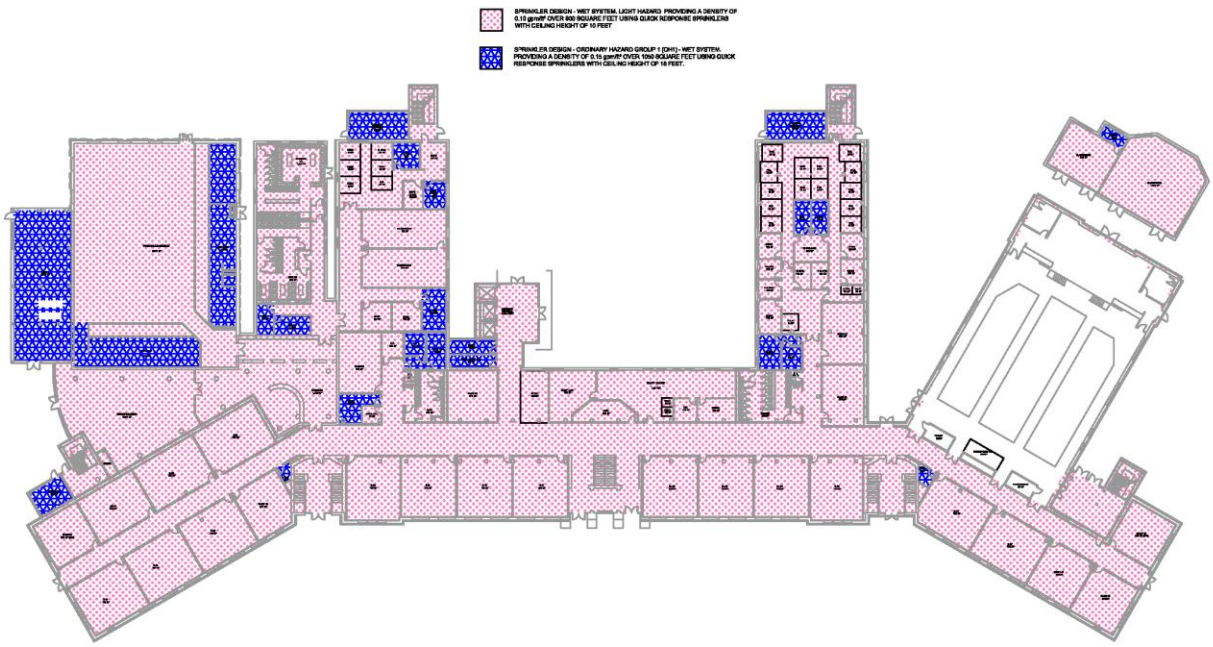
Address: 1200 Herman Pressler Houston, TX 77030

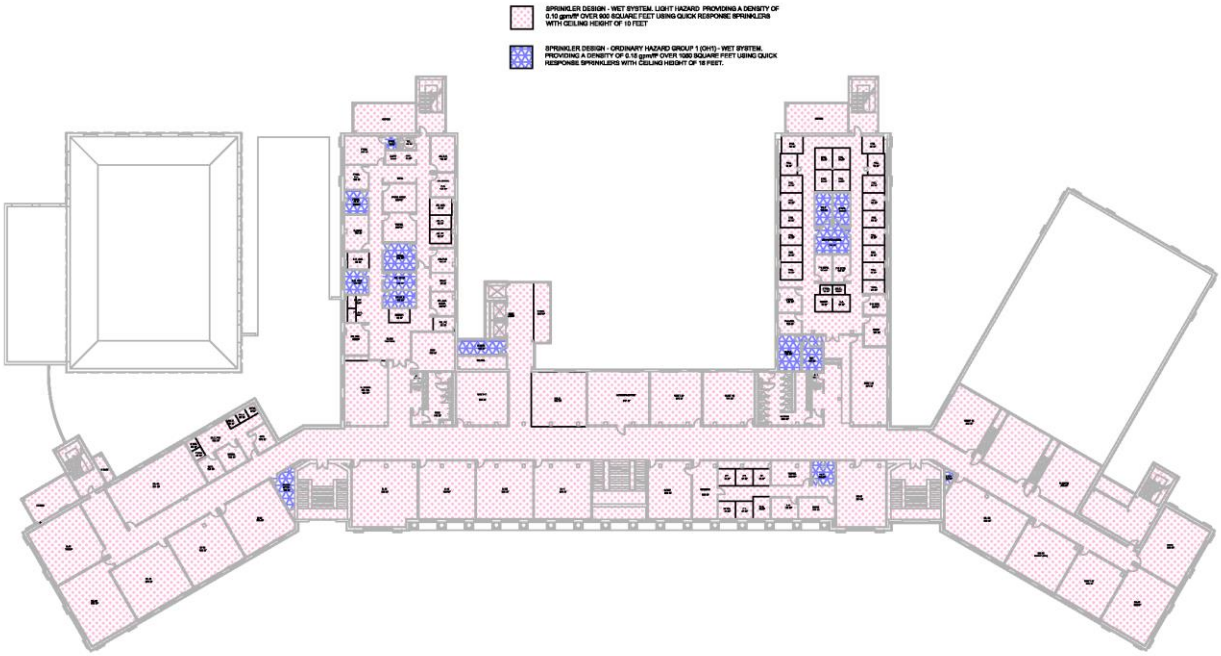
Signature(s): _____ (Tester) Justin Espinosa

_____ (City of Houston Personnel) Velicia Horn


LOCATION
1200 Herman Parkes
DATE
4-27-11
TIME
10:45am
INSPECTOR
Justin Espinosa, RJA / Velcia Horn, COH
$Q_{20} = Q_T \left(\frac{P_s - P_a}{P_s - P_R}\right)^{0.54} = 1126 \left(\frac{64-20}{64-58}\right)^{0.54}$
RJA
Test Data:
Static = 64 psi
Residual = 58 psi
Flow = 1126 gpm
$Q_{20} = 3302$ gpm
Static = 64 psi
Residual = 58 psi
Flow @ 20 psi
PRESSURE PSI
WATER FLOW GPM
Attachment #2

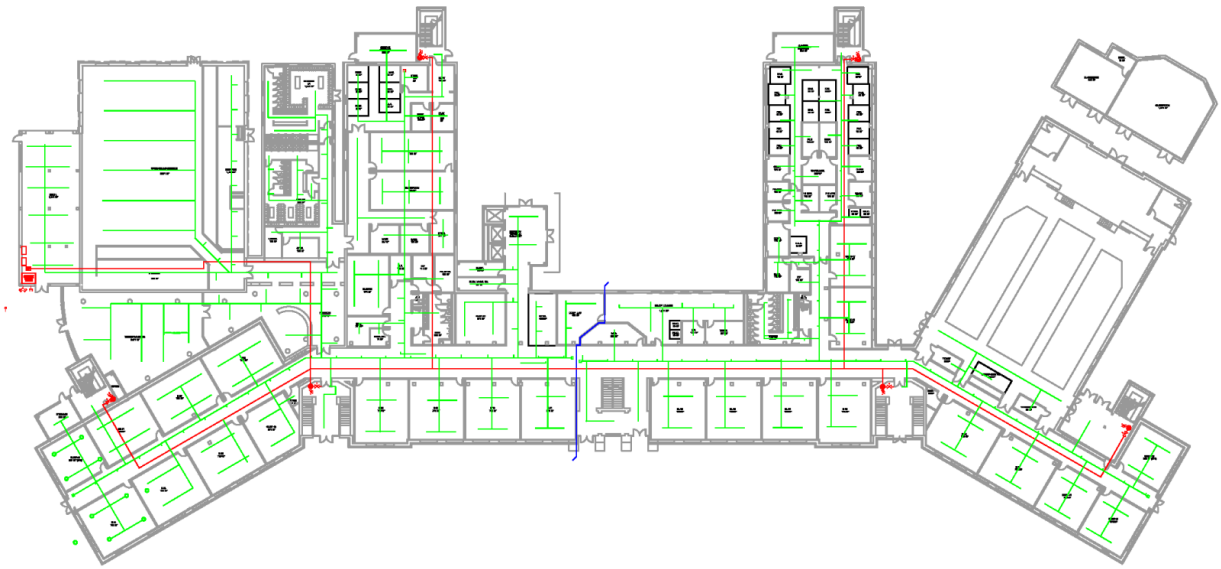
Appendix D: Sprinkler Hazard Classification Areas




SPRINKLER DESIGN - WET SYSTEM, LIGHT HAZARD PROVIDING A DENSITY OF 0.10 gpm/ft² OVER 900 SQUARE FEET USING QUICK RESPONSE SPRINKLERS WITH CEILING HEIGHT OF 10 FEET
SPRINKLER DESIGN - ORDINARY HAZARD GROUP 1 (OH1) - WET SYSTEM PROVIDING A DENSITY OF 0.15 gpm/ft² OVER 1500 SQUARE FEET USING QUICK RESPONSE SPRINKLERS WITH CEILING HEIGHT OF 10 FEET.


SPRINKLER DESIGN - WET SYSTEM, LIGHT HAZARD PROVIDING A DENSITY OF 0.10 gpm/ft² OVER 900 SQUARE FEET USING QUICK RESPONSE SPRINKLERS WITH CEILING HEIGHT OF 10 FEET
SPRINKLER DESIGN - ORDINARY I HAZARD GROUP 1 (OX1) - WET SYSTEM PROVIDING A DENSITY OF 0.1o gpm/ft² OVER 1500 SQUARE FEET USING QUICK RESPONSE SPRINKLERS WITH CEILING HEIGHT OF 16 FEET.

Appendix E: Sprinkler Layout



Appendix F: Design Area and Sprinkler Demand Calculations

Design area: light hazard, 900 sq. ft.

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	
	Sprink 1	q	0.0	1in		L	3	C =	120	Pt	7.2	Pt		k=5.6	q=.1*150
1					T	F	5		0.076	Pe		Pv			P=(15/5.6)^2
		Q	15.0	1.049		T	8	pf		Pf	0.6	Pn		Pt=	
		q				L		C =		Pt		Pt			Qadj=15*(8.5/7.8)^.5
2						F				Pe		Pv			
		Q	15.7			T		pf		Pf		Pn		k=5.62	k=15.7/(7.8)^.5
	Sprink 2	q	0.0	1in		L	12	C =	120	Pt	7.2	Pt		k=5.6	q=.1*150
3					T	F	5		0.076	Pe		Pv			
		Q	15.0	1.049		T	17	pf		Pf	1.3	Pn		k=5.15	k=15/(8.5)^.5
	RN1to2	q	19.5+18.7			L	15	C =	120	Pt	8.5	Pt			
4				2in		F			0.011	Pe		Pv			
		Q	30.7	2.067		T	15	pf		Pf	0.2	Pn			
	Sprink 3	q	16.6			L		C =		Pt		Pt		k=5.62	Q=5.62*(8.7)^.5
5					T	F				Pe		Pv			
		Q				T		pf		Pf		Pn			
	Sprink 4	q	15.2			L		C =		Pt		Pt		k=5.15	Q=5.15*(8.7)^.5
6					T	F				Pe		Pv			
		Q				T		pf		Pf		Pn			
	RN2 toRN3	q	16.6+15.2+30.7			L	15	C =	120	Pt	13.3	Pt			
7				2in		F			0.039	Pe		Pv			
		Q	62.4	2.067		T		pf		Pf	0.6	Pn			

8	Sprink 5	q				L		C =		Pt		Pt		k=5.62	Q=5.62*13.9)^.5
					T	F				Pe		Pv			
		Q	21.0			T		pf		Pf		Pn			
9	Sprink 6	q				L		C =		Pt		Pt		k=5.15	Q=5.15*(13.9)^.5
					T	F				Pe		Pv			
		Q	19.2			T		pf		Pf		Pn			
	RN3toMain	q	21+19.2+62.4			L	87	C =	120	Pt	13.9	Pt			
10				2in	T	F	10		0.099	Pe		Pv			
		Q	102.6	2.067		T	97	pf		Pf	9.6	Pn			
	MAINtoTOR	q				L	85	C =	120	Pt	23.5	Pt			
11				4in	45,T,T, GV	F	46		0.004	Pe		Pv			
		Q	102.6	4.026		T	131	pf		Pf	0.5	Pn			
12	TORtoBOR	q				L	36	C =	120	Pt	24.0	Pt			
				4in		F			0.004	Pe	15.6	Pv			
		Q	102.6	4.026		T		pf		Pf	39.6	Pn			

Appendix G: Viking QRPS Cut Sheet

November 15, 2012 Sprinkler 41a

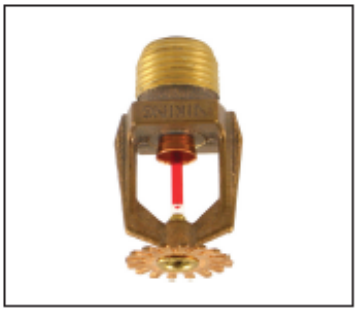
VIKING® TECHNICAL DATA

MICROFAST® AND MicrofastHP® QUICK RESPONSE PENDENT SPRINKLERS

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

1. DESCRIPTION

Viking Microfast® and MicrofastHP® Quick Response Pendent Sprinklers are small, thermosensitive, glass-bulb spray sprinklers available in several different finishes and temperature ratings and K-Factors to meet design requirements. The special Polyester,Polytetrafluoroethylene (PTFE), and Electroless Nickel PTFE (ENT) coatings can be used in decorative applications where colors are desired. In addition, these coatings have been investigated for installation in corrosive atmospheres and are cULus listed as corrosion resistant as indicated in the Approval Chart. (Note: FM Global has no approval classification for PTFE and Polyester coatings as corrosion resistant.)



2. LISTINGS AND APPROVALS

cULus Listed: Category VNIV
FM Approved: Classes 2001, 2002, 2015, and 2017
NYC Approved: Calendar Number 219-76-SA and MEA 89-92-E, Volume 16
ABS Certified: Certificate 04-HS407984C-PDA
VdS Approved: Certificates G4040095, G4040097, G4060056, G4060057, G4880045, G4930038, and G4980021
LPC Approved: Ref. Nos. 096e/03 and 096e/04
CE Certified: Standard EN 12259-1, EC-certificates of conformity 0786-CPD-40130, 0786-CPD-40170 and 0786-CPD-40279, 0832-CPD-2001, and 0832-CPD-2003
MED Certified: Standard EN 12259-1, EC-certificate of conformity 0832-MED-1003 and 0832-MED-1008
NOTE: Other International approval certificates are available upon request.

Refer to Approval Chart 1 and Design Criteria on page 41d for cULus Listing requirements and refer to Approval Chart 2 and Design Criteria on page 41f for FM Approval requirements that must be followed.

3. TECHNICAL DATA

Specifications:
Available since 1987.
Minimum Operating Pressure: 7 psi (0.5 bar)*
Maximum Working Pressure: Sprinklers 12282 and 12290 are rated for use with water working pressures ranging from the minimum 7 psi (0.5 bar) up to 250 psi (17 bar) for high-pressure systems. High-pressure (HP) sprinklers can be identified by locating "250" stamped on the deflector. All other Part Nos. not mentioned above are rated to a maximum 175 psi (12 bar) wwp.
Factory tested hydrostatically to 500 psi (34.5 bar)
Thread size: Refer to the Approval Charts
Nominal K-Factor: Refer to the Approval Charts
Glass-bulb fluid temperature rated to -65 °F (-55 °C)
Overall Length: Refer to the Approval Charts

Viking Technical Data may be found on The Viking Corporation's Web site at http://www.vikinggroupinc.com. The Web site may include a more recent edition of this Technical Data Page.

*cULus Listing, FM Approval, and NFPA 13 installs require a minimum of 7 psi (0.5 bar). The minimum operating pressure for LPCB and CE Approvals ONLY is 5 psi (0.35 bar).

Material Standards:
Frame Casting: Brass UNS-C84400 or QM Brass for Sprinklers 06662B and 12282. Brass UNS-C84400 for all other sprinklers.
Deflector: Phosphor Bronze UNS-C51000 or Copper UNS-C19500 for Sprinklers 06662B, 06666B, and 06765B. Copper UNS-C19500 for Sprinkler 12282. Phosphor Bronze UNS-C51000, Copper UNS-C19500 or Brass UNS-C26000 for Sprinkler 06720B. Brass UNS-C26000 for all other Sprinklers.
Bushing (for Sprinklers 06718B, 06720B, and 12290): Brass UNS-C36000
Bulb: Glass, nominal 3 mm diameter
Belleville Spring Sealing Assembly: Nickel Alloy, coated on both sides with PTFE Tape
Screw: Brass UNS-C36000
Pip Cap and Insert Assembly: Copper UNS-C11000 and Stainless Steel UNS-S30400
For PTFE Coated Sprinklers: Belleville Spring-Exposed, Screw-Nickel Plated, Pip Cap-PTFE Coated
For Polyester Coated Sprinklers: Belleville Spring-Exposed
For ENT Coated Sprinklers: Belleville Spring-Exposed, Screw and Pipcap - ENT coated.

Replaces page 41a-f, dated September 19, 2012.
(Removed MED from 06662B)

SYSTEM SENSOR®

WFD Series Waterflow Detector

The System Sensor WFD series is compatible with schedule 10 through 40 steel pipe, sizes 2˝ through 8˝, and can be mounted in a vertical or horizontal position.

Features

- Two-inch mounting hole provided in new WFD30-2 models
- UL-listed models are NEMA 4 rated
- Sealed retard mechanism immune to dust and other contaminants
- Visual switch activation
- Field-replaceable retard mechanism and SPDT switches
- Rugged, dual SPDT switches enclosed in a durable terminal block
- Accommodates up to 12 AWG wire
- Designed for both indoor and outdoor use
- 100 percent synchronization activates both alarm panel and local bell
- Tamper-resistant cover screws

Robust Construction. The WFD series consists of a rugged, NEMA 4-rated enclosure. Designed for both indoor and outdoor use, the WFD series operates across a wide temperature range, from 32°F to 120°F.

Reliable Performance. UL-listed models are equipped with tamper-resistant cover screws to prevent unauthorized entry. Inside, two sets of SPDT (Form C) synchronized switches are enclosed in a durable terminal block to assure reliable performance.

False Alarm Immunity. The WFD series incorporates a mechanical retard feature, which minimizes the risk of false alarm due to pressure surges or air trapped in the sprinkler system. In addition, the mechanical retard's unique sealed design is immune to dust and other contaminants.

Simplified Operation. The WFD series is designed to simplify installation. Two conduit openings permit easy attachment to the local alarm system. The retard mechanism and dual SPDT switches are field-replaceable.

Agency Listings

UL LISTED 5739 · ULC CS169 · 7770-1653:114 · MEA approved 167-93-E · FM APPROVED 3006195

Waterflow Detector Specifications

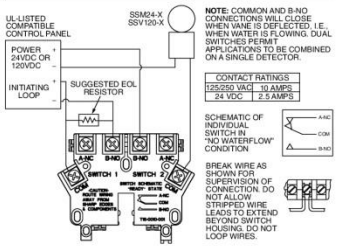
Engineering Specifications

Vane-type waterflow detectors shall be installed on system piping as designated on the drawing and/or as specified herein. Detectors shall mount on any clear pipe span of the appropriate nominal size, either a vertical upflow or horizontal run, at least 6″ from any fittings that may change water direction, flow rate, or pipe diameter or no closer than 24″ from a valve or drain. Detectors shall have a sensitivity in the range of 4 to 10 gallons per minute and a static pressure rating of 450 psi* for 2″ – 8″ pipes. The detector shall respond to waterflow in the specified direction after a preset time delay that is field adjustable. The delay mechanism shall be a sealed mechanical pneumatic unit with visual indication of actuation. The actuation mechanism shall include a polyethylene vane inserted through a hole in the pipe and connected by a mechanical linkage to the delay mechanism. Outputs shall consist of dual SPDT switches (Form C contacts). Two conduit entrances for standard fittings of commonly used electrical conduit shall be provided on the detectors. A grounding provision is provided. Unless noted, enclosures shall be NEMA 4 listed by Underwriters Laboratories Inc. All detectors shall be listed by Underwriters Laboratories Inc. for indoor or outdoor use.

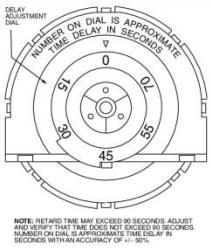
Standard Specifications

Static Pressure Rating	450 PSI*	**Operating Temperature Range**	32°F to 120°F (0°C to 49°C)
Maximum Surge	18 Feet Per Second (FPS)	**Enclosure Rating***	NEMA 4 – suitable for indoor/outdoor use
Triggering Threshold Bandwidth (Flow Rate)	4–10 GPM	**Cover Tamper Switch**	Standard with ULC models, optional for UL models, part no. 546-7000
Conduit Entrances	Two openings for ½″ conduit. One open, one knock-out type	**Service Use**	Automatic Sprinkler: NFPA-13 One or Two Family Dwelling: NFPA 13D Residential Occupancies up to 4 Stories: NFPA 13R National Fire Alarm Code: NFPA-72
Contact Ratings	Two sets of SPDT (Form C) 10.0 A, ½ HP @ 125/250 VAC 2.5 A @ 6/12/24 VDC	**U.S. Patent Numbers**	5,213,205
Compatible Pipe	Steel water pipe, schedule 10 through 40	**Warranty**	3 Years

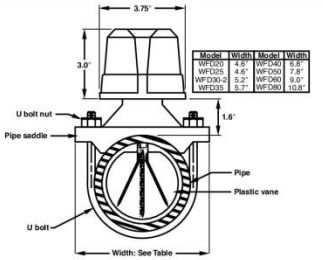
WFD Field Wiring Diagram



Delay Adjustment Dial



Overall Dimensions, Installed



Ordering Information

UL Model	ULC Model	Pipe Size	Hole Size	Shipping Weight
WFD20	WFD20A	2″	1¼″	4.2 lbs.
WFD25	WFD25A	2½″	1¼″	4.3 lbs.
WFD30-2	WFD30-2A	3″	2″	4.5 lbs.
WFD35	WFD35A	3½″	1¼″	4.7 lbs.
WFD40	WFD40A	4″	2″	5.2 lbs.
WFD50	WFD50A	5″	2″	6.3 lbs.
WFD60*	WFD60A	6″	2″	6.8 lbs.
WFD80*	WFD80A	8″	2″	7.5 lbs.
Accessories				
A3008-00	Retard mechanism			
A77-01-02	Terminal block			
546-7000	Tamper-proof switch kit			
WFDW	Tamper-proof wrench for cover			
WFDN4	Gasket kit			

*Maximum pressure rating 400 psi as approved by Factory Mutual.

SYSTEM SENSOR®

3825 Ohio Avenue • St. Charles, IL 60174
Phone: 800-SENSOR2 • Fax: 630-377-6495

A05-0180-013 • 1/09 • #1922

Simplex

Multi-Application Peripherals

UL, ULC, CSFM Listed; FM Approved;
*MEA (NYC) Acceptance**

IDNet or MAPNET II Communicating Devices
Addressable Manual Stations

Features

Individually addressable manual fire alarm stations with:

- Power and data supplied via IDNet or MAPNET II addressable communications using a single wire pair
- Operation that complies with ADA requirements
- The NO GRIP Single Action Station and Retrofit Kit are available with a more easily operated pull lever for applications where anticipated users may find the standard station lever difficult to activate
- Pull lever that protrudes when alarmed
- Break-rod supplied (use is optional)
- Models are available with single or double action (breakglass or push) operation
- UL listed to Standard 38

Compatible with the following Simplex® control panels:

- Model Series 4100ES, 4010ES, 4008, 4010, 4100U, 4020, 4100, and 4120 fire alarm control panels equipped with either IDNet or MAPNET II communications
- Model Series 2120 Communicating Device Transponders (CDTs) equipped with MAPNET II communications

Compact construction:

- Electronics module enclosure minimizes dust infiltration
- Allows mounting in standard electrical boxes
- Screw terminals for wiring connections

Tamper resistant reset key lock (keyed same as Simplex fire alarm cabinets)

Multiple mounting options:

- Surface or semi-flush with standard boxes or matching Simplex boxes
- Flush mount adapter kit
- Adapters are available for retrofitting to commonly available existing boxes

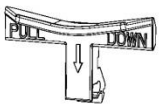
Description

The Simplex addressable manual station combines the familiar Simplex manual station housing with a compact communication module that is easily installed to satisfy demanding applications. Its integral individual addressable module (IAM) constantly monitors status and communicates changes to the connected control panel via IDNet or MAPNET II communications wiring.

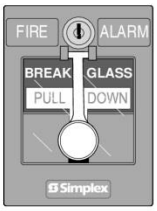
* Refer to page 2 for specific model listings. This product has been approved by the California State Fire Marshal (CSFM) pursuant to Section 13144.1 of the California Health and Safety Code. See CSFM Listing 7150-0026:224 for allowable values and/or conditions concerning material presented in this document. It is subject to re-examination, revision, and possible cancellation. Accepted for use – City of New York Department of Buildings – MEA35-93E. Additional listings may be applicable; contact your local Simplex product supplier for the latest status. Listings and approvals under Simplex Time Recorder Co. are the property of Tyco Fire Protection Products.

4099-9001
Single action

4099-9020
NO GRIP
Single action



4099-9805
NO GRIP
Retrofit kit



4099-9002
Breakglass

4099-9003
Push

With 2099-9828
Institutional
Cover kit

Operation

Activation of the 4099-9001 single action manual station requires a firm downward pull to activate the alarm switch. Completing the action breaks an internal plastic break-rod (visible below the pull lever, use is optional). The use of a break-rod can be a deterrent to vandalism without interfering with the minimum pull requirements needed for easy activation. The pull lever latches into the alarm position and remains extended out of the housing to provide a visible indication.

Single Action NO GRIP Station 4099-9020. For applications such as California Building Code, Title 24, which requires "Controls and operating mechanisms shall be operable with one hand and shall not require tight grasping, pinching or twisting of the wrist" the model 4099-9020 station provides a more easily operated pull lever compared to standard stations. Retrofit of existing stations is available using the 4099-9805 Retrofit kit.

Double Action Stations (Breakglass) require the operator to strike the front mounted hammer to break the glass and expose the recessed pull lever. The pull lever then operates as a single action station.

Double Action Stations (Push Type) require that a spring loaded interference plate (marked PUSH) be pushed back to access the pull lever of the single action station.

Station reset requires the use of a key to reset the manual station lever and deactivate the alarm switch. (If the break-rod is used, it must be replaced.)

Station testing is performed by physical activation of the pull lever. Electrical testing can be also performed by unlocking the station housing to activate the alarm switch.

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Addressable Manual Station Product Selection

Addressable Manual Stations, Red Housing with White Letters and White Pull Lever

Model	Description	Housing	Pull Lever	Listings
4099-9001	Single action, English	FIRE ALARM	PULL DOWN	UL, ULC, FM, CSFM, MEA
4099-9001CB	Single action, Bilingual English and French	FEU FIRE	TIREZ PULL	ULC, FM
4099-9001CF	Single action, French	ALARME FEU	ABAISSEZ	
4099-9002	Double action, Breakglass operation, English	FIRE ALARM	PULL DOWN	UL, ULC, FM, CSFM, MEA
4099-9003	Double action, Push operation, English			
4099-9020	Single action NO GRIP operation, English	FIRE ALARM	PULL DOWN	UL, ULC, FM, CSFM

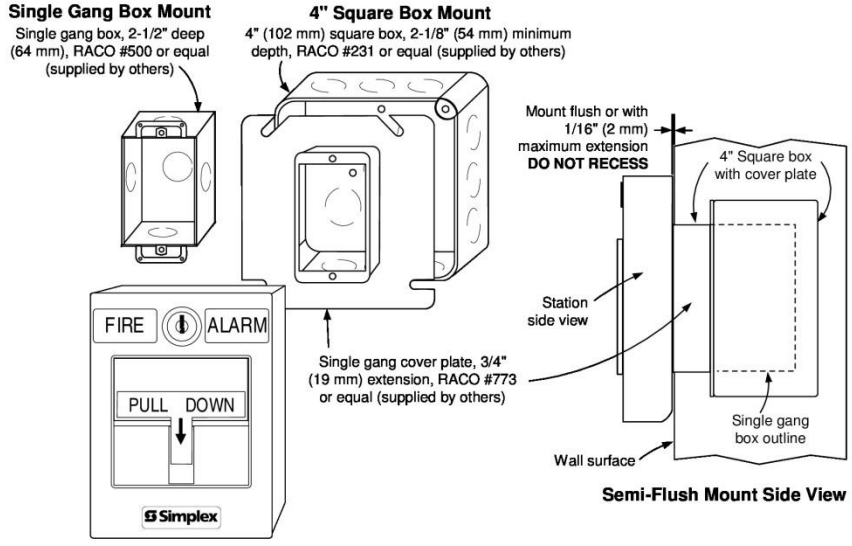
Accessories

Model	Description	
2975-9178	Surface mount steel box, red	Refer to page 3 for dimensions
2975-9022	Cast aluminum surface mount box, red	
2099-9813	Semi-flush trim plate for double gang switch box, red	Typically for retrofit, refer to page 4
2099-9814	Surface trim plate for Wiremold box V5744-2, red	
2099-9819	Flush mount adapter kit, black	Refer to page 4 for details
2099-9820	Flush mount adapter kit, beige	
2099-9803	Replacement breakglass	
2099-9804	Replacement break-rod	
2099-9828	Institutional cover kit for field installation on 4099-9001	
4099-9805	Retrofit Kit for field conversion of a single action station to a NO GRIP station; refer to Installation Instructions 579-1007 for details	

Specifications (refer to Installation Instructions 574-332 for additional information)

Power and Communications	IDNet or MAPNET II communications, 1 address per station
Address Means	DIP switch, 8 position
Wire Connections	Screw terminal for in/out wiring, for 18 to 14 AWG wire
UL Listed Temperature Range	32° to 120° F (0° to 49° C) intended for indoor operation
Humidity Range	Up to 93% RH at 100° F (38° F)
Housing Color	Red with white raised lettering
Material	Housing and pull lever are Lexan polycarbonate or equal
Pull Lever Color	White with red raised lettering
Housing Dimensions	5" H x 3-3/4" W x 1" D (127 mm x 95 mm x 25 mm)

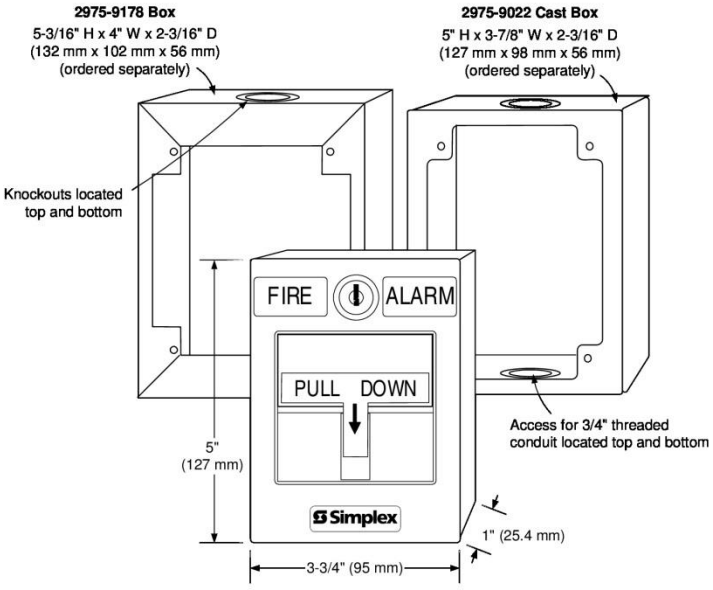
Addressable Manual Station Semi-Flush Mounting



Addressable Manual Stations Surface Mounting

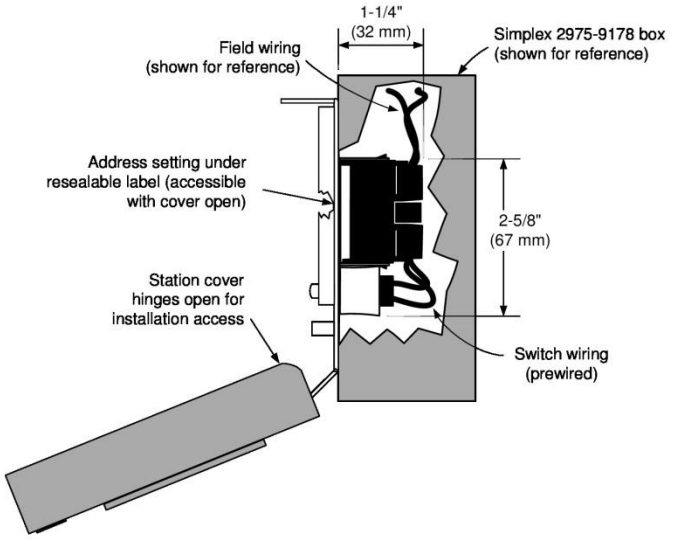
Preferred Mounting. For surface mounting of these addressable manual stations, the preferred electrical boxes are shown in the illustration to the right.

Additional Mounting Reference. Refer to page 4 for Wiremold box mounting compatibility.



4099 Series Addressable Manual Station

Surface Mount Side View with Internal Detail



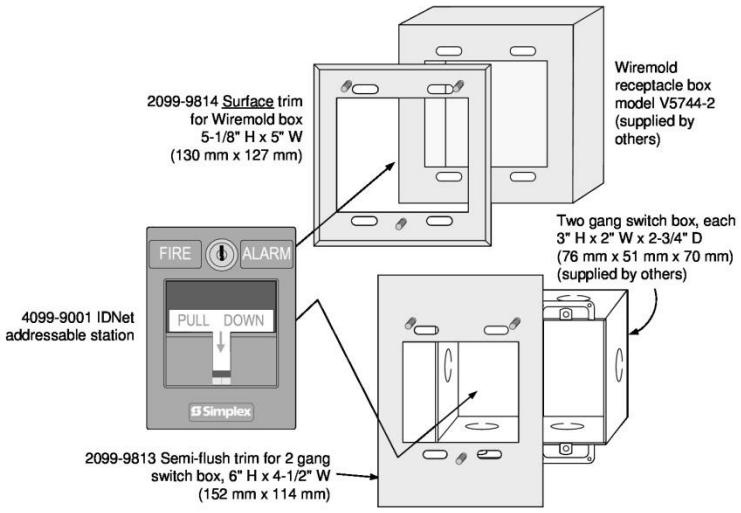
Application Reference

Refer to NFPA 72, the *National Fire Alarm and Signaling Code*, and all applicable local codes for complete requirements for manual stations. The following summarizes the basic requirements.

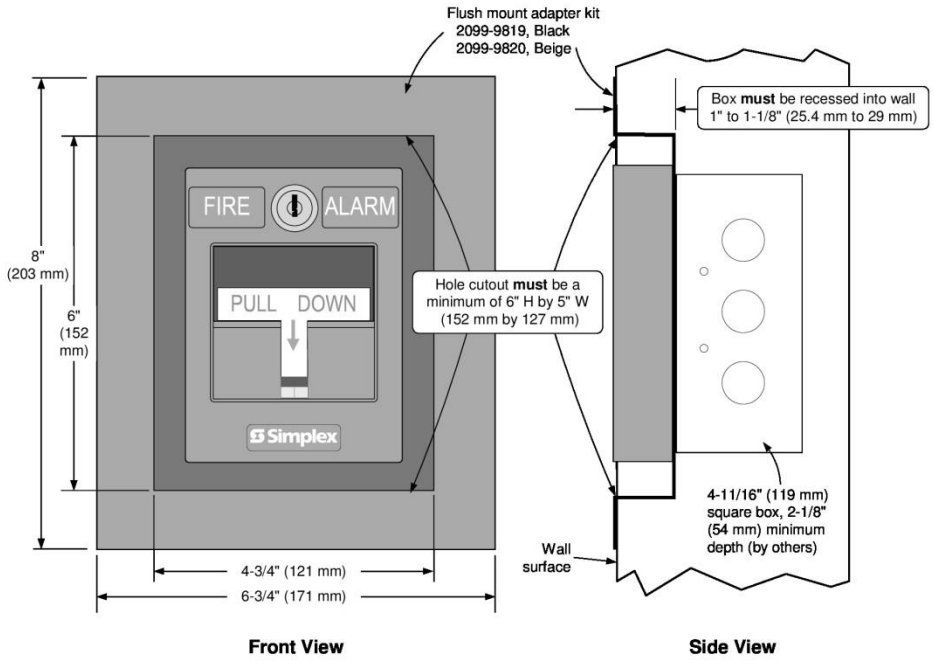
1. Stations shall be located in the normal path of exit and distributed in the protected area such that they are unobstructed and readily accessible.
2. Mounting shall be with the operable part not less than 42 in (1.07 m) and not more than 48 in (1.22 m) above floor level.
3. At least one station shall be provided on each floor. Additional stations shall be provided to obtain a travel distance not more than 200 ft (61 m) to the nearest station from any point in the building.
4. When manual station coverage appears limited in any way, additional stations should be installed.

Addressable Manual Station, Additional Mounting Information

For retrofit and new installations, additional compatible mounting boxes and the required adapter plates are shown in the illustration to the right.



Addressable Manual Station, Flush Mounting Information



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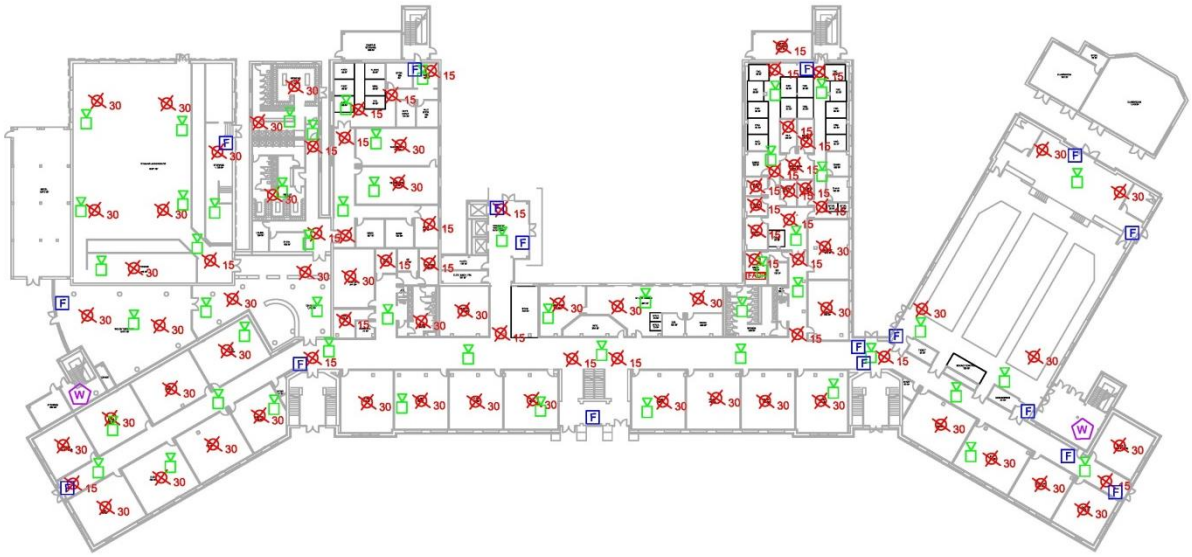
Appendix J: Fire Alarm Device Locations



Appendix K: Fire Alarm Scenario DETACT Models

INPUT PARAMETERS			CALC. PARAMETERS	
Ceiling height (H)	2.743	m	R/H	1.179
Radial distance (R)	3.2	m	dT(cj)/dT(pl)	0.269
Ambient temperature (To)	20	C	u(cj)/u(pl)	0.174
Actuation temperature (Td)	76	C	Rep. t2 coeff.	k
Response time index (RTI)	88.7	(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)	2	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	0.00
2	0.2	20.3	0.07	20.00	0.00
4	0.8	20.7	0.11	20.00	0.00
6	1.7	21.2	0.15	20.01	0.01
8	3.0	21.8	0.18	20.02	0.01
10	4.7	22.4	0.21	20.03	0.01
12	6.8	23.0	0.24	20.06	0.02
14	9.2	23.7	0.26	20.09	0.02
16	12.0	24.4	0.29	20.13	0.03
18	15.2	25.2	0.31	20.18	0.03
20	18.8	26.0	0.33	20.25	0.04
22	22.7	26.8	0.35	20.32	0.04
24	27.1	27.6	0.37	20.41	0.05
26	31.8	28.5	0.39	20.51	0.06
28	36.8	29.4	0.41	20.62	0.06
30	42.3	30.3	0.43	20.75	0.07
32	48.1	31.2	0.45	20.89	0.08
34	54.3	32.1	0.47	21.04	0.09
36	60.9	33.1	0.49	21.22	0.09
38	67.9	34.1	0.51	21.40	0.10
40	75.2	35.1	0.53	21.61	0.11
42	82.9	36.1	0.54	21.83	0.12
44	91.0	37.1	0.56	22.06	0.13
46	99.5	38.1	0.58	22.32	0.14
48	108.3	39.2	0.59	22.59	0.14
50	117.5	40.3	0.61	22.88	0.15
52	127.1	41.4	0.63	23.18	0.16

54	137.1	42.5	0.64	23.51	0.17
56	147.4	43.6	0.66	23.85	0.18
58	158.1	44.7	0.67	24.21	0.19
60	169.2	45.9	0.69	24.59	0.20
62	180.7	47.0	0.70	24.99	0.21
64	192.5	48.2	0.72	25.41	0.22
66	204.7	49.4	0.73	25.84	0.23
68	217.3	50.6	0.75	26.30	0.24
70	230.3	51.8	0.76	26.77	0.25
72	243.6	53.0	0.78	27.26	0.26
74	257.4	54.2	0.79	27.77	0.27
76	271.5	55.4	0.81	28.31	0.27
78	285.9	56.7	0.82	28.85	0.28
80	300.8	58.0	0.83	29.42	0.29
82	316.0	59.2	0.85	30.01	0.30
84	331.6	60.5	0.86	30.62	0.31
86	347.6	61.8	0.88	31.24	0.32
88	364.0	63.1	0.89	31.89	0.33
90	380.7	64.4	0.90	32.55	0.34
92	397.8	65.7	0.92	33.23	0.35
94	415.3	67.1	0.93	33.94	0.36
96	433.2	68.4	0.94	34.66	0.37
98	451.4	69.7	0.96	35.39	0.38
100	470.0	71.1	0.97	36.15	0.39
102	489.0	72.5	0.98	36.93	0.40
104	508.4	73.8	0.99	37.72	0.41
106	528.1	75.2	1.01	38.53	0.42
108	548.2	76.6	1.02	39.36	0.42
110	568.7	78.0	1.03	40.21	0.43
112	589.6	79.4	1.04	41.08	0.44
114	610.8	80.9	1.06	41.96	0.45
116	632.4	82.3	1.07	42.86	0.46
118	654.4	83.7	1.08	43.78	0.47
120	676.8	85.2	1.09	44.72	0.48
122	699.5	86.6	1.11	45.67	0.49
124	722.7	88.1	1.12	46.65	0.49
126	746.2	89.5	1.13	47.63	0.50
128	770.0	91.0	1.14	48.64	0.51
130	794.3	92.5	1.15	49.66	0.52
132	818.9	94.0	1.17	50.70	0.53
134	843.9	95.5	1.18	51.75	0.54

136	869.3	97.0	1.19	52.82	0.54
138	895.1	98.5	1.20	53.91	0.55
140	921.2	100.0	1.21	55.01	0.56
142	947.7	101.6	1.22	56.13	0.57
144	974.6	103.1	1.24	57.26	0.57
146	1001.9	104.6	1.25	58.41	0.58
148	1029.5	106.2	1.26	59.57	0.59
150	1057.5	107.7	1.27	60.75	0.60
152	1085.9	109.3	1.28	61.95	0.60
154	1114.7	110.9	1.29	63.16	0.61
156	1143.8	112.5	1.30	64.38	0.62
158	1173.3	114.0	1.31	65.62	0.63
160	1203.2	115.6	1.33	66.87	0.63
162	1233.5	117.2	1.34	68.13	0.64
164	1264.1	118.8	1.35	69.41	0.65
166	1295.1	120.4	1.36	70.71	0.65
168	1326.5	122.1	1.37	72.01	0.66
170	1358.3	123.7	1.38	73.33	0.67
172	1390.4	125.3	1.39	74.67	0.67
174	1423.0	127.0	1.40	76.01	0.68

DETACT Model 2: 30 ft. ceiling

INPUT PARAMETERS			CALC. PARAMETERS	
Ceiling height (H)	9.144	m	R/H	0.354
Radial distance (R)	3.2	m	dT(cj)/dT(pl)	0.600
Ambient temperature (To)	20	C	u(cj)/u(pl)	0.476
Actuation temperature (Td)	76	C	Rep. t2 coeff.	k
Response time index (RTI)	88.7	(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)	2	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	0.00
2	0.2	20.1	0.13	20.00	0.00
4	0.8	20.2	0.21	20.00	0.00
6	1.7	20.4	0.27	20.00	0.00
8	3.0	20.5	0.33	20.01	0.00
10	4.7	20.7	0.38	20.01	0.00

12	6.8	20.9	0.43	20.02	0.01
14	9.2	21.1	0.48	20.04	0.01
16	12.0	21.3	0.52	20.05	0.01
18	15.2	21.6	0.56	20.07	0.01
20	18.8	21.8	0.60	20.10	0.01
22	22.7	22.0	0.64	20.13	0.02
24	27.1	22.3	0.68	20.16	0.02
26	31.8	22.5	0.72	20.20	0.02
28	36.8	22.8	0.76	20.25	0.03
30	42.3	23.1	0.79	20.30	0.03
32	48.1	23.4	0.83	20.35	0.03
34	54.3	23.6	0.86	20.42	0.03
36	60.9	23.9	0.90	20.48	0.04
38	67.9	24.2	0.93	20.56	0.04
40	75.2	24.5	0.96	20.64	0.04
42	82.9	24.8	0.99	20.72	0.05
44	91.0	25.1	1.02	20.81	0.05
46	99.5	25.4	1.05	20.91	0.05
48	108.3	25.8	1.08	21.02	0.06
50	117.5	26.1	1.11	21.13	0.06
52	127.1	26.4	1.14	21.25	0.06
54	137.1	26.7	1.17	21.37	0.07
56	147.4	27.1	1.20	21.50	0.07
58	158.1	27.4	1.23	21.64	0.07
60	169.2	27.8	1.26	21.78	0.08
62	180.7	28.1	1.29	21.94	0.08
64	192.5	28.5	1.31	22.09	0.08
66	204.7	28.8	1.34	22.26	0.09
68	217.3	29.2	1.37	22.43	0.09
70	230.3	29.5	1.39	22.61	0.09
72	243.6	29.9	1.42	22.79	0.10
74	257.4	30.3	1.45	22.98	0.10
76	271.5	30.6	1.47	23.18	0.10
78	285.9	31.0	1.50	23.38	0.11
80	300.8	31.4	1.52	23.59	0.11
82	316.0	31.8	1.55	23.81	0.11
84	331.6	32.2	1.57	24.03	0.11
86	347.6	32.5	1.60	24.26	0.12
88	364.0	32.9	1.62	24.50	0.12
90	380.7	33.3	1.65	24.74	0.12
92	397.8	33.7	1.67	24.99	0.13
94	415.3	34.1	1.70	25.24	0.13

96	433.2	34.5	1.72	25.50	0.13
98	451.4	34.9	1.74	25.77	0.14
100	470.0	35.3	1.77	26.04	0.14
102	489.0	35.7	1.79	26.32	0.14
104	508.4	36.2	1.82	26.61	0.15
106	528.1	36.6	1.84	26.90	0.15
108	548.2	37.0	1.86	27.19	0.15
110	568.7	37.4	1.88	27.49	0.15
112	589.6	37.8	1.91	27.80	0.16
114	610.8	38.3	1.93	28.11	0.16
116	632.4	38.7	1.95	28.43	0.16
118	654.4	39.1	1.97	28.75	0.16
120	676.8	39.5	2.00	29.08	0.17
122	699.5	40.0	2.02	29.42	0.17
124	722.7	40.4	2.04	29.75	0.17
126	746.2	40.9	2.06	30.10	0.17
128	770.0	41.3	2.09	30.45	0.18
130	794.3	41.8	2.11	30.80	0.18
132	818.9	42.2	2.13	31.16	0.18
134	843.9	42.6	2.15	31.52	0.18
136	869.3	43.1	2.17	31.89	0.19
138	895.1	43.6	2.19	32.26	0.19
140	921.2	44.0	2.21	32.64	0.19
142	947.7	44.5	2.23	33.02	0.19
144	974.6	44.9	2.26	33.41	0.20
146	1001.9	45.4	2.28	33.80	0.20
148	1029.5	45.9	2.30	34.19	0.20
150	1057.5	46.3	2.32	34.59	0.20
152	1085.9	46.8	2.34	34.99	0.20
154	1114.7	47.3	2.36	35.40	0.21
156	1143.8	47.7	2.38	35.81	0.21
158	1173.3	48.2	2.40	36.22	0.21
160	1203.2	48.7	2.42	36.64	0.21
162	1233.5	49.2	2.44	37.07	0.21
164	1264.1	49.6	2.46	37.49	0.21
166	1295.1	50.1	2.48	37.92	0.22
168	1326.5	50.6	2.50	38.36	0.22
170	1358.3	51.1	2.52	38.79	0.22
172	1390.4	51.6	2.54	39.23	0.22
174	1423.0	52.1	2.56	39.68	0.22
176	1455.9	52.6	2.58	40.12	0.23

178	1489.1	53.1	2.60	40.58	0.23
180	1522.8	53.6	2.62	41.03	0.23
182	1556.8	54.1	2.64	41.49	0.23
184	1591.2	54.6	2.66	41.95	0.23
186	1626.0	55.1	2.67	42.41	0.23
188	1661.2	55.6	2.69	42.88	0.23
190	1696.7	56.1	2.71	43.35	0.24
192	1732.6	56.6	2.73	43.82	0.24
194	1768.9	57.1	2.75	44.30	0.24
196	1805.6	57.6	2.77	44.77	0.24
198	1842.6	58.1	2.79	45.26	0.24
200	1880.0	58.6	2.81	45.74	0.24
202	1917.8	59.1	2.83	46.23	0.24
204	1956.0	59.7	2.84	46.72	0.25
206	1994.5	60.2	2.86	47.21	0.25
208	2033.4	60.7	2.88	47.70	0.25
210	2072.7	61.2	2.90	48.20	0.25
212	2112.4	61.8	2.92	48.70	0.25
214	2152.4	62.3	2.94	49.20	0.25
216	2192.8	62.8	2.96	49.71	0.25
218	2233.6	63.3	2.97	50.22	0.25
220	2274.8	63.9	2.99	50.73	0.26
222	2316.3	64.4	3.01	51.24	0.26
224	2358.3	64.9	3.03	51.75	0.26
226	2400.6	65.5	3.05	52.27	0.26
228	2443.2	66.0	3.06	52.79	0.26
230	2486.3	66.5	3.08	53.31	0.26
232	2529.7	67.1	3.10	53.84	0.26
234	2573.5	67.6	3.12	54.36	0.26
236	2617.7	68.2	3.14	54.89	0.27
238	2662.3	68.7	3.15	55.42	0.27
240	2707.2	69.3	3.17	55.95	0.27
242	2752.5	69.8	3.19	56.49	0.27
244	2798.2	70.4	3.21	57.02	0.27
246	2844.3	70.9	3.22	57.56	0.27
248	2890.7	71.5	3.24	58.10	0.27
250	2937.5	72.0	3.26	58.64	0.27
252	2984.7	72.6	3.28	59.19	0.27
254	3032.3	73.1	3.29	59.73	0.27
256	3080.2	73.7	3.31	60.28	0.27
258	3128.5	74.2	3.33	60.83	0.28

260	3177.2	74.8	3.34	61.38	0.28
262	3226.3	75.4	3.36	61.94	0.28
264	3275.7	75.9	3.38	62.49	0.28
266	3325.5	76.5	3.40	63.05	0.28
268	3375.7	77.1	3.41	63.61	0.28
270	3426.3	77.6	3.43	64.17	0.28
272	3477.2	78.2	3.45	64.73	0.28
274	3528.6	78.8	3.46	65.29	0.28
276	3580.3	79.4	3.48	65.86	0.28
278	3632.3	79.9	3.50	66.43	0.28
280	3684.8	80.5	3.51	67.00	0.29
282	3737.6	81.1	3.53	67.57	0.29
284	3790.8	81.7	3.55	68.14	0.29
286	3844.4	82.2	3.56	68.71	0.29
288	3898.4	82.8	3.58	69.29	0.29
290	3952.7	83.4	3.60	69.87	0.29
292	4007.4	84.0	3.61	70.45	0.29
294	4062.5	84.6	3.63	71.03	0.29
296	4118.0	85.2	3.65	71.61	0.29
298	4173.8	85.7	3.66	72.19	0.29
300	4230.0	86.3	3.68	72.77	0.29
302	4286.6	86.9	3.70	73.36	0.29
304	4343.6	87.5	3.71	73.95	0.29
306	4400.9	88.1	3.73	74.54	0.30
308	4458.6	88.7	3.74	75.13	0.30
310	4516.7	89.3	3.76	75.72	0.30
312	4575.2	89.9	3.78	76.31	0.30
314	4634.0	90.5	3.79	76.91	0.30
316	4693.2	91.1	3.81	77.51	0.30
318	4752.8	91.7	3.82	78.10	0.30
320	4812.8	92.3	3.84	78.70	0.30
322	4873.1	92.9	3.86	79.30	0.30
324	4933.9	93.5	3.87	79.90	0.30

Appendix L: Notification Device Cutsheets

Simplex **TrueAlert® Addressable Notification Appliances**

*UL, ULC, CSFM Listed; FM Approved; MEA (NYC) Acceptance**

Multi-Candela Visible Only (V/O) Appliances with TrueNAC™ Voltage Drop Diagnostics

Features

Individually addressed and controlled multi-candela V/O (visible only) notification appliances provide:

- High intensity multi-candela xenon strobe with intensity ***programmable from a Simplex® 4100U fire alarm control panel with TrueAlert Addressable Power Supply (TPS)*** or jumper selected as 15, 30, 75, or 110 cd
- Synchronized 1 Hz strobe flash rate
- Wiring supervision to each appliance allowing "T-tapped" connections for Class B circuits to simplify wiring (Class A circuits require in/out wiring)
- Backwards compatibility with fixed candela TrueAlert addressable strobes on same Signaling Line Circuit (SLC) allowing convenient expansion and replacement
- Compatibility with ADA requirements; (refer to important installation information on page 4)
- UL listed to Standard 1971

Compatible TrueAlert Addressable Host Controls:

- ***4100U TrueAlert Addressable Power Supply (TPS)*** mounted in the control panel or in a remote cabinet
- ***TrueAlert Addressable Controller (4009T)*** interface panel

With multi-candela appliances and 4100U fire alarm control panels with TPS, TrueNAC™ voltage drop diagnostics provide:

- ***Individual appliance voltage drop analysis*** using appliance intensity selection, measured appliance voltage, and SLC output voltage and current**
- ***Device Reports*** that detail type, candela rating, and location of addressable appliances on the SLC *(also available with TrueAlert Addressable Controller connected to 4100U using RUI communications)*
- ***Status Reports*** that list the diagnostic results per appliance on the SLC (see details on page 2)
- Requires 4100U Software Revision 12.04 or higher and compatible TPS version

LED indicator and magnet test feature:

- Appliance LED can be selected to display each polling cycle to indicate appliance supervision
- In diagnostic mode, the magnet test pulses the LED to indicate appliance address ***AND pulses to indicate the intensity selection***; a brief output of the strobe is also selectable to confirm operation

Mechanical design features:

- Rugged, high impact, flame retardant thermoplastic housings are available in red or white for flush or surface, wall or ceiling mount
- Rear of housing does not extend into box and easily mounts to standard electrical boxes
- Access to wall mount in/out wiring terminals (18 AWG to 12 AWG) from front of housing assists installation, inspection, and testing
- Mounting options include electrical box adapters, separate covers to convert color, and red wire guards

Wall and Ceiling Mount Addressable V/Os

Description

TrueAlert Addressable Multi-Candela Strobes are individually addressed and individually controlled with power, supervision, and control supplied from a TrueAlert Addressable SLC.

4100U Additional Features. When controlled from a Simplex 4100U control panel with TPS, additional features are available such as software selection of strobe intensity, detailed reports of actual appliance intensity selection (see sample reports on page 2), TrueNAC voltage drop diagnostics, and additional setup and test diagnostics (further detailed on page 2).

Strobe Intensity Selection

Selectable at Appliance or Remotely Selected. During installation, a plug at the back of the housing (visible after installation) is inserted to select strobe output as 15, 30, 75, or 110 cd; ***or FACP.*** *FACP is the factory default setting and allows a 4100U control panel with TPS to program the output intensity.*

FACP Selection Advantages. When intensity is selected in software from a 4100U fire alarm panel, it can be easily changed if renovations or other usage conditions are revised, and intensity selection errors at installation are effectively eliminated.

* See page 3 for wire guard listings. This product has been approved by the California State Fire Marshal (CSFM) pursuant to Section 13144.1 of the California Health and Safety Code. See CSFM Listing 7125-0026:235 for allowable values and/or conditions concerning material presented in this document. It is subject to re-examination, revision, and possible cancellation. Accepted for use – City of New York Department of Buildings – MEA35-93E. Additional listings may be applicable; contact your local Simplex product supplier for the latest status. Listings and approvals under Simplex Time Recorder Co. are the property of Tyco Safety Products Westminster.

** TrueAlert addressable notification is protected under U.S. Patent Nos. 6,313,744; 6,426,697; 6,693,532; 7,006,003; and 7,091,847. TrueNAC diagnostics are protected under U.S. patent No. 7,333,010.

S4906-0004-2 3/2008

Strobe Application Reference

Proper selection of visible notification is dependent on occupancy, location, local codes, and proper applications of: the *National Fire Alarm Code®* (NFPA 72®), ANSI A117.1; the appropriate model building code: BOCA, ICBO, or SBCCI; and the application guidelines of the Americans with Disabilities Act (ADA).

TrueAlert Addressable Advantage

TrueAlert Addressable Operation provides separate audible and visible appliance control functions using a single two-wire circuit that also *confirms connection to the individual notification appliance's electronic circuit*. This operation increases circuit supervision integrity by providing supervision beyond the appliance wiring connections.

Opportunities for Reducing Installation and Testing Time. Separate controls carried on the same two-wire SLC can significantly reduce installation time and expense for both retrofit and new construction. When Class B (Style 4) wiring is used, *wiring can be T- tapped*, allowing savings in distance, wire, junction boxes, and overall installation efficiency. In addition, TrueNAC diagnostics further improve installation efficiency by analyzing individual appliance wiring connections.

Addressable Product Reference

Product	Data Sheet
A/V (horn/strobe)	S4906-0005
S/V (speaker/strobe)	S4906-0006
Amber Lens Strobes (Mass Notification)	S4906-0007
TrueAlert Isolator	S4905-0001
TrueAlert Addressable Horn	S4901-0012
TrueAlert Addressable Controller (4009T)	S4009-0003
4100U Fire Alarm Panels	S4100-0031

TrueAlert Addressable Diagnostics

Appliance Type and Intensity Check. The TrueAlert Addressable Host Control is programmed with address, location, device type, and intensity selection. An incorrect appliance replacement or substitution will produce a location specific trouble allowing easy correction.

LED Communications Indicator. The host control can be selected to pulse each appliance's LED when it receives a supervision poll. This feature can be left on continuously, or activated for system testing.

Silent Mode Appliance Magnet Testing. In this test mode, the local magnet test activates the appliance LED to pulse sequentially to indicate the appliance's address *and* to indicate the appliance's strobe intensity selection.

Operational (non-silent mode) Appliance Magnet Test. When this test mode is selected at the host control, after the address and intensity selection is indicated, the strobe will flash once to indicate proper operation.

4100U TrueNAC Diagnostic Operation

Individual Appliance Performance Analysis. With appliances on the SLC activated, each appliance measures its terminal voltage and reports it to the 4100U TPS where its address and appliance type is stored in memory. The 4100U TPS measures its output voltage and current and then iteratively analyzes all of this information against known appliance power requirements to determine equivalent impedance to each appliance. TrueNAC diagnostics then analyze each appliance's wiring connection for performance under worst case conditions and identifies problems by appliance address.

TrueAlert Device Reports detail type, candela rating, and location per appliance (first sample below). Fixed candela appliances will also report, but are not compatible with TrueNAC voltage drop diagnostics.

TrueNAC Status Reports detail the diagnostic results as shown in the second report example below.

TrueAlert Device and Device Status Reports

```
Service Port                                                          Page 1
REPORT 5 : TrueAlert Device Report                  12:34:56am  WED  2-Jan-08

                                                      DEVICE
POINT ID     CUSTOM LABEL                               TYPE       CANDELA
T14-1-1      Location Label . . . up to 40 characters    V/O           15
T14-1-2      Break Room 5                                A/V          110
T14-1-3      Boiler Room                                 A/V           75
T14-1-4      Elec. Room 7                                A/V           30
```

```
Service Port                                                          Page 1
REPORT 6 : TrueNAC Status Report                    12:34:56am  WED  2-Jan-08

TPS AT ADDRESS 3
SLC    1

POINT ID     CUSTOM LABEL                                  TEST RESULT
T14-1-1      Location Label . . . up to 40 characters      PASSED
T14-1-3      West Hall South End                           PASSED
T14-1-5      Classroom 2                                   PASSED
T14-1-6      Classroom 3                                   FAILED          -0.6

NOMINAL CURRENT (A) :                                  1.34
WORST CASE CURRENT (A) :                               1.97
WORST CASE VOLTAGE ABOVE/BELOW THRESHOLD (V) :         -0.6

SLC HAS NOT PASSED UNLESS ALL DEVICES ARE MARKED AS PASSED
```

Product Selection

Multi-Candela Addressable Strobe

Model	Mounting	Housing Color	"FIRE" Lettering	Dimensions	Description
4906-9201	Wall	Red	White	5-1/8" H x 5" W x 2-3/4" D (130 mm x 127 mm x 70 mm)	Multi-Candela Addressable Strobe; intensity selectable as: 15, 30, 75, or 110 candela
4906-9203		White	Red		
4906-9202	Ceiling	Red	White	4-3/4" x 2-5/16" x 2-5/8" D (121 mm x 75 mm x 67 mm)	
4906-9204		White	Red		

V/O Adapters (see diagram on page 4)

Model	Description	Dimensions
4905-9937	Red — Wall Mount, Surface Mount Adapter Skirt; use to cover 1-1/2" (38 mm) deep surface mounted boxes	5-3/8" H x 5-1/4" W x 1-5/8" D (136 mm x 133 mm x 41 mm) depth with strobe = 4-3/8" (111 mm)
4905-9940	White — Wall Mount, Surface Mount Adapter Skirt; use to cover 1-1/2" (38 mm) deep surface mounted boxes	5-3/8" H x 5-1/4" W x 1-5/8" D (136 mm x 133 mm x 41 mm) depth with strobe = 4-3/8" (111 mm)
4905-9931	Wall Mount, Red Adapter Plate for mounting to Simplex 2975-9145 box (typically for retrofit, may be mounted vertical or horizontal)	8-5/16" x 5-3/4" x 0.060" Thick (211 mm x 146 mm x 1.5 mm)
2975-9145	Wall Mount, Red Mounting Box, requires Adapter Plate 4905-9931	7-7/8" x 5-1/8" x 2-3/4" D (200 mm x 130 mm x 70 mm)
4905-9910	Ceiling Mount, Surface Mount Adapter Plate, zinc plated; **required for ceiling surface mount**	4-7/8" x 3-1/8" (124 mm x 79 mm)

Replacement Covers for Wall Mount Strobes

Model	Description	Dimensions
4905-9992	Red cover with white "FIRE" lettering	5-1/8" H x 5" W x 1-1/2" D (130 mm x 127 mm x 38 mm)
4905-9993	White cover with red "FIRE" lettering	5-1/8" H x 5" W x 1-1/2" D (130 mm x 127 mm x 38 mm)

Wire Guards (see diagram on page 4)

Model	Description	Dimensions
4905-9961*	Wall Mount — Red wire guard with mounting plate, compatible with semi-flush or surface mounted boxes	6-1/16" H x 6-1/16" W x 3-1/8" D (154 mm x 154 mm x 79 mm)
4905-9926*	Ceiling Mount — Red wire guard with mounting plate, compatible with semi-flush or surface mounted boxes	6-1/8" x 4-3/8" x 2-7/8" (156 mm x 111 mm x 73 mm)

* UL listed by Space Age Electronics Inc.

Addressable V/O Specifications

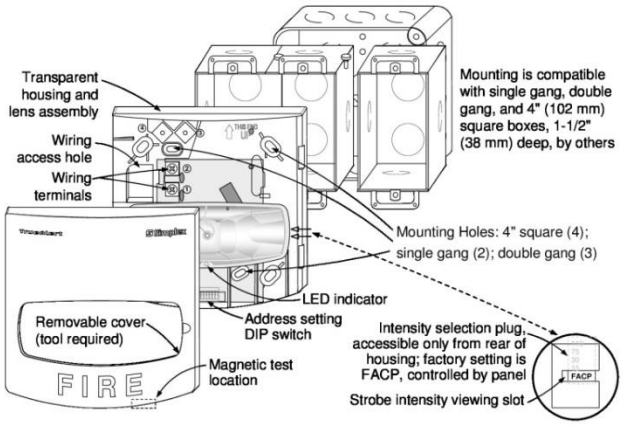
Wall Mount or Ceiling Mount, Common Specifications

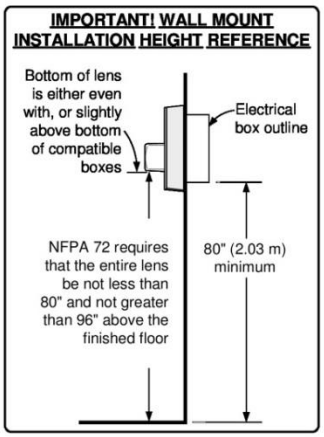
Rated Voltage Range	UL Listed Rating	Special Application, 17 to 31 VRMS, see Note 1 below			
	ULC Listed Rating	21.25 to 28.2 VRMS			
Supervisory Requirements		1 unit load			
Strobe Flash Rate and SLC Loading		1 Hz; with up to 46 synchronized addressable strobes maximum per SLC			
Environmental; Temperature and Humidity		32° to 122° F (0° to 50° C); 10% to 93%, non-condensing at 100° F (38° C)			
Terminal Block Connections		18 AWG to 12 AWG (0.82 mm^2 to 3.31 mm^2); 2 wires per terminal for in/out wiring			
Wall Mount Current	Housing Dimensions (with lens)	5-1/8" H x 5" W x 2-3/4" D (130 mm x 127 mm x 70 mm)			
	Maximum RMS Current Rating per Strobe Intensity (see Note 2)	**15 cd** / **64 mA**	**30 cd** / **98 mA**	**75 cd** / **187 mA**	**110 cd** / **253 mA**
	RMS Currents at other voltages (Reference) 18 VRMS	60 mA	93 mA	177 mA	239 mA
	RMS Currents at other voltages (Reference) 24 VRMS	45 mA	69 mA	132 mA	179 mA
Ceiling Mount Current	Housing Dimensions (with lens)	4-3/4" x 2-5/16" x 2-5/8" D (121 mm x 75 mm x 67 mm)			
	Maximum RMS Current Rating per Strobe Intensity (see Note 2)	**15 cd** / **76 mA**	**30 cd** / **128 mA**	**75 cd** / **242 mA**	**110 cd** / **328 mA**
	RMS Currents at other voltages (Reference) 18 VRMS	72 mA	121 mA	229 mA	310 mA
	RMS Currents at other voltages (Reference) 24 VRMS	54 mA	91 mA	171 mA	232 mA

NOTES:

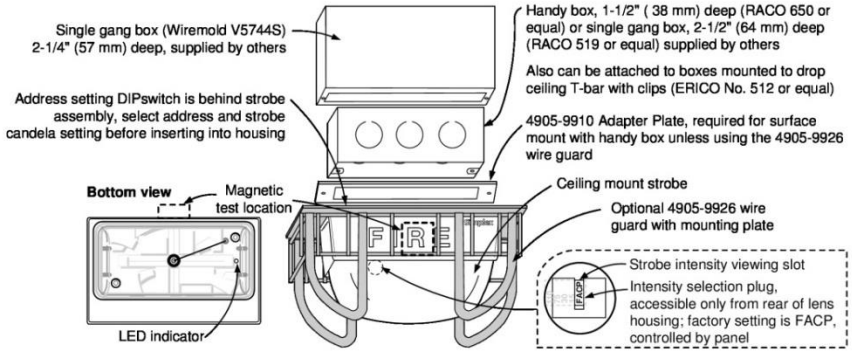
1. "Special Application" refers to the operating category under UL Standard 1971, *Signaling Devices for the Hearing Impaired*. The rated voltage range listed is the absolute operating range. Operation outside of this range may cause permanent damage to the appliance. Please note that 17 VRMS is the lowest operating voltage that is allowed at the last appliance on the TrueAlert signaling line circuit under worst case conditions.
2. The maximum RMS current listed is the appliance nameplate rating. Strobe designs are constant wattage and the maximum RMS current rating occurs at the lowest allowable operating voltage.

Wall Mount Installation Reference, Surface or Semi-Flush Mounting

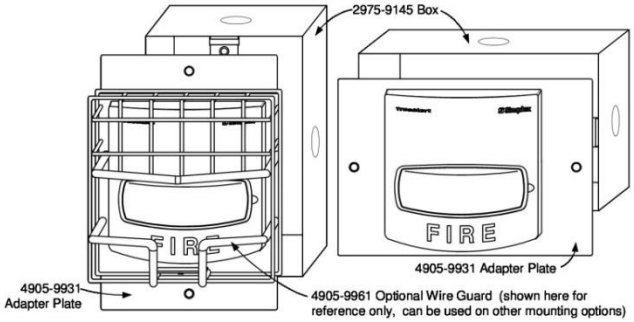




Ceiling Mount V/O and Guard Installation Reference



Wall Mount Installation Reference; Adapter Plate, Guard, and Adapter Skirt



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S4906-0004-2 3/2008

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TrueAlert® Addressable Notification Appliances

*UL, ULC Listed; FM, CSFM, and MEA (NYC) Approved**

Audible Notification Appliances, Electronic Horns
Models 4901-9850 and 4901-9853

Features

Individually addressable, low power electronic horn provides:

- Supervision of each individual appliance's wiring and connections
- Ability to connect using "T" tapping for Class B/Style 4 circuits to simplify wiring (Class A/Style 6 circuits require in/out wiring)
- Harmonically rich output sound suitable for either coded or steady operation
- Magnetic test diagnostics to assist checkout and testing of appliances and wiring
- Sound level that can be chosen at the controller to be activated as a "high" output or a "low" output (~5 dBA difference)
- Rugged, high impact, flame retardant thermoplastic housing available in red or white (covers are available separately to convert color)

UL listed to Standard 464

LED Indicator and magnetic test feature:

- LED indicator can be selected to display each polling cycle to indicate appliance supervision
- When the TrueAlert addressable controller is in diagnostic mode, the magnetic test pulses the LED to indicate appliance address and is selectable to also briefly sound the horn to confirm operation

TrueAlert two-wire addressable control of audible (and visible notification) provides:

- Horns sounded as Temporal or March Time pattern, or continuous, controlled separately from visible appliances on the same two-wire circuit
- Addressable March Time rates are 60 or 120 beats per minute
- Visible appliances connected to the same circuit operated at a synchronized 1 Hz flash rate

TrueAlert addressable notification appliance design provides flexible, easy, and convenient flush or surface wall box mounting:

- Rear of housing does not extend into box and easily mounts to single gang, double gang, or 4-inch square outlet box
- In/out wiring terminals, 18 AWG to 12 AWG
- Optional mounting adapters are available to cover surface mounted electrical boxes and to adapt to Simplex® 2975-9145 boxes

* These products have been approved by the California State Fire Marshal (CSFM) pursuant to Section 13144.1 of the California Health and Safety Code. See CSFM Listing 7135-0026:238 for allowable values and/or conditions concerning material presented in this document. It is subject to re-examination, revision, and possible cancellation. Accepted for use – City of New York Department of Buildings – MEA35-93E. Additional listings may be applicable; contact your local Simplex product supplier for the latest status. Listings and approvals under Simplex Time Recorder Co. are the property of Tyco Safety Products Westminster.

TrueAlert Addressable Horns are Available in Red with White Lettering and White with Red Lettering

Description

TrueAlert addressable horns are individually addressed audible notification appliances that receive power, supervision, and control signals from a TrueAlert addressable Signaling Line Circuit (SLC) channel. When activated, they produce an audible output that is a loud and penetrating, harmonically rich sound.

TrueAlert addressable operation** allows horns to be wired onto the same two-wire SLC circuit as visible appliances but with separately controlled operation. Typical applications are audible notification appliances activated as "on-until-silenced" and visible notification appliances activated "on-until-reset." In addition, visible appliances (strobes) on the same circuit are activated with synchronized flashes.

TrueAlert Addressable Advantage

Background. Fire alarm control panels typically activate both audible and visible notification upon receipt of an alarm. At the direction of an authorized operator (or by pre-determined program), audible notification appliances may be silenced before the alarm condition is reset (on-until-silenced) while the visible notification appliances are kept activated until the alarm condition is reset (on-until-reset). This operation has traditionally required two different circuits (four-wire operation).

** TrueAlert addressable notification is protected under U.S. Patent Nos. 6,313,744; 6,426,697; and 6,693,532.

S4901-0012-3 6/2005

TrueAlert Addressable Advantage *(Continued)*

TrueAlert addressable operation provides separate audible and visible appliance control functions using a single two-wire circuit that also *confirms connection to the individual notification appliance's electronic circuit*. This operation increases circuit supervision integrity by providing supervision that extends beyond the appliance wiring connections.

Opportunities for Reducing Installation and Testing Time. Allowing separate controls to be carried on the same two-wire SLC can significantly reduce installation time and expense for both retrofit and new construction. When Class B (Style 4) wiring is used, *wiring can be "T" tapped*, allowing even more savings in distance, wire, junction boxes, and overall installation efficiency. The magnetic test feature (described below) also can provide improved installation efficiency.

TrueAlert Addressable Control

Compatible controllers include the following:

- **4100U Series TrueAlert Power Supply** (refer to data sheet S4100-0031 for additional information)
- **TrueAlert Addressable Controller**, an intelligent interface panel that connects between the host fire alarm control panel and the TrueAlert addressable notification appliances (refer to data sheet S4009-0003 for additional information.)

TrueAlert Addressable Diagnostics

Test Features. The TrueAlert Addressable Controller can be selected to pulse each appliance's LED when that appliance receives a supervision poll. When the TrueAlert Addressable Controller is selected for diagnostic mode, the TrueAlert addressable appliance magnetic test feature provides a response at the individual appliance being tested.

Silent Appliance Testing. In this test mode, in response to the magnetic test, the appliance LED pulses sequentially to conveniently indicate the appliance's address.

Operational Appliance Testing. The LED diagnostic test mode can be selected at the TrueAlert Addressable Controller such that after the address is indicated, the horn will briefly sound to indicate proper operation.

TrueAlert Addressable Wiring Isolator

The 4905-9929 Isolator Module is available for use on TrueAlert addressable circuits to isolate short circuited wiring from functioning wiring. (Refer to data sheet S4905-0001 for further information about the TrueAlert Addressable Isolator Module.)

Product Selection

TrueAlert Addressable Electronic Horns

Model	Description		Dimensions
4901-9850	TrueAlert Addressable Electronic Horn	Red with white "FIRE" lettering	5-1/8" H x 5" W x 1-1/2" D (130 mm x 127 mm x 38 mm)
4901-9853		White with red "FIRE" lettering	

Mounting Adapters

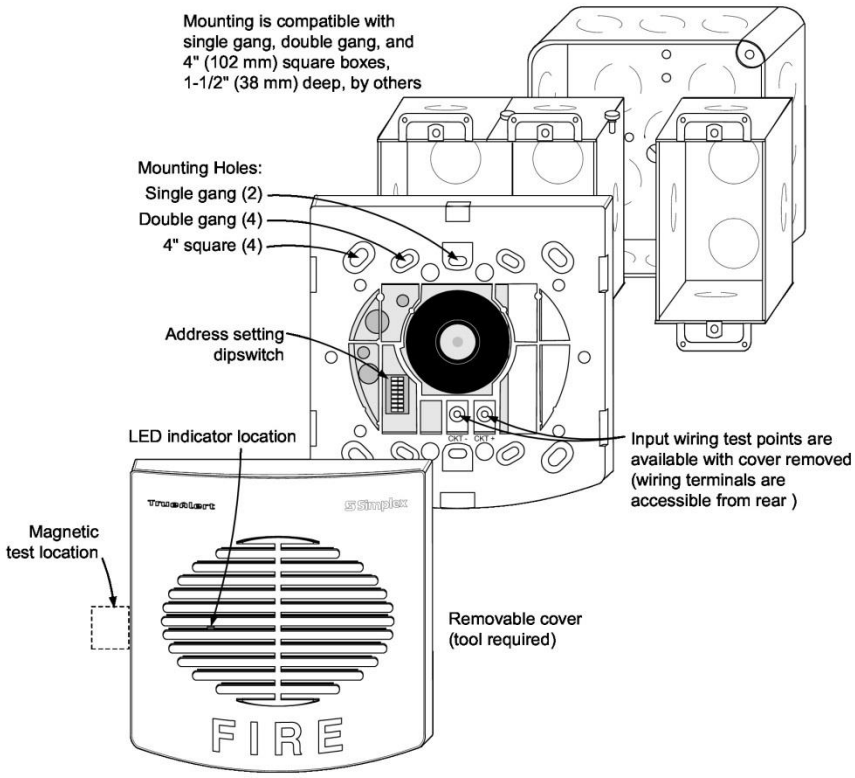
Model	Description		Dimensions
4905-9937	Red Surface Mount Adapter Skirt	Use to cover 1-1/2" deep surface mounted boxes	5-3/8" H x 5-1/4" W x 1-5/8" D (136 mm x 133 mm x 41 mm) Total depth with horn = 3-1/8" (79 mm)
4905-9940	White Surface Mount Adapter Skirt		
4905-9931	Adapter Plate, red, for mounting to Simplex 2975-9145 Box (typically for retrofit, may be mounted vertical or horizontal)		8-5/16" x 5-3/4" x 0.060" Thick (211 mm x 146 mm x 1.5 mm)
2975-9145	Red Mounting Box, requires 4905-9931 Adapter Plate		7-7/8" x 5-1/8" x 2-3/4" D (200 mm x 130 mm x 70 mm)

Optional Covers and Guard

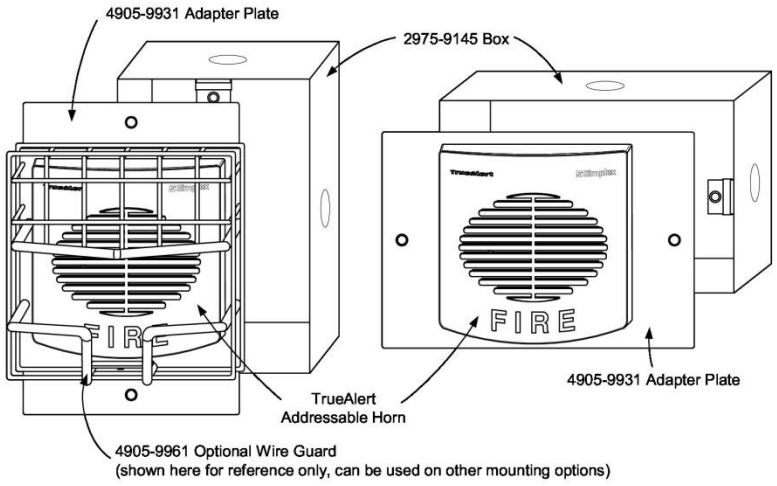
Model	Description		Dimensions
4905-9988	Red horn cover with white "FIRE" lettering	For replacement or color conversion	5-1/8" H x 5" W x 1-1/2" D (130 mm x 127 mm x 38 mm)
4905-9989	White horn cover with red "FIRE" lettering		
4905-9961	Red Wire guard with mounting plate, compatible with surface or semi-flush mounted boxes*		6-1/16" H x 6-1/16" W x 3-1/8" D (154 mm x 154 mm x 79 mm)

* UL listed by Space Age Electronics Inc.

Installation Reference



Adapter Plate Installation Reference



Specifications

Electrical Ratings

Rated Voltage Range		17 VRMS to 31 VRMS, see notes below					
Supervisory Requirements		1 unit load					
Current Ratings, Horn Activated		17 VRMS		24 VRMS		31 VRMS	
	Setting	High	Low	High	Low	High	Low
	Current	19 mA	14 mA	27 mA	22 mA	37 mA	29 mA

Sound Output Ratings (dBA) @ 10 ft (3 m)

	17 VRMS				24 VRMS				31 VRMS			
Sound Type (see Note 3)	Steady		Coded		Steady		Coded		Steady		Coded	
Setting	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Reverberant Chamber, UL 464 Test	84.6	79.1	80.6	75.5	86.3	81.5	82.4	77.2	88.4	84.3	84.5	79.2
Anechoic Chamber (see Note 3)	90	84	86	80	93	87	89	83	94	90	90	86

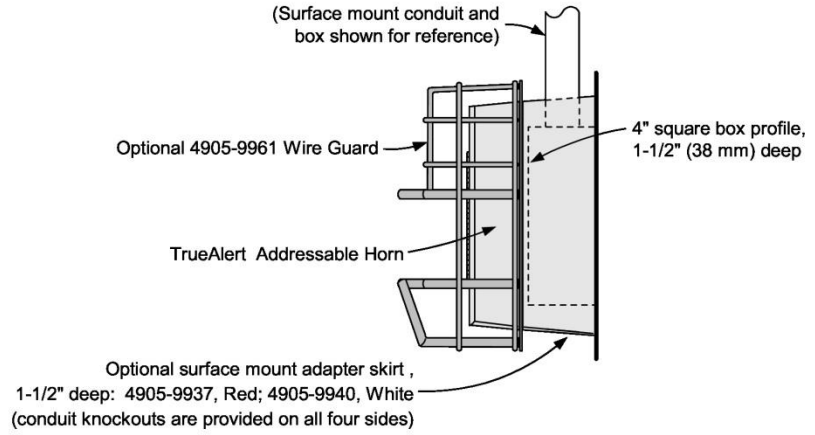
General Specifications

Sound Output Characteristics	2400 to 3700 Hz sweep, modulated at 120 Hz rate
Temperature Range	32° to 122° F (0° to 50° C)
Humidity Range	10% to 93%, non-condensing @ 100° F (38° C)
Connections	Terminal blocks for 18 AWG to 12 AWG (0.82 mm^2 to 3.31 mm^2); two wires per terminal for in/out wiring

NOTES:

1. TrueAlert addressable appliances are required to be connected to a TrueAlert Addressable Channel where both power and communications are supplied. Refer to TrueAlert Addressable Controller data sheet S4009-0003 for additional information about wiring rules and distance limitations.
2. The rated voltage range listed is the absolute operating range. Operation outside of this range may cause permanent damage to the horn. Please note that 17 VRMS is the lowest operating voltage that is allowed at the last appliance on the TrueAlert signaling line circuit under worst case conditions. Voltage drops and standby battery calculations should be made using anticipated operating conditions.
3. Coded values are typical of the output measured with a Temporal or a March Time pattern and with a sound level meter reading on a "fast" setting. Under the same test conditions, coded horn output "peak" sound level readings are typically 4 dBA higher. Anechoic horn output ratings are typically more representative of actual installed sound output.

Side View, Horn with Surface Mount Adapter Skirt



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Appendix M: NFPA 72 Table 14.3.1

Table 14.3.1 Visual Inspection

	Component	Initial Acceptance	Periodic Frequency	Method	Reference
1.	All equipment	X	Annual	Ensure there are no changes that affect equipment performance. Inspect for building modifications, occupancy changes, changes in environmental conditions, device location, physical obstructions, device orientation, physical damage, and degree of cleanliness.	14.3.4
2.	Control equipment:				
	(a) Fire alarm systems monitored for alarm, supervisory, and trouble signals			Verify a system normal condition.	
	(1) Fuses	X	Annual		
	(2) Interfaced equipment	X	Annual		
	(3) Lamps and LEDs	X	Annual		
	(4) Primary (main) power supply	X	Annual		
	(5) Trouble signals	X	Semiannual		
	(b) Fire alarm systems unmonitored for alarm, supervisory, and trouble signals			Verify a system normal condition.	
	(1) Fuses	X	Weekly		
	(2) Interfaced equipment	X	Weekly		
	(3) Lamps and LEDs	X	Weekly		
	(4) Primary (main) power supply	X	Weekly		
	(5) Trouble signals	X	Weekly		
3.	Reserved				
4.	Supervising station alarm systems — transmitters			Verify location, physical condition, and a system normal condition.	
	(a) Digital alarm communicator transmitter (DACT)	X	Annual		
	(b) Digital alarm radio transmitter (DART)	X	Annual		
	(c) McCulloh	X	Annual		
	(d) Radio alarm transmitter (RAT)	X	Annual		
	(e) All other types of communicators	X	Annual		
5.	In-building fire emergency voice/alarm communications equipment	X	Semiannual	Verify location and condition.	
6.	Reserved				
7.	Reserved				
8.	Reserved				
9.	Batteries			Inspect for corrosion or leakage. Verify tightness of connections. Verify marking of the month/year of manufacture (all types).	10.6.10
	(a) Lead-acid	X	Monthly	Visually inspect electrolyte level.	
	(b) Nickel-cadmium	X	Semiannual		
	(c) Primary (dry cell)	X	Monthly		
	(d) Sealed lead-acid	X	Semiannual		
10.	Reserved				

Table 14.3.1 *Continued*

	Component	Initial Acceptance	Periodic Frequency	Method	Reference
11.	Remote annunciators	X	Semiannual	Verify location and condition.	
12.	Notification appliance circuit power extenders	X	Annual	Verify proper fuse ratings, if any. Verify that lamps and LEDs indicate normal operating status of the equipment.	10.6
13.	Remote power supplies	X	Annual	Verify proper fuse ratings, if any. Verify that lamps and LEDs indicate normal operating status of the equipment.	10.6
14.	Transient suppressors	X	Semiannual	Verify location and condition.	
15.	Reserved				
16.	Fiber-optic cable connections	X	Annual	Verify location and condition.	
17.	Initiating devices			Verify location and condition (all devices).	
	(a) Air sampling				
	(1) General	X	Semiannual	Verify that in-line filters, if any, are clean.	17.7.3.6
	(2) Sampling system piping and sampling ports	X		Verify that sampling system piping and fittings are installed properly, appear airtight, and are permanently fixed. Confirm that sampling pipe is conspicuously identified. Verify that sample ports or points are not obstructed.	17.7.3.6
	(b) Duct detectors				
	(1) General	X	Semiannual	Verify that detector is rigidly mounted. Confirm that no penetrations in a return air duct exist in the vicinity of the detector. Confirm the detector is installed so as to sample the airstream at the proper location in the duct.	17.7.5.5
	(2) Sampling tube	X		Verify proper orientation. Confirm the sampling tube protrudes into the duct in accordance with system design.	17.7.5.5
	(c) Electromechanical releasing devices	X	Semiannual		
	(d) Fire extinguishing system(s) or suppression system(s) switches	X	Semiannual		
	(e) Manual fire alarm boxes	X	Semiannual		
	(f) Heat detectors	X	Semiannual		
	(g) Radiant energy fire detectors	X	Quarterly	Verify no point requiring detection is obstructed or outside the detector's field of view.	17.8
	(h) Video image smoke and fire detectors	X	Quarterly	Verify no point requiring detection is obstructed or outside the detector's field of view.	17.7.7; 17.11.5
	(i) Smoke detectors (excluding one- and two-family dwellings)	X	Semiannual		
	(j) Projected beam smoke detectors	X	Semiannual	Verify beam path is unobstructed.	
	(k) Supervisory signal devices	X	Quarterly		
	(l) Waterflow devices	X	Quarterly		
18.	Reserved				

Table 14.3.1 *Continued*

	Component	Initial Acceptance	Periodic Frequency	Method	Reference
19.	Combination systems			Verify location and condition (all types).	
	(a) Fire extinguisher electronic monitoring device/systems	X	Semiannual		
	(b) Carbon monoxide detectors/systems	X	Semiannual		
20.	Fire alarm control interface and emergency control function interface	X	Semiannual	Verify location and condition.	
21.	Guard's tour equipment	X	Semiannual	Verify location and condition.	
22.	Notification appliances			Verify location and condition (all appliances).	
	(a) Audible appliances	X	Semiannual		
	(b) Audible textual notification appliances	X	Semiannual		
	(c) Visible appliances				
	(1) General	X	Semiannual		18.5.5
	(2) Candela rating	X		Verify that the candela rating marking agrees with the approved drawings.	18.5.5
23.	Exit marking audible notification appliances	X	Semiannual	Verify location and condition.	
24.	Reserved				
25.	Area of refuge two-way communication system	X	Annual	Verify location and condition.	
26.	Reserved				
27.	Supervising station alarm systems — receivers				
	(a) Signal receipt	X	Daily	Verify receipt of signal.	
	(b) Receivers	X	Annual	Verify location and normal condition.	
28.	Public emergency alarm reporting system transmission equipment			Verify location and condition.	
	(a) Publicly accessible alarm box	X	Semiannual		
	(b) Auxiliary box	X	Annual		
	(c) Master box				
	(1) Manual operation	X	Semiannual		
	(2) Auxiliary operation	X	Annual		
29.	Reserved				
30.	Mass notification system				
	(a) Monitored for integrity			Verify a system normal condition.	
	(1) Control equipment				
	(i) Fuses	X	Annual		
	(ii) Interfaces	X	Annual		
	(iii) Lamps/LED	X	Annual		
	(iv) Primary (main) power supply	X	Annual		
	(2) Secondary power batteries	X	Annual		
	(3) Initiating devices	X	Annual		
	(4) Notification appliances	X	Annual		

(continues)

Table 14.3.1 *Continued*

	Component	Initial Acceptance	Periodic Frequency	Method	Reference
30.	Mass notification system *(continued)*				
	(b) Not monitored for integrity; installed prior to adoption of the 2010 edition			Verify a system normal condition.	
	(1) Control equipment				
	(i) Fuses	X	Semiannual		
	(ii) Interfaces	X	Semiannual		
	(iii) Lamps/LED	X	Semiannual		
	(iv) Primary (main) power supply	X	Semiannual		
	(2) Secondary power batteries	X	Semiannual		
	(3) Initiating devices	X	Semiannual		
	(4) Notification appliances	X	Semiannual		
	(c) Antenna	X	Annual	Verify location and condition.	
	(d) Transceivers	X	Annual	Verify location and condition.	

Appendix N: NFPA 72 Table 14.4.3.2

Table 14.4.3.2 Testing

	Component	Initial Acceptance	Periodic Frequency	Method
1.	All equipment	X		See Table 14.3.1.
2.	Control equipment and transponder			
	(a) Functions	X	Annually	Verify correct receipt of alarm, supervisory, and trouble signals (inputs); operation of evacuation signals and auxiliary functions (outputs); circuit supervision, including detection of open circuits and ground faults; and power supply supervision for detection of loss of ac power and disconnection of secondary batteries.
	(b) Fuses	X	Annually	Verify rating and supervision.
	(c) Interfaced equipment	X	Annually	Verify integrity of single or multiple circuits providing interface between two or more control units. Test interfaced equipment connections by operating or simulating operation of the equipment being supervised. Verify signals required to be transmitted at the control unit.
	(d) Lamps and LEDs	X	Annually	Illuminate lamps and LEDs.
	(e) Primary (main) power supply	X	Annually	Disconnect and test all secondary (standby) power under maximum load, including all alarm appliances requiring simultaneous operation. Reconnect all secondary (standby) power at end of test. Test redundant power supplies separately.
3.	Fire alarm control unit trouble signals			
	(a) Audible and visual	X	Annually	Verify operation of control unit trouble signals. Verify ring-back feature for systems using a trouble-silencing switch that requires resetting.
	(b) Disconnect switches	X	Annually	If control unit has disconnect or isolating switches, verify performance of intended function of each switch. Verify receipt of trouble signal when a supervised function is disconnected.
	(c) Ground-fault monitoring circuit	X	Annually	If the system has a ground detection feature, verify the occurrence of ground-fault indication whenever any installation conductor is grounded.
	(d) Transmission of signals to off-premises location	X	Annually	Activate an initiating device and verify receipt of alarm signal at the off-premises location. Create a trouble condition and verify receipt of a trouble signal at the off-premises location. Activate a supervisory device and verify receipt of a supervisory signal at the off-premises location. If a transmission carrier is capable of operation under a single- or multiple-fault condition, activate an initiating device during such fault condition and verify receipt of an alarm signal and a trouble signal at the off-premises location.
4.	Supervising station alarm systems — transmission Equipment			
	(a) All equipment	X	Annually	*Test all system functions and features in accordance with the equipment manufacturer's published instructions for correct operation in conformance with the applicable sections of Chapter 26. Except for DACT, activate initiating device and verify receipt of the correct initiating device signal at the supervising station within 90 seconds. Upon completion of the test, restore the system to its functional operating condition. If test jacks are used, conduct the first and last tests without the use of the test jack.
	(b) Digital alarm communicator transmitter (DACT)	X	Annually	Except for DACTs installed prior to adoption of the 2013 edition of NFPA 72 that are connected to a telephone line (number) that is also supervised for adverse conditions by a derived local channel, ensure connection of the DACT to two separate means of transmission. Test DACT for line seizure capability by initiating a signal while using the telephone line (primary line for DACTs using two telephone lines) for a telephone call. Ensure that the call is interrupted and that the communicator connects to the digital alarm receiver. Verify receipt of the correct signal at the supervising station. Verify each transmission attempt is completed within 90 seconds from going off-hook to on-hook.

(continues)

Table 14.4.3.2 *Continued*

	Component	Initial Acceptance	Periodic Frequency	Method
4.	Supervising station alarm systems — transmission Equipment			
	(b) Digital alarm communicator transmitter (DACT) *(continued)*			Disconnect the telephone line (primary line for DACTs using two telephone lines) from the DACT. Verify indication of the DACT trouble signal occurs at the premises fire alarm control unit within 4 minutes of detection of the fault. Verify receipt of the telephone line trouble signal at the supervising station. Restore the telephone line (primary line for DACTs using two telephone lines), reset the fire alarm control unit, and verify that the telephone line fault trouble signal returns to normal. Verify that the supervising station receives the restoral signal from the DACT. Disconnect the secondary means of transmission from the DACT. Verify indication of the DACT trouble signal occurs at the premises fire alarm control unit within 4 minutes of detection of the fault. Verify receipt of the secondarey means trouble signal at the supervising station. Restore the secondary means of transmission, reset the fire alarm control unit, and verify that the trouble signal returns to normal. Verify that the supervising station receives the restoral signal from the secondary transmitter. Cause the DACT to transmit a signal to the DACR while a fault in the telephone line (number) (primary line for DACTs using two telephone lines) is simulated. Verify utilization of the secondary communication path by the DACT to complete the transmission to the DACR.
	(c) Digital alarm radio transmitter (DART)	X	Annually	Disconnect the primary telephone line. Verify transmission of a trouble signal to the supervising station by the DART occurs within 4 minutes.
	(d) McCulloh transmitter	X	Annually	Actuate initiating device. Verify production of not less than three complete rounds of not less than three signal impulses each by the McCulloh transmitter. If end-to-end metallic continuity is present and with a balanced circuit, cause each of the following four transmission channel fault conditions in turn, and verify receipt of correct signals at the supervising station: (1) Open (2) Ground (3) Wire-to-wire short (4) Open and ground If end-to-end metallic continuity is not present and with a properly balanced circuit, cause each of the following three transmission channel fault conditions in turn, and verify receipt of correct signals at the supervising station: (1) Open (2) Ground (3) Wire-to-wire short
	(e) Radio alarm transmitter (RAT)	X	Annually	Cause a fault between elements of the transmitting equipment. Verify indication of the fault at the protected premises, or transmission of trouble signal to the supervising station.
	(f) Performance-based technologies	X	Annually	Perform tests to ensure the monitoring of integrity of the transmission technology and technology path. Where a single communications path is used, disconnect the communication path. Manually initiate an alarm signal transmission or allow the check-in (handshake) signal to be transmitted automatically.[b] Verify the premises unit annunciates the failure within 200 seconds of the transmission failure. Restore the communication path. Where multiple communication paths are used, disconnect both communication paths. Manually initiate an alarm signal transmission. Verify the premises control unit annunciates the failure within 200 seconds of the transmission failure. Restore both communication paths.
5.	Emergency communications equipment			
	(a) Amplifier/tone generators	X	Annually	Verify correct switching and operation of backup equipment.
	(b) Call-in signal silence	X	Annually	Operate/function and verify receipt of correct visual and audible signals at control unit.
	(c) Off-hook indicator (ring down)	X	Annually	Install phone set or remove phone from hook and verify receipt of signal at control unit.
	(d) Phone jacks	X	Annually	Visually inspect phone jack and initiate communications path through jack.

Table 14.4.3.2 *Continued*

	Component	Initial Acceptance	Periodic Frequency	Method
	(e) Phone set	X	Annually	Activate each phone set and verify correct operation.
	(f) System performance	X	Annually	Operate the system with a minimum of any five handsets simultaneously. Verify voice quality and clarity.
6.	Engine-driven generator	X	Monthly	If an engine-driven generator dedicated to the system is used as a required power source, verify operation of the generator in accordance with NFPA 110, *Standard for Emergency and Standby Power Systems*, by the building owner.
7.	Secondary (standby) power supply[c]	X	Annually	Disconnect all primary (main) power supplies and verify the occurrence of required trouble indication for loss of primary power. Measure or verify the system's standby and alarm current demand and verify the ability of batteries to meet standby and alarm requirements using manufacturer's data. Operate general alarm systems a minimum of 5 minutes and emergency voice communications systems for a minimum of 15 minutes. Reconnect primary (main) power supply at end of test.
8.	Uninterruptible power supply (UPS)	X	Annually	If a UPS system dedicated to the system is used as a required power source, verify by the building owner operation of the UPS system in accordance with NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*.
9.	Battery tests			Prior to conducting any battery testing, verify by the person conducting the test, that all system software stored in volatile memory is protected from loss.
	(a) Lead-acid type			
	(1) Battery replacement	X	Annually	Replace batteries in accordance with the recommendations of the alarm equipment manufacturer or when the recharged battery voltage or current falls below the manufacturer's recommendations.
	(2) Charger test	X	Annually	With the batteries fully charged and connected to the charger, measure the voltage across the batteries with a voltmeter. Verify the voltage is 2.30 volts per cell ±0.02 volts at 77°F (25°C) or as specified by the equipment manufacturer.
	(3) Discharge test	X	Annually	With the battery charger disconnected, load test the batteries following the manufacturer's recommendations. Verify the voltage level does not fall below the levels specified. Load testing can be by means of an artificial load equal to the full fire alarm load connected to the battery.
	(4) Load voltage test	X	Semiannually	With the battery charger disconnected, load test the batteries following the manufacturer's recommendations. Verify the voltage level does not fall below the levels specified. Load testing can be by means of an artificial load equal to the full fire alarm load connected to the battery. Verify the battery does not fall below 2.05 volts per cell under load.
	(5) Specific gravity	X	Semiannually	Measure as required the specific gravity of the liquid in the pilot cell or all of the cells. Verify the specific gravity is within the range specified by the manufacturer. Although the specified specific gravity varies from manufacturer to manufacturer, a range of 1.205–1.220 is typical for regular lead-acid batteries, while 1.240–1.260 is typical for high-performance batteries. Do not use a hydrometer that shows only a pass or fail condition of the battery and does not indicate the specific gravity, because such a reading does not give a true indication of the battery condition.
	(b) Nickel-cadmium type			
	(1) Battery replacement	X	Annually	Replace batteries in accordance with the recommendations of the alarm equipment manufacturer or when the recharged battery voltage or current falls below the manufacturer's recommendations.
	(2) Charger test[d]	X	Annually	With the batteries fully charged and connected to the charger, place an ampere meter in series with the battery under charge. Verify the charging current is in accordance with the manufacturer's recommendations for the type of battery used. In the absence of specific information, use 1/50 to 1/25 of the battery rating.
	(3) Discharge test	X	Annually	With the battery charger disconnected, load test the batteries following the manufacturer's recommendations. Verify the voltage level does not fall below the levels specified. Load testing can be by means of an artificial load equal to the full fire alarm load connected to the battery.
	(4) Load voltage test	X	Semiannually	With the battery charger disconnected, load test the batteries following the manufacturer's recommendations. Verify the voltage level does not fall below the levels specified. Load testing can be by means of an artificial load equal to the full fire alarm load connected to the battery. Verify the float voltage for the entire battery is 1.42 volts per cell, nominal, under load. If possible, measure cells individually.

(continues)

Table 14.4.3.2 *Continued*

Component	Initial Acceptance	Periodic Frequency	Method
9. Battery tests *(continued)*			
(c) Sealed lead-acid type			
(1) Battery replacement	X	Annually	Replace batteries in accordance with the recommendations of the alarm equipment manufacturer or when the recharged battery voltage or current falls below the manufacturer's recommendations.
(2) Charger test	X	Annually	With the batteries fully charged and connected to the charger, measure the voltage across the batteries with a voltmeter. Verify the voltage is 2.30 volts per cell ±0.02 volts at 77°F (25°C) or as specified by the equipment manufacturer.
(3) Discharge test	X	Annually	With the battery charger disconnected, load test the batteries following the manufacturer's recommendations. Verify the voltage level does not fall below the levels specified. Load testing can be by means of an artificial load equal to the full fire alarm load connected to the battery.
(4) Load voltage test	X	Semiannually	Verify the battery performs under load, in accordance with the battery manufacturer's specifications.
10. Public emergency alarm reporting system — wired system	X	Daily	Manual tests of the power supply for public reporting circuits shall be made and recorded at least once during each 24-hour period. Such tests shall include the following: (1) Current strength of each circuit. Changes in current of any circuit exceeding 10 percent shall be investigated immediately. (2) Voltage across terminals of each circuit inside of terminals of protective devices. Changes in voltage of any circuit exceeding 10 percent shall be investigated immediately. (3)* Voltage between ground and circuits. If this test shows a reading in excess of 50 percent of that shown in the test specified in (2), the trouble shall be immediately located and cleared. Readings in excess of 25 percent shall be given early attention. These readings shall be taken with a calibrated voltmeter of not more than 100 ohms resistance per volt. Systems in which each circuit is supplied by an independent current source (Forms 3 and 4) require tests between ground and each side of each circuit. Common current source systems (Form 2) require voltage tests between ground and each terminal of each battery and other current source. (4) Ground current reading shall be permitted in lieu of (3). If this method of testing is used, all grounds showing a current reading in excess of 5 percent of the supplied line current shall be given immediate attention. (5) Voltage across terminals of common battery on switchboard side of fuses. (6) Voltage between common battery terminals and ground. Abnormal ground readings shall be investigated immediately. Tests specified in (5) and (6) shall apply only to those systems using a common battery. If more than one common battery is used, each common battery shall be tested.
11. Remote annunciators	X	Annually	Verify the correct operation and identification of annunciators. If provided, verify the correct operation of annunciator under a fault condition.
12. Reserved			
13. Reserved			
14. Reserved			
15. Conductors — metallic			
(a) Stray voltage	X	N/A	Test all installation conductors with a volt/ohmmeter to verify that there are no stray (unwanted) voltages between installation conductors or between installation conductors and ground. Verify the maximum allowable stray voltage does not exceed 1 volt ac/dc, unless a different threshold is specified in the published manufacturer's instructions for the installed equipment.
(b) Ground faults	X	N/A	Test all installation conductors, other than those intentionally and permanently grounded, for isolation from ground per the installed equipment manufacturer's published instructions.
(c) Short-circuit faults	X	N/A	Test all installation conductors, other than those intentionally connected together, for conductor-to-conductor isolation per the published manufacturer's instructions for the installed equipment. Also test these same circuits conductor-to-ground.

Table 14.4.3.2 *Continued*

Component	Initial Acceptance	Periodic Frequency	Method
(d) Loop resistance	X	N/A	With each initiating and indicating circuit installation conductor pair short-circuited at the far end, measure and record the resistance of each circuit. Verify that the loop resistance does not exceed the limits specified in the published manufacturer's instructions for the installed equipment.
(e) Circuit integrity	X	N/A	For initial and reacceptance testing, confirm the introduction of a fault in any circuit monitored for integrity results in a trouble indication at the fire alarm control unit. Open one connection at not less than 10 percent of the initiating devices, notification appliances and controlled devices on every initiating device circuit, notification appliance circuit, and signaling line circuit. Confirm all circuits perform as indicated in Sections 23.5, 23.6, and 23.7.
	N/A	Annually	For periodic testing, test each initiating device circuit, notification appliance circuit, and signaling line circuit for correct indication at the control unit. Confirm all circuits perform as indicated in Sections 23.5, 23.6, and 23.7.
16. Conductors — nonmetallic			
(a) Fiber optics	X	N/A	Test the fiber-optic transmission line by the use of an optical power meter or by an optical time domain reflectometer used to measure the relative power loss of the line. Test result data must meet or exceed ANSI/TIA 568.C.3, *Optical Fiber Cabling Components Standard*, related to fiber-optic lines and connection/splice losses and the control unit manufacturer's published specifications.
(b) Circuit integrity	X	N/A	For initial and reacceptance testing, confirm the introduction of a fault in any circuit monitored for integrity results in a trouble indication at the fire alarm control unit. Open one connection at not less than 10 percent of the initiating devices, notification appliances, and controlled devices on every initiating device circuit, notification appliance circuit, and signaling line circuit. Confirm all circuits perform as indicated in Sections 23.5, 23.6, and 23.7.
	N/A	Annually	For periodic testing, test each initiating device circuit, notification appliance circuit, and signaling line circuit for correct indication at the control unit. Confirm all circuits perform as indicated in Sections 23.5, 23.6, and 23.7.
17. Initiating devices[f]			
(a) Electromechanical releasing device			
(1) Nonrestorable-type link	X	Annually	Verify correct operation by removal of the fusible link and operation of the associated device. Lubricate any moving parts as necessary.
(2) Restorable-type link[g]	X	Annually	Verify correct operation by removal of the fusible link and operation of the associated device. Lubricate any moving parts as necessary.
(b) Fire extinguishing system(s) or suppression system(s) alarm switch	X	Annually	Operate the switch mechanically or electrically and verify receipt of signal by the fire alarm control unit.
(c) Fire-gas and other detectors	X	Annually	Test fire-gas detectors and other fire detectors as prescribed by the manufacturer and as necessary for the application.
(d) Heat detectors			
(1) Fixed-temperature, rate-of-rise, rate of compensation, restorable line, spot type (excluding pneumatic tube type)	X	Annually (see 14.4.4.5)	Perform heat test with a listed and labeled heat source or in accordance with the manufacturer's published instructions. Assure that the test method for the installed equipment does not damage the nonrestorable fixed-temperature element of a combination rate-of-rise/fixed-temperature element detector.
(2) Fixed-temperature, nonrestorable line type	X	Annually	Do not perform heat test. Test functionality mechanically and electrically. Measure and record loop resistance. Investigate changes from acceptance test.
(3) Fixed-temperature, nonrestorable spot type	X	See Method	After 15 years from initial installation, replace all devices or have 2 detectors per 100 laboratory tested. Replace the 2 detectors with new devices. If a failure occurs on any of the detectors removed, remove and test additional detectors to determine either a general problem involving faulty detectors or a localized problem involving 1 or 2 defective detectors. If detectors are tested instead of replaced, repeat tests at intervals of 5 years.
(4) Nonrestorable (general)	X	Annually	Do not perform heat tests. Test functionality mechanically and electrically.
(5) Restorable line type, pneumatic tube only	X	Annually	Perform heat tests (where test chambers are in circuit), with a listed and labeled heat source or in accordance with the manufacturer's published instructions of the detector or conduct a test with pressure pump.

(continues)

Table 14.4.3.2 *Continued*

Component	Initial Acceptance	Periodic Frequency	Method
17. Initiating devices[f]			
(d) Heat detectors *(continued)*			
(6) Single- and multiple-station heat alarms	X	Annually	Conduct functional tests according to manufacturer's published instructions. Do not test nonrestorable heat detectors with heat.
(e) Manual fire alarm boxes	X	Annually	Operate manual fire alarm boxes per the manufacturer's published instructions. Test both key-operated presignal and general alarm manual fire alarm boxes.
(f) Radiant energy fire detectors	X	Semiannually	Test flame detectors and spark/ember detectors in accordance with the manufacturer's published instructions to determine that each detector is operative. Determine flame detector and spark/ember detector sensitivity using any of the following: (1) Calibrated test method (2) Manufacturer's calibrated sensitivity test instrument (3) Listed control unit arranged for the purpose (4) Other approved calibrated sensitivity test method that is directly proportional to the input signal from a fire, consistent with the detector listing or approval If designed to be field adjustable, replace detectors found to be outside of the approved range of sensitivity or adjust to bring them into the approved range. Do not determine flame detector and spark/ember detector sensitivity using a light source that administers an unmeasured quantity of radiation at an undefined distance from the detector.
(g) Smoke detectors — functional test			
(1) In other than one- and two-family dwellings, system detectors	X	Annually	[h]Test smoke detectors in place to ensure smoke entry into the sensing chamber and an alarm response. Use smoke or a listed and labeled product acceptable to the manufacturer or in accordance with their published instructions. Other methods listed in the manufacturer's published instructions that ensure smoke entry from the protected area, through the vents, into the sensing chamber can be used.
(2) Single- and multiple-station smoke alarms connected to protected premises systems	X	Annually	Perform a functional test on all single- and multiple-station smoke alarms connected to a protected premises fire alarm system by putting the smoke alarm into an alarm condition and verifying that the protected premises system receives a supervisory signal and does not cause a fire alarm signal.
(3) System smoke detectors used in one- and two-family dwellings	X	Annually	Conduct functional tests according to manufacturer's published instructions.
(4) Air sampling	X	Annually	Test with smoke or a listed and labeled product acceptable to the manufacturer or in accordance with their published instructions. Test from the end sampling port or point on each pipe run. Verify airflow through all other ports or points.
(5) Duct type	X	Annually	In addition to the testing required in Table 14.4.3.2(g)(1) and Table 14.4.3.2(h), test duct smoke detectors that use sampling tubes to ensure that they will properly sample the airstream in the duct using a method acceptable to the manufacturer or in accordance with their published instructions.
(6) Projected beam type	X	Annually	Test the detector by introducing smoke, other aerosol, or an optical filter into the beam path.
(7) Smoke detector with built-in thermal element	X	Annually	Operate both portions of the detector independently as described for the respective devices.
(8) Smoke detectors with control output functions	X	Annually	Verify that the control capability remains operable even if all of the initiating devices connected to the same initiating device circuit or signaling line circuit are in an alarm state.
(h) Smoke detectors — sensitivity testing			
In other than one- and two-family dwellings, system detectors	N/A	See 14.4.4.3	Perform any of the following tests to ensure that each smoke detector is within its listed and marked sensitivity range: (1) Calibrated test method (2) Manufacturer's calibrated sensitivity test instrument (3) Listed control equipment arranged for the purpose

Table 14.4.3.2 *Continued*

Component	Initial Acceptance	Periodic Frequency	Method
			(4) Smoke detector/control unit arrangement whereby the detector causes a signal at the control unit when its sensitivity is outside its listed sensitivity range (5) Other calibrated sensitivity test method approved by the authority having jurisdiction
(i) Carbon monoxide detectors/carbon monoxide alarms for the purposes of fire detection	X	Annually	Test the devices in place to ensure CO entry to the sensing chamber by introduction through the vents, to the sensing chamber of listed and labeled product acceptable to the manufacturer or in accordance with their published instructions.
(j) Initiating devices, supervisory			
(1) Control valve switch	X	Annually	Operate valve and verify signal receipt to be within the first two revolutions of the handwheel or within one-fifth of the travel distance, or per the manufacturer's published instructions.
(2) High- or low-air pressure switch	X	Annually	Operate switch and verify receipt of signal is obtained where the required pressure is increased or decreased a maximum 10 psi (70 kPa) from the required pressure level.
(3) Room temperature switch	X	Annually	Operate switch and verify receipt of signal to indicate the decrease in room temperature to 40°F (4.4°C) and its restoration to above 40°F (4.4°C).
(4) Water level switch	X	Annually	Operate switch and verify receipt of signal indicating the water level raised or lowered a maximum 3 in. (70 mm) from the required level within a pressure tank, or a maximum 12 in. (300 mm) from the required level of a nonpressure tank. Also verify its restoral to required level.
(5) Water temperature switch	X	Annually	Operate switch and verify receipt of signal to indicate the decrease in water temperature to 40°F (4.4°C) and its restoration to above 40°F (4.4°C).
(k) Mechanical, electrosonic, or pressure-type waterflow device	X	Semiannually	Water shall be flowed through an inspector's test connection indicating the flow of water equal to that from a single sprinkler of the smallest orifice size installed in the system for wet-pipe systems, or an alarm test bypass connection for dry-pipe, pre-action, or deluge systems in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*.
(l) Multi-sensor fire detector or multi-criteria fire detector or combination fire detector	X	Annually	Test each of the detection principles present within the detector (e.g., smoke/heat/CO, etc.) independently for the specific detection principle, regardless of the configuration status at the time of testing. Also test each detector in accordance with the published manufacturer's instructions. Test individual sensors together if the technology allows individual sensor responses to be verified. Perform tests as described for the respective devices by introduction of the physical phenomena to the sensing chamber of element, and an electronic check (magnets, analogue values, etc.) is not sufficient to comply with this requirement. Confirm the result of each sensor test through indication at the detector or control unit. Where individual sensors cannot be tested individually, test the primary sensor. Record all tests and results.
18. Special hazard equipment			
(a) Abort switch (dead-man type)	X	Annually	Operate abort switch and verify correct sequence and operation.
(b) Abort switch (recycle type)	X	Annually	Operate abort switch and verify development of correct matrix with each sensor operated.
(c) Abort switch (special type)	X	Annually	Operate abort switch and verify correct sequence and operation in accordance with authority having jurisdiction. Observe sequencing as specified on as-built drawings or in system owner's manual.
(d) Cross-zone detection circuit	X	Annually	Operate one sensor or detector on each zone. Verify occurrence of correct sequence with operation of first zone and then with operation of second zone.
(e) Matrix-type circuit	X	Annually	Operate all sensors in system. Verify development of correct matrix with each sensor operated.
(f) Release solenoid circuit[k]	X	Annually	Verify operation of solenoid.
(g) Squibb release circuit	X	Annually	Use ACI flashbulb or other test light approved by the manufacturer. Verify operation of flashbulb or light.
(h) Verified, sequential, or counting zone circuit	X	Annually	Operate required sensors at a minimum of four locations in circuit. Verify correct sequence with both the first and second detector in alarm.
(i) All above devices or circuits or combinations thereof	X	Annually	Verify supervision of circuits by creating an open circuit.

(continues)

Table 14.4.3.2 *Continued*

Component	Initial Acceptance	Periodic Frequency	Method
19. Combination systems			
(a) Fire extinguisher electronic monitoring device/system	X	Annually	Test communication between the device connecting the fire extinguisher electronic monitoring device/system and the fire alarm control unit to ensure proper signals are received at the fire alarm control unit and remote annunciator(s) if applicable.
(b) Carbon monoxide[l] device/system	X	Annually	Test communication between the device connecting the carbon monoxide device/system and the fire alarm control unit to ensure proper signals are received at the fire alarm control unit and remote annunciator(s) if applicable.
20. Interface equipment[m]	X	See 14.4.4.4	Test interface equipment connections by operating or simulating the equipment being supervised. Verify signals required to be transmitted are received at the control unit. Test frequency for interface equipment is the same as the frequency required by the applicable NFPA standard(s) for the equipment being supervised.
21. Guard's tour equipment	X	Annually	Test the device in accordance with the manufacturer's published instructions.
22. Alarm notification appliances			
(a) Audible[n]	X	N/A	For initial and reacceptance testing, measure sound pressure levels for signals with a sound level meter meeting ANSI S1.4a, *Specifications for Sound Level Meters*, Type 2 requirements. Measure sound pressure levels throughout the protected area to confirm that they are in compliance with Chapter 18. Set the sound level meter in accordance with ANSI S3.41, *American National Standard Audible Evacuation Signal*, using the time-weighted characteristic F (FAST).
	N/A	Annually	[n]For periodic testing, verify the operation of the notification appliances.
(b) Audible textual notification appliances (speakers and other appliances to convey voice messages)	X	N/A	For initial and reacceptance testing, measure sound pressure levels for signals with a sound level meter meeting ANSI S1.4a, *Specifications for Sound Level Meters*, Type 2 requirements. Measure sound pressure levels throughout the protected area to confirm that they are in compliance with Chapter 18. Set the sound level meter in accordance with ANSI S3.41, *American National Standard Audible Evacuation Signal*, using the time-weighted characteristic F (FAST). Verify audible information to be distinguishable and understandable and in compliance with 14.4.11.
	N/A	Annually	[n]For periodic testing, verify the operation of the notification appliances.
(c) Visible	X	N/A	Perform initial and reacceptance testing in accordance with the manufacturer's published instructions. Verify appliance locations to be per approved layout and confirm that no floor plan changes affect the approved layout. Verify that the candela rating marking agrees with the approved drawing. Confirm that each appliance flashes.
	N/A	Annually	For periodic testing, verify that each appliance flashes.
23. Exit marking audible notification appliance	X	Annually	Perform tests in accordance with manufacturer's published instructions.
24. Emergency control functions[o]	X	Annually	For initial, reacceptance, and periodic testing, verify emergency control function interface device activation. Where an emergency control function interface device is disabled or disconnected during initiating device testing, verify that the disabled or disconnected emergency control function interface device has been properly restored. [
25. Area of refuge two-way communication system	X	Annually	At a minimum, test the two-way communication system to verify operation and receipt of visual and audible signals at the transmitting and receiving unit respectively. Operate systems with more than five stations with a minimum of five stations operating simultaneously. Verify voice quality and clarity.
26. Special procedures			
(a) Alarm verification	X	Annually	Verify time delay and alarm response for smoke detector circuits identified as having alarm verification.
(b) Multiplex systems	X	Annually	Verify communications between sending and receiving units under both primary and secondary power. Verify communications between sending and receiving units under open-circuit and short-circuit trouble conditions.

Table 14.4.3.2 *Continued*

Component	Initial Acceptance	Periodic Frequency	Method
			Verify communications between sending and receiving units in all directions where multiple communications pathways are provided. If redundant central control equipment is provided, verify switchover and all required functions and operations of secondary control equipment. Verify all system functions and features in accordance with manufacturer's published instructions.
27. Supervising station alarm systems — receiving equipment			
(a) All equipment	X	Monthly	Perform tests on all system functions and features in accordance with the equipment manufacturer's published instructions for correct operation in conformance with the applicable sections of Chapter 26. Actuate initiating device and verify receipt of the correct initiating device signal at the supervising station within 90 seconds. Upon completion of the test, restore the system to its functional operating condition. If test jacks are used, perform the first and last tests without the use of the test jack.
(b) Digital alarm communicator receiver (DACR)	X	Monthly	Disconnect each transmission means in turn from the DACR, and verify audible and visual annunciation of a trouble signal in the supervising station. Cause a signal to be transmitted on each individual incoming DACR line (path) at least once every 6 hours (24 hours for DACTs installed prior to adoption of the 2013 edition of *NFPA 72*). Verify receipt of these signals.
(c) Digital alarm radio receiver (DARR)	X	Monthly	Cause the following conditions of all DARRs on all subsidiary and repeater station receiving equipment. Verify receipt at the supervising station of correct signals for each of the following conditions: (1) AC power failure of the radio equipment (2) Receiver malfunction (3) Antenna and interconnecting cable failure (4) Indication of automatic switchover of the DARR (5) Data transmission line failure between the DARR and the supervising or subsidiary station
(d) McCulloh systems	X	Monthly	Test and record the current on each circuit at each supervising and subsidiary station under the following conditions: (1) During functional operation (2) On each side of the circuit with the receiving equipment conditioned for an open circuit Cause a single break or ground condition on each transmission channel. If such a fault prevents the functioning of the circuit, verify receipt of a trouble signal. Cause each of the following conditions at each of the supervising or subsidiary stations and all repeater station radio transmitting and receiving equipment; verify receipt of correct signals at the supervising station: (1) RF transmitter in use (radiating) (2) AC power failure supplying the radio equipment (3) RF receiver malfunction (4) Indication of automatic switchover
(e) Radio alarm supervising station receiver (RASSR) and radio alarm repeater station receiver (RARSR)	X	Monthly	Cause each of the following conditions at each of the supervising or subsidiary stations and all repeater station radio transmitting and receiving equipment; verify receipt of correct signals at the supervising station: (1) AC power failure supplying the radio equipment (2) RF receiver malfunction (3) Indication of automatic switchover, if applicable
(f) Private microwave radio systems	X	Monthly	Cause each of the following conditions at each of the supervising or subsidiary stations and all repeater station radio transmitting and receiving equipment; verify receipt of correct signals at the supervising station: (1) RF transmitter in use (radiating) (2) AC power failure supplying the radio equipment (3) RF receiver malfunction (4) Indication of automatic switchover

(continues)

Table 14.4.3.2 *Continued*

Component	Initial Acceptance	Periodic Frequency	Method
27. Supervising station alarm systems — receiving equipment *(continued)*			
(g) Performance-based technologies	X	Monthly	Perform tests to ensure the monitoring of integrity of the transmission technology and technology path. Where a single communications path is used, disconnect the communication path. Verify that failure of the path is annunciated at the supervising station within 60 minutes of the failure (within 5 minutes for communication equipment installed prior to adoption of the 2013 edition of *NFPA 72*). Restore the communication path. Where multiple communication paths are used, disconnect both communication paths and confirm that failure of the path is annunciated at the supervising station within not more than 6 hours of the failure (within 24 hours for communication equipment installed prior to adoption of the 2013 edition of *NFPA 72*). Restore both communication paths.
28. Public emergency alarm reporting system transmission equipment			
(a) Publicly accessible alarm box	X	Semiannually	Actuate publicly accessible initiating device(s) and verify receipt of not less than three complete rounds of signal impulses. Perform this test under normal circuit conditions. If the device is equipped for open circuit operation (ground return), test it in this condition as one of the semiannual tests.
(b) Auxiliary box	X	Annually	Test each initiating circuit of the auxiliary box by actuation of a protected premises initiating device connected to that circuit. Verify receipt of not less than three complete rounds of signal impulses.
(c) Master box			
(1) Manual operation	X	Semiannually	Perform the tests prescribed for 28(a).
(2) Auxiliary operation	X	Annually	Perform the tests prescribed for 28(b).
29. Low-power radio (wireless systems)	X	N/A	The following procedures describe additional acceptance and reacceptance test methods to verify wireless protection system operation: (1) Use the manufacturer's published instructions and the as-built drawings provided by the system supplier to verify correct operation after the initial testing phase has been performed by the supplier or by the supplier's designated representative. (2) Starting from the functional operating condition, initialize the system in accordance with the manufacturer's published instructions. Confirm the alternative communications path exists between the wireless control unit and peripheral devices used to establish initiation, indication, control, and annunciation. Test the system for both alarm and trouble conditions. (3) Check batteries for all components in the system monthly unless the control unit checks all batteries and all components daily.
30. Mass notification systems			
(a) Functions	X	Annually	At a minimum, test control equipment to verify correct receipt of alarm, supervisory, and trouble signals (inputs); operation of evacuation signals and auxiliary functions (outputs); circuit supervision, including detection of open circuits and ground faults; and power supply supervision for detection of loss of ac power and disconnection of secondary batteries.
(b) Fuses	X	Annually	Verify the rating and supervision.
(c) Interfaced equipment	X	Annually	Verify integrity of single or multiple circuits providing interface between two or more control units. Test interfaced equipment connections by operating or simulating operation of the equipment being supervised. Verify signals required to be transmitted at the control unit.
(d) Lamps and LEDs	X	Annually	Illuminate lamps and LEDs.
(e) Primary (main) power supply	X	Annually	Disconnect all secondary (standby) power and test under maximum load, including all alarm appliances requiring simultaneous operation. Reconnect all secondary (standby) power at end of test. For redundant power supplies, test each separately.
(f) Audible textual notification appliances (speakers and other appliances to convey voice messages)	X	Annually	Measure sound pressure level with a sound level meter meeting ANSI S1.4a, *Specifications for Sound Level Meters*, Type 2 requirements. Measure and record levels throughout protected area. Set the sound level meter in accordance with ANSI S3.41, *American National Standard Audible Emergency Evacuation Signal*, using the time-weighted characteristic F (FAST). Record the maximum output when the audible emergency evacuation signal is on. Verify audible information to be distinguishable and understandable.

Table 14.4.3.2 *Continued*

Component	Initial Acceptance	Periodic Frequency	Method
(g) Visible	X	Annually	Perform test in accordance with manufacturer's published instructions. Verify appliance locations to be per approved layout and confirm that no floor plan changes affect the approved layout. Verify that the candela rating marking agrees with the approved drawing. Confirm that each appliance flashes.
(h) Control unit functions and no diagnostic failures are indicated	X	Annually	Review event log file and verify that the correct events were logged. Review system diagnostic log file; correct deficiencies noted in file. Delete unneeded log files. Delete unneeded error files. Verify that sufficient free disk space is available. Verify unobstructed flow of cooling air is available. Change/clean filters, cooling fans, and intake vents.
(i) Control unit reset	X	Annually	Power down the central control unit computer and restart it.
(j) Control unit security	X	Annually	If remote control software is loaded onto the system, verify that it is disabled to prevent unauthorized system access.
(k) Audible/visible functional test	X	Annually	Send out an alert to a diverse set of predesignated receiving devices and confirm receipt. Include at least one of each type of receiving device.
(l) Software backup	X	Annually	Make full system software backup. Rotate backups based on accepted practice at site.
(m) Secondary power test	X	Annually	Disconnect ac power. Verify the ac power failure alarm status on central control equipment. With ac power disconnected, verify battery voltage under load.
(n) Wireless signals	X	Annually	Check forward/reflected radio power is within specifications.
(o) Antenna	X	Annually	Check forward/reflected radio power is within specifications. Verify solid electrical connections with no observable corrosion.
(p) Transceivers	X	Annually	Verify proper operation and mounting is not compromised.

[a] Some transmission equipment (such as but not limited to cable modems, fiber-optic interface nodes, and VoIP interfaces) are typically powered by the building's electrical system using a standby power supply that does not meet the requirements of this Code. This is intended to ensure that the testing authority verifies full standby power as required by Chapter 10. Additionally, refer to Table 14.4.3.2, Items 7 through 9 for secondary power supply testing.

[b] The automatic transmission of the check-in (handshake) signal can take up to 60 minutes to occur.

[c] See Table 14.4.3.2, Item 4(a) for the testing of transmission equipment.

[d] Example: 4000 mAh × 1/40 = 160 mA charging current at 77°F (25°C).

[e] The voltmeter sensitivity has been changed from 1000 ohms per volt to 100 ohms per volt so that the false ground readings (caused by induced voltages) are minimized.

[f] Initiating devices such as smoke detectors used for elevator recall, closing dampers, or releasing doors held in the open position that are permitted by the Code *(see* NFPA *101, Life Safety Code, 9.6.3)* to initiate supervisory signals at the fire alarm control unit (FACU) should be tested at the same frequency (annual) as those devices when they are generating an alarm signal. They are not supervisory devices, but they initiate a supervisory signal at the FACU.

[g] Fusible thermal link detectors are commonly used to close fire doors and fire dampers. They are actuated by the presence of external heat, which causes a solder element in the link to fuse, or by an electric thermal device, which, when energized, generates heat within the body of the link, causing the link to fuse and separate.

[h] Note, it is customary for the manufacturer of the smoke detector to test a particular product from an aerosol provider to determine acceptability for use in smoke entry testing of their smoke detector/ smoke alarm. Magnets are not acceptable for smoke entry tests.

[i] There are some detectors that use magnets as a manufacturer's calibrated sensitivity test instrument.

[j] For example, it might not be possible to individually test the heat sensor in a thermally enhanced smoke detector.

[k] Manufacturer's instructions should be consulted to ensure a proper operational test. No suppression gas or agent is expected to be discharged during the test of the solenoid. See Test Plan of 14.2.10.

[l] Testing of CO device should be done to the requirements of NFPA 720, *Standard for the Installation of Carbon Monoxide (CO) Detection and Warning Equipment.*

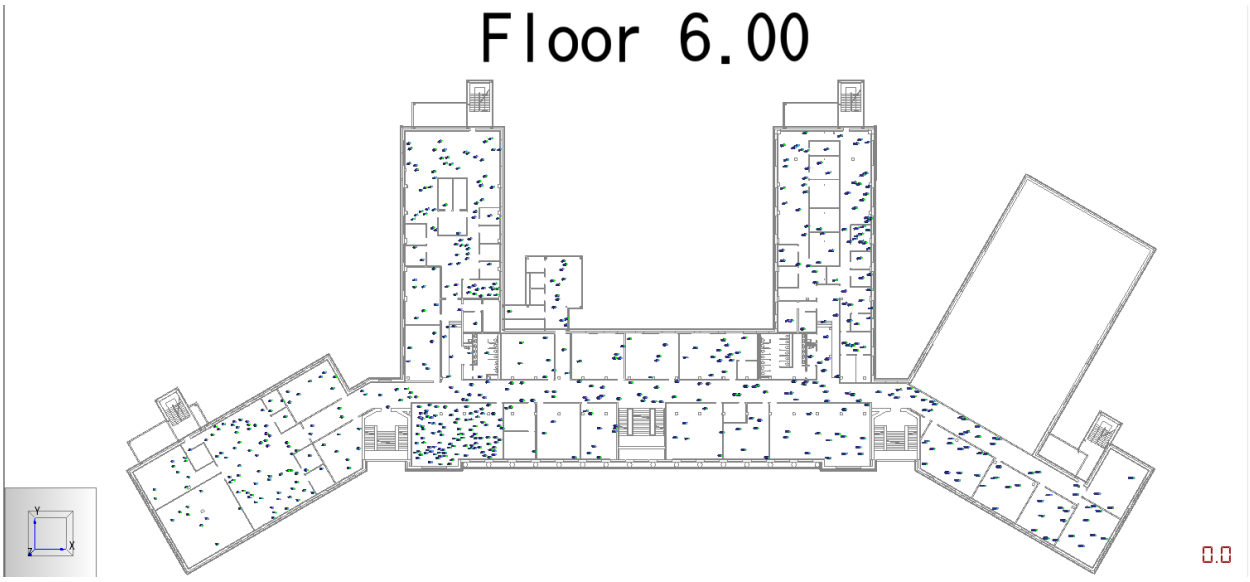
[m] A monitor module installed on an interface device is not considered a supervisory device and therefore not subject to the quarterly testing frequency requirement. Test frequencies for interface devices should be in accordance with the applicable standard. For example, fire pump controller alarms such as phase reversal are required to be tested annually. If a monitor module is installed to identify phase reversal on the fire alarm control panel, it is not necessary to test for phase reversal four times a year.

[n] Chapter 18 would require 15 dB over average ambient sound for public mode spaces. Sometimes the ambient sound levels are different from what the design was based upon. Private operating mode would require 10 dB over average ambient at the location of the device.

[o] Where building, system, or occupancy changes have been observed, the owner should be notified of the changes. New devices might need to be installed and tested per the initial acceptance testing criteria.

[p] See A.14.4.3.2, and Table 14.4.3.2, Item 24.

Appendix O: Pathfinder Results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0.0

Appendix P: Flow Model “Hand” Calculations

Each stair is 40 in. wide, each door is 36 in. wide.

$$F_{sm,stairs} = 17.1 \frac{persons/min.}{ft.} \qquad F_{sm,doors} = 24 \frac{persons/min.}{ft.}$$

$$F_c = F_s W_e = 17.1 \cdot \frac{40}{12} = 56.6 \frac{persons}{min.} \qquad F_c = 24 \cdot \frac{40}{12} = 72 \frac{persons}{min.}$$

Stairs are the restricting factor.

$$S_f = 20\%$$

$$\rightarrow F_{c,stair} = 48 \frac{persons}{min.}$$

$$502\ persons \Big/ 2 \cdot 48 \frac{persons}{min.} = 5.2\ min. = 314\ s$$

$$266\ persons \Big/ 2 \cdot 48 \frac{persons}{min.} = 2.8\ min. = 165\ s$$

Appendix Q: FDS Model Input File

```
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Generated by PyroSim - Version 2014.1.0110
May 5, 2014 8:14:48 PM

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&DUMP RENDER_FILE='Scenario_3sg.ge1', DT_HRR=0.02, DT_RESTART=300.0/

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&SPEC ID='WATER VAPOR'/

&PART ID='Water_PART',
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     H=1.7,
     O=0.3,
     N=0.08,
     CO_YIELD=0.042,
     SOOT_YIELD=0.0356/

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     FLOW_RATE=54.5,
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&OBST XB=109.5,110.5,198.75,199.0,4.0,4.5, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,199.0,199.5,4.25,4.5, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,199.5,199.75,4.5,4.75, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,199.75,200.0,4.5,5.0, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,200.0,200.25,4.75,5.25, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,200.25,200.5,5.0,5.5, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,200.5,201.0,5.25,5.5, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,201.0,201.25,5.5,5.75, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,201.25,201.5,5.5,6.0, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,201.5,201.75,5.75,6.25, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,201.75,202.0,6.0,6.5, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,202.0,202.5,6.25,6.5, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,202.5,202.75,6.5,6.75, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,202.75,203.0,6.5,7.0, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,203.0,203.25,6.75,7.25, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,203.25,203.5,7.0,7.5, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,203.5,204.0,7.25,7.5, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,204.0,204.25,7.5,7.75, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,204.25,204.5,7.5,8.0, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,205.0,206.25,7.75,8.0, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,204.5,204.75,7.75,8.25, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=109.5,110.5,204.75,205.0,8.0,8.5, COLOR='INVISIBLE', SURF_ID='INERT'/ Obstruction

&OBST XB=93.75,94.0,203.75,236.75,0.0,16.0, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,95.0,227.5,227.75,2.0,2.25, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,96.0,227.75,229.0,2.0,2.25, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,96.25,206.0,206.25,3.75,4.0, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,100.75,198.75,203.75,3.75,4.0, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,100.75,203.75,205.75,3.75,4.0, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,101.0,198.5,198.75,0.0,9.5, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,101.0,205.75,206.0,3.75,4.0, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,101.0,205.25,206.25,7.75,8.0, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,101.0,204.25,205.25,8.0,8.25, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,101.0,203.25,203.75,8.25,8.5, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,101.0,203.75,204.25,8.25,8.5, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,101.0,202.25,203.25,8.5,8.75, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,101.0,201.25,202.25,8.75,9.0, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,101.0,200.25,201.25,9.0,9.25, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,101.0,199.25,200.25,9.25,9.5, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,101.0,198.25,198.5,9.5,9.75, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,101.0,198.5,199.25,9.5,9.75, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,101.0,198.5,198.75,9.75,16.0, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,107.0,236.5,236.75,2.0,2.25, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,117.25,229.0,236.5,2.0,2.25, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,117.5,206.25,207.25,7.75,8.0, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

&OBST XB=94.5,96.0,227.75,228.0,0.0,2.0, SURF_ID='INERT'/ Obstruction

&OBST XB=95.75,96.0,228.0,229.0,0.0,2.0, SURF_ID='INERT'/ Obstruction

&OBST XB=95.75,115.5,229.0,229.25,0.0,2.0, SURF_ID='INERT'/ Obstruction

&OBST XB=96.25,96.5,198.75,200.75,0.0,2.75, SURF_ID='INERT'/ Obstruction

&OBST XB=96.25,98.0,232.5,232.75,0.0,2.0, SURF_ID='INERT'/ Obstruction

&OBST XB=96.25,98.0,232.5,232.75,2.25,4.75, SURF_ID='INERT'/ Obstruction

&OBST XB=96.25,101.0,206.0,206.25,4.0,7.75, SURF_ID='INERT'/ Obstruction

&OBST XB=97.5,101.0,200.5,200.75,0.0,2.75, SURF_ID='INERT'/ Obstruction

&OBST XB=97.75,98.0,235.0,236.75,0.0,2.0, SURF_ID='INERT'/ Obstruction

&OBST XB=97.75,98.0,235.0,236.75,2.25,4.75, SURF_ID='INERT'/ Obstruction

&OBST XB=100.75,101.0,198.75,200.5,0.0,2.75, SURF_ID='INERT'/ Obstruction

&OBST XB=100.75,101.0,205.25,205.75,4.0,7.75, SURF_ID='INERT'/ Obstruction

&OBST XB=100.75,101.0,198.25,198.5,4.0,8.0, SURF_ID='INERT'/ Obstruction

&OBST XB=100.75,101.0,198.75,205.25,4.0,8.0, SURF_ID='INERT'/ Obstruction

&OBST XB=101.0,102.0,198.5,198.75,0.0,16.0, SURF_ID='INERT'/ Obstruction

&OBST XB=101.75,102.0,198.25,198.5,4.0,8.0, SURF_ID='INERT'/ Obstruction

&OBST XB=101.75,102.0,198.75,203.25,4.0,8.0, SURF_ID='INERT'/ Obstruction

&OBST XB=102.0,109.25,198.5,198.75,0.0,3.75, SURF_ID='INERT'/ Obstruction

&OBST XB=102.0,109.25,198.5,206.0,3.75,4.0, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

&OBST XB=102.0,109.25,206.0,206.25,4.0,7.75, SURF_ID='INERT'/ Obstruction

&OBST XB=102.0,109.25,198.5,198.75,4.0,9.5, SURF_ID='INERT'/ Obstruction

&OBST XB=102.0,109.25,205.25,206.25,7.75,8.0, SURF_ID='INERT'/ Obstruction

&OBST XB=102.0,109.25,204.25,205.25,8.0,8.25, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=102.0,109.25,203.25,204.25,8.25,8.5, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=102.0,109.25,202.25,203.25,8.5,8.75, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=102.0,109.25,201.25,202.25,8.75,9.0, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=102.0,109.25,200.25,201.25,9.0,9.25, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=102.0,109.25,199.25,200.25,9.25,9.5, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=102.0,109.25,198.25,199.25,9.5,9.75, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=102.0,109.25,198.5,198.75,9.75,16.0, SURF_ID='INERT'/ Obstruction

&OBST XB=102.5,102.75,198.75,202.0,0.0,2.75, SURF_ID='INERT'/ Obstruction

&OBST XB=108.25,108.5,198.75,201.75,0.0,2.75, SURF_ID='INERT'/ Obstruction

&OBST XB=109.25,109.5,198.25,198.5,4.0,8.0, SURF_ID='INERT'/ Obstruction

&OBST XB=109.25,109.5,198.75,206.25,4.0,8.0, SURF_ID='INERT'/ Obstruction

&OBST XB=109.25,110.25,198.5,198.75,0.0,16.0, SURF_ID='INERT'/ Obstruction

&OBST XB=110.0,110.25,198.75,200.75,0.0,2.75, SURF_ID='INERT'/ Obstruction

&OBST XB=110.0,114.75,200.75,201.0,0.0,2.75, SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,114.75,198.5,198.75,3.75,4.0, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,117.25,205.5,206.0,3.75,4.0, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,117.5,198.75,205.5,3.75,4.0, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,117.75,206.0,206.25,4.0,7.75, SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,117.75,205.25,206.0,7.75,8.0, SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,117.75,206.0,206.25,7.75,8.0, SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,117.75,204.25,205.25,8.0,8.25, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,117.75,203.25,204.25,8.25,8.5, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,117.75,202.25,203.25,8.5,8.75, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,117.75,201.25,202.25,8.75,9.0, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,117.75,200.25,201.25,9.0,9.25, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,117.75,199.25,200.25,9.25,9.5, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,117.75,198.25,199.25,9.5,9.75, RGB=51,51,0, SURF_ID='INERT'/ Obstruction

&OBST XB=114.5,114.75,198.5,200.5,0.0,2.75, SURF_ID='INERT'/ Obstruction

&OBST XB=114.75,117.5,198.25,198.5,0.0,9.5, SURF_ID='INERT'/ Obstruction

&OBST XB=114.75,117.5,198.5,198.75,3.75,4.0, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

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&OBST XB=115.25,115.5,228.0,229.0,0.0,2.0, SURF_ID='INERT'/ Obstruction

&OBST XB=115.25,117.25,227.75,228.0,0.0,2.0, SURF_ID='INERT'/ Obstruction

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&OBST XB=94.0,94.5,227.75,227.75,0.0,2.0, SURF_ID='INERT'/ Obstruction

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&OBST XB=94.0,96.25,232.5,232.5,2.25,4.75, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,96.25,206.25,206.25,4.0,7.75, SURF_ID='INERT'/ Obstruction

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&OBST XB=110.25,110.5,198.5,198.5,0.0,16.0, SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,114.5,198.5,198.5,0.0,3.75, SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,114.75,198.5,198.5,4.0,9.5, SURF_ID='INERT'/ Obstruction

&OBST XB=110.5,114.75,198.5,198.5,9.75,16.0, SURF_ID='INERT'/ Obstruction

&OBST XB=113.5,117.25,232.5,232.5,0.0,2.0, SURF_ID='INERT'/ Obstruction

&OBST XB=113.5,117.25,232.5,232.5,2.25,4.75, SURF_ID='INERT'/ Obstruction

&OBST XB=114.5,114.75,198.5,198.5,2.75,3.75, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,94.0,198.75,203.75,0.0,3.75, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,94.0,203.25,203.75,4.0,8.25, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,94.0,202.25,203.25,4.0,8.5, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,94.0,201.25,202.25,4.0,8.75, SURF_ID='INERT'/ Obstruction

&OBST XB=94.0,94.0,200.25,201.25,4.0,9.0, SURF_ID='INERT'/ Obstruction

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&OBST XB=94.0,94.0,199.25,200.25,4.0,9.25, SURF_ID='INERT'/ Obstruction
&OBST XB=94.0,94.0,198.75,199.25,4.0,9.5, SURF_ID='INERT'/ Obstruction
&OBST XB=94.0,94.0,203.25,203.75,8.5,16.0, SURF_ID='INERT'/ Obstruction
&OBST XB=94.0,94.0,202.25,203.25,8.75,16.0, SURF_ID='INERT'/ Obstruction
&OBST XB=94.0,94.0,201.25,202.25,9.0,16.0, SURF_ID='INERT'/ Obstruction
&OBST XB=94.0,94.0,200.25,201.25,9.25,16.0, SURF_ID='INERT'/ Obstruction
&OBST XB=94.0,94.0,199.25,200.25,9.5,16.0, SURF_ID='INERT'/ Obstruction
&OBST XB=94.0,94.0,198.75,199.25,9.75,16.0, SURF_ID='INERT'/ Obstruction
&OBST XB=98.0,98.0,232.75,235.0,0.0,2.0, SURF_ID='INERT'/ Obstruction
&OBST XB=98.0,98.0,232.75,235.0,2.25,4.75, SURF_ID='INERT'/ Obstruction
&OBST XB=101.0,101.0,205.75,206.0,4.0,7.75, SURF_ID='INERT'/ Obstruction
&OBST XB=102.0,102.0,205.25,206.0,4.0,7.75, SURF_ID='INERT'/ Obstruction
&OBST XB=102.0,102.0,203.25,205.25,4.0,8.0, SURF_ID='INERT'/ Obstruction
&OBST XB=110.5,110.5,205.25,206.0,4.0,7.75, SURF_ID='INERT'/ Obstruction
&OBST XB=110.5,110.5,198.0,205.25,4.0,8.0, SURF_ID='INERT'/ Obstruction
&OBST XB=113.5,113.5,232.5,236.5,0.0,2.0, SURF_ID='INERT'/ Obstruction
&OBST XB=113.5,113.5,236.5,236.75,0.0,4.75, SURF_ID='INERT'/ Obstruction
&OBST XB=113.5,113.5,232.5,236.5,2.25,4.75, SURF_ID='INERT'/ Obstruction
&OBST XB=114.75,114.75,200.5,200.75,0.0,2.75, SURF_ID='INERT'/ Obstruction
&OBST XB=93.75,117.5,203.75,236.75,-2.25,-0.25, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction
&OBST XB=94.0,117.5,198.5,203.75,-2.25,-0.25, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction
&OBST XB=114.75,117.5,198.25,198.5,-2.25,-0.25, COLOR='GRAY 80', SURF_ID='INERT'/ Obstruction

&HOLE XB=109.4,110.389,197.975,199.1,0.0,2.0/ Hole
&HOLE XB=101.0,101.75,197.975,199.1,4.0,6.0/ Hole
&HOLE XB=101.0,101.75,197.975,199.1,0.0,2.0/ Hole
&HOLE XB=109.4,110.389,197.975,199.1,4.0,6.0/ Hole

&VENT SURF_ID='Fire', XB=106.5,107.5,232.5,233.5,2.25,2.25/ Vent

&SLCF QUANTITY='TEMPERATURE', PBY=213.482/
&SLCF QUANTITY='VELOCITY', VECTOR=.TRUE., PBY=213.482/
&SLCF QUANTITY='VISIBILITY', PBY=213.482/
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&TAIL /
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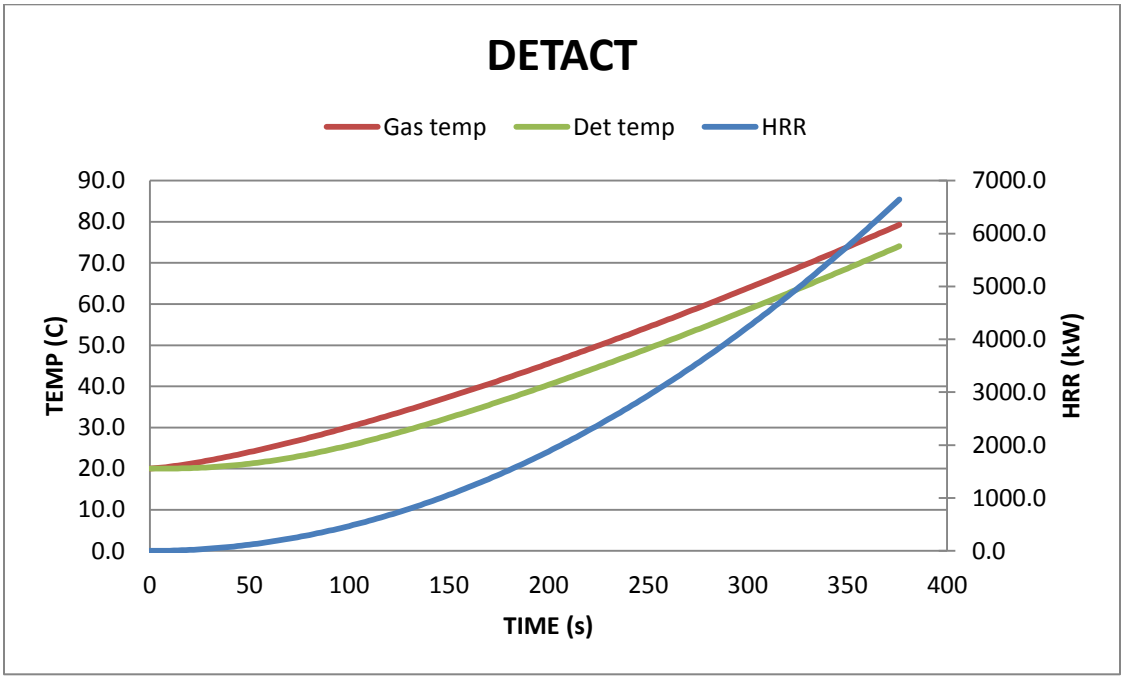
Appendix R: Sprinkler Activation DETACT Model



INPUT PARAMETERS			CALC. PARAMETERS	
Ceiling height (H)	12	m	R/H	0.333
Radial distance (R)	4.0	m	dT(cj)/dT(pl)	0.624
Ambient temperature (To)	20	C	u(cj)/u(pl)	0.500
Actuation temperature (Td)	74	C	Rep. t2 coeff.	k
Response time index (RTI)	50	(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)	2	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	0.00
2	0.2	20.1	0.13	20.00	0.00
4	0.8	20.1	0.20	20.00	0.00
6	1.7	20.2	0.26	20.00	0.00
8	3.0	20.3	0.32	20.01	0.00
10	4.7	20.5	0.37	20.02	0.01
12	6.8	20.6	0.41	20.03	0.01
14	9.2	20.7	0.46	20.04	0.01
16	12.0	20.9	0.50	20.06	0.01
18	15.2	21.0	0.54	20.08	0.01
20	18.8	21.2	0.58	20.11	0.02

22	22.7	21.3	0.62	20.14	0.02
24	27.1	21.5	0.66	20.18	0.02
26	31.8	21.7	0.69	20.22	0.02
28	36.8	21.9	0.73	20.27	0.03
30	42.3	22.0	0.76	20.33	0.03
32	48.1	22.2	0.79	20.39	0.03
34	54.3	22.4	0.83	20.45	0.04
36	60.9	22.6	0.86	20.52	0.04
38	67.9	22.8	0.89	20.60	0.04
40	75.2	23.0	0.92	20.68	0.04
42	82.9	23.2	0.95	20.77	0.05
44	91.0	23.4	0.98	20.87	0.05
46	99.5	23.6	1.01	20.97	0.05
48	108.3	23.8	1.04	21.07	0.06
50	117.5	24.0	1.07	21.18	0.06
52	127.1	24.2	1.10	21.30	0.06
54	137.1	24.5	1.13	21.42	0.06
56	147.4	24.7	1.15	21.55	0.07
58	158.1	24.9	1.18	21.69	0.07
60	169.2	25.1	1.21	21.83	0.07
62	180.7	25.4	1.23	21.97	0.08
64	192.5	25.6	1.26	22.12	0.08
66	204.7	25.8	1.29	22.28	0.08
68	217.3	26.1	1.31	22.44	0.08
70	230.3	26.3	1.34	22.60	0.09
72	243.6	26.5	1.36	22.78	0.09
74	257.4	26.8	1.39	22.95	0.09
76	271.5	27.0	1.41	23.13	0.09
78	285.9	27.3	1.44	23.32	0.09
80	300.8	27.5	1.46	23.51	0.10
82	316.0	27.8	1.49	23.70	0.10
84	331.6	28.0	1.51	23.90	0.10
86	347.6	28.3	1.53	24.10	0.10
88	364.0	28.5	1.56	24.31	0.11
90	380.7	28.8	1.58	24.52	0.11
92	397.8	29.1	1.60	24.74	0.11
94	415.3	29.3	1.63	24.96	0.11
96	433.2	29.6	1.65	25.18	0.11
98	451.4	29.9	1.67	25.41	0.12
100	470.0	30.1	1.70	25.64	0.12
102	489.0	30.4	1.72	25.87	0.12

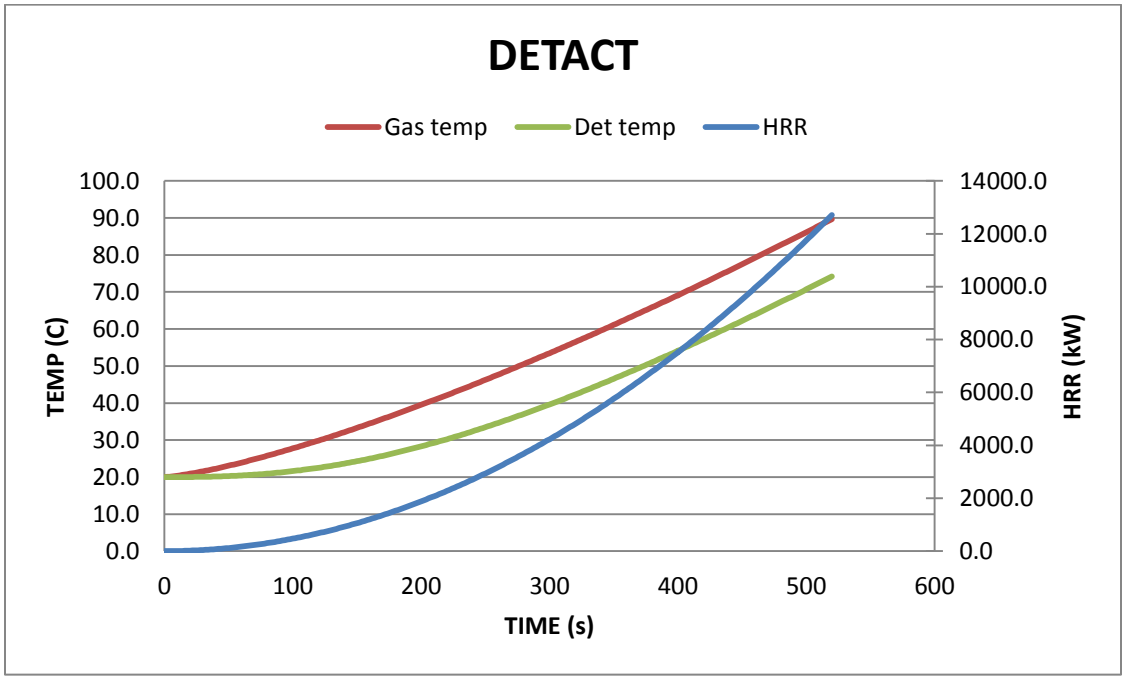
104	508.4	30.7	1.74	26.11	0.12
106	528.1	31.0	1.76	26.35	0.12
108	548.2	31.2	1.79	26.60	0.12
110	568.7	31.5	1.81	26.84	0.13
112	589.6	31.8	1.83	27.10	0.13
114	610.8	32.1	1.85	27.35	0.13
116	632.4	32.4	1.87	27.61	0.13
118	654.4	32.6	1.89	27.87	0.13
120	676.8	32.9	1.92	28.13	0.13
122	699.5	33.2	1.94	28.39	0.13
124	722.7	33.5	1.96	28.66	0.14
126	746.2	33.8	1.98	28.93	0.14
128	770.0	34.1	2.00	29.21	0.14
130	794.3	34.4	2.02	29.48	0.14
132	818.9	34.7	2.04	29.76	0.14
134	843.9	35.0	2.06	30.04	0.14
136	869.3	35.3	2.08	30.33	0.14
138	895.1	35.6	2.10	30.61	0.14
140	921.2	35.9	2.12	30.90	0.14
142	947.7	36.2	2.14	31.19	0.15
144	974.6	36.5	2.16	31.48	0.15
146	1001.9	36.8	2.18	31.78	0.15
148	1029.5	37.1	2.20	32.07	0.15
150	1057.5	37.4	2.22	32.37	0.15
152	1085.9	37.7	2.24	32.67	0.15
154	1114.7	38.0	2.26	32.97	0.15
156	1143.8	38.3	2.28	33.28	0.15
158	1173.3	38.7	2.30	33.58	0.15
160	1203.2	39.0	2.32	33.89	0.15
162	1233.5	39.3	2.34	34.20	0.16
164	1264.1	39.6	2.36	34.51	0.16
166	1295.1	39.9	2.38	34.82	0.16
168	1326.5	40.2	2.40	35.14	0.16
170	1358.3	40.6	2.42	35.45	0.16
172	1390.4	40.9	2.44	35.77	0.16
174	1423.0	41.2	2.45	36.09	0.16
176	1455.9	41.5	2.47	36.41	0.16
178	1489.1	41.9	2.49	36.73	0.16
180	1522.8	42.2	2.51	37.06	0.16
182	1556.8	42.5	2.53	37.38	0.16
184	1591.2	42.9	2.55	37.71	0.16

186	1626.0	43.2	2.57	38.04	0.16
188	1661.2	43.5	2.58	38.37	0.17
190	1696.7	43.9	2.60	38.70	0.17
192	1732.6	44.2	2.62	39.03	0.17
194	1768.9	44.5	2.64	39.37	0.17
196	1805.6	44.9	2.66	39.70	0.17
198	1842.6	45.2	2.68	40.04	0.17
200	1880.0	45.5	2.69	40.38	0.17
202	1917.8	45.9	2.71	40.71	0.17
204	1956.0	46.2	2.73	41.05	0.17
206	1994.5	46.6	2.75	41.40	0.17
208	2033.4	46.9	2.76	41.74	0.17
210	2072.7	47.3	2.78	42.08	0.17
212	2112.4	47.6	2.80	42.43	0.17
214	2152.4	48.0	2.82	42.77	0.17
216	2192.8	48.3	2.84	43.12	0.17
218	2233.6	48.7	2.85	43.47	0.17
220	2274.8	49.0	2.87	43.82	0.18
222	2316.3	49.4	2.89	44.17	0.18
224	2358.3	49.7	2.90	44.52	0.18
226	2400.6	50.1	2.92	44.88	0.18
228	2443.2	50.4	2.94	45.23	0.18
230	2486.3	50.8	2.96	45.59	0.18
232	2529.7	51.1	2.97	45.94	0.18
234	2573.5	51.5	2.99	46.30	0.18
236	2617.7	51.8	3.01	46.66	0.18
238	2662.3	52.2	3.02	47.02	0.18
240	2707.2	52.6	3.04	47.38	0.18
242	2752.5	52.9	3.06	47.74	0.18
244	2798.2	53.3	3.08	48.11	0.18
246	2844.3	53.7	3.09	48.47	0.18
248	2890.7	54.0	3.11	48.83	0.18
250	2937.5	54.4	3.13	49.20	0.18
252	2984.7	54.8	3.14	49.57	0.18
254	3032.3	55.1	3.16	49.94	0.18
256	3080.2	55.5	3.18	50.30	0.18
258	3128.5	55.9	3.19	50.67	0.19
260	3177.2	56.2	3.21	51.05	0.19
262	3226.3	56.6	3.22	51.42	0.19
264	3275.7	57.0	3.24	51.79	0.19
266	3325.5	57.4	3.26	52.16	0.19

268	3375.7	57.7	3.27	52.54	0.19
270	3426.3	58.1	3.29	52.91	0.19
272	3477.2	58.5	3.31	53.29	0.19
274	3528.6	58.9	3.32	53.67	0.19
276	3580.3	59.2	3.34	54.05	0.19
278	3632.3	59.6	3.35	54.43	0.19
280	3684.8	60.0	3.37	54.81	0.19
282	3737.6	60.4	3.39	55.19	0.19
284	3790.8	60.8	3.40	55.57	0.19
286	3844.4	61.1	3.42	55.95	0.19
288	3898.4	61.5	3.43	56.34	0.19
290	3952.7	61.9	3.45	56.72	0.19
292	4007.4	62.3	3.47	57.11	0.19
294	4062.5	62.7	3.48	57.50	0.19
296	4118.0	63.1	3.50	57.88	0.19
298	4173.8	63.5	3.51	58.27	0.19
300	4230.0	63.9	3.53	58.66	0.20
302	4286.6	64.2	3.54	59.05	0.20
304	4343.6	64.6	3.56	59.44	0.20
306	4400.9	65.0	3.58	59.83	0.20
308	4458.6	65.4	3.59	60.23	0.20
310	4516.7	65.8	3.61	60.62	0.20
312	4575.2	66.2	3.62	61.02	0.20
314	4634.0	66.6	3.64	61.41	0.20
316	4693.2	67.0	3.65	61.81	0.20
318	4752.8	67.4	3.67	62.20	0.20
320	4812.8	67.8	3.68	62.60	0.20
322	4873.1	68.2	3.70	63.00	0.20
324	4933.9	68.6	3.72	63.40	0.20
326	4995.0	69.0	3.73	63.80	0.20
328	5056.4	69.4	3.75	64.20	0.20
330	5118.3	69.8	3.76	64.60	0.20
332	5180.5	70.2	3.78	65.01	0.20
334	5243.1	70.6	3.79	65.41	0.20
336	5306.1	71.0	3.81	65.81	0.20
338	5369.5	71.4	3.82	66.22	0.20
340	5433.2	71.8	3.84	66.63	0.20
342	5497.3	72.2	3.85	67.03	0.20
344	5561.8	72.6	3.87	67.44	0.20
346	5626.7	73.0	3.88	67.85	0.20
348	5691.9	73.5	3.90	68.26	0.21

350	5757.5	73.9	3.91	68.67	0.21
352	5823.5	74.3	3.93	69.08	0.21
354	5889.9	74.7	3.94	69.49	0.21
356	5956.6	75.1	3.96	69.90	0.21
358	6023.7	75.5	3.97	70.32	0.21
360	6091.2	75.9	3.99	70.73	0.21
362	6159.1	76.3	4.00	71.14	0.21
364	6227.3	76.8	4.01	71.56	0.21
366	6295.9	77.2	4.03	71.98	0.21
368	6364.9	77.6	4.04	72.39	0.21
370	6434.3	78.0	4.06	72.81	0.21
372	6504.0	78.4	4.07	73.23	0.21
374	6574.2	78.8	4.09	73.65	0.21
376	6644.7	79.3	4.10	74.07	0.21

Appendix S: Fusible Link Activation DETACT Model



INPUT PARAMETERS			CALC. PARAMETERS	
Ceiling height (H)	12	m	R/H	0.500
Radial distance (R)	6.0	m	dT(cj)/dT(pl)	0.476
Ambient temperature (To)	20	C	u(cj)/u(pl)	0.356
Actuation temperature (Td)	74	C	Rep. t2 coeff.	k
Response time index (RTI)	167	(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)	2	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	0.00
2	0.2	20.0	0.09	20.00	0.00
4	0.8	20.1	0.14	20.00	0.00
6	1.7	20.2	0.19	20.00	0.00
8	3.0	20.3	0.22	20.00	0.00
10	4.7	20.4	0.26	20.00	0.00
12	6.8	20.5	0.29	20.01	0.00
14	9.2	20.6	0.33	20.01	0.00
16	12.0	20.7	0.36	20.01	0.00
18	15.2	20.8	0.39	20.02	0.00

20	18.8	20.9	0.41	20.02	0.00
22	22.7	21.0	0.44	20.03	0.00
24	27.1	21.2	0.47	20.04	0.00
26	31.8	21.3	0.49	20.05	0.01
28	36.8	21.4	0.52	20.06	0.01
30	42.3	21.6	0.54	20.07	0.01
32	48.1	21.7	0.57	20.08	0.01
34	54.3	21.8	0.59	20.10	0.01
36	60.9	22.0	0.61	20.11	0.01
38	67.9	22.1	0.63	20.13	0.01
40	75.2	22.3	0.66	20.15	0.01
42	82.9	22.4	0.68	20.17	0.01
44	91.0	22.6	0.70	20.19	0.01
46	99.5	22.7	0.72	20.22	0.01
48	108.3	22.9	0.74	20.24	0.01
50	117.5	23.1	0.76	20.27	0.01
52	127.1	23.2	0.78	20.30	0.02
54	137.1	23.4	0.80	20.33	0.02
56	147.4	23.6	0.82	20.36	0.02
58	158.1	23.7	0.84	20.40	0.02
60	169.2	23.9	0.86	20.43	0.02
62	180.7	24.1	0.88	20.47	0.02
64	192.5	24.3	0.90	20.51	0.02
66	204.7	24.4	0.92	20.56	0.02
68	217.3	24.6	0.94	20.60	0.02
70	230.3	24.8	0.95	20.65	0.02
72	243.6	25.0	0.97	20.70	0.03
74	257.4	25.2	0.99	20.75	0.03
76	271.5	25.4	1.01	20.80	0.03
78	285.9	25.6	1.03	20.85	0.03
80	300.8	25.7	1.04	20.91	0.03
82	316.0	25.9	1.06	20.97	0.03
84	331.6	26.1	1.08	21.03	0.03
86	347.6	26.3	1.09	21.09	0.03
88	364.0	26.5	1.11	21.16	0.03
90	380.7	26.7	1.13	21.23	0.03
92	397.8	26.9	1.14	21.30	0.04
94	415.3	27.1	1.16	21.37	0.04
96	433.2	27.3	1.18	21.44	0.04
98	451.4	27.5	1.19	21.52	0.04
100	470.0	27.7	1.21	21.60	0.04

102	489.0	27.9	1.23	21.68	0.04
104	508.4	28.2	1.24	21.76	0.04
106	528.1	28.4	1.26	21.85	0.04
108	548.2	28.6	1.27	21.94	0.04
110	568.7	28.8	1.29	22.03	0.05
112	589.6	29.0	1.31	22.12	0.05
114	610.8	29.2	1.32	22.21	0.05
116	632.4	29.4	1.34	22.31	0.05
118	654.4	29.6	1.35	22.41	0.05
120	676.8	29.9	1.37	22.51	0.05
122	699.5	30.1	1.38	22.61	0.05
124	722.7	30.3	1.40	22.72	0.05
126	746.2	30.5	1.41	22.82	0.05
128	770.0	30.7	1.43	22.93	0.06
130	794.3	31.0	1.44	23.04	0.06
132	818.9	31.2	1.46	23.16	0.06
134	843.9	31.4	1.47	23.27	0.06
136	869.3	31.7	1.49	23.39	0.06
138	895.1	31.9	1.50	23.51	0.06
140	921.2	32.1	1.51	23.64	0.06
142	947.7	32.3	1.53	23.76	0.06
144	974.6	32.6	1.54	23.89	0.06
146	1001.9	32.8	1.56	24.02	0.07
148	1029.5	33.0	1.57	24.15	0.07
150	1057.5	33.3	1.59	24.28	0.07
152	1085.9	33.5	1.60	24.42	0.07
154	1114.7	33.8	1.61	24.56	0.07
156	1143.8	34.0	1.63	24.70	0.07
158	1173.3	34.2	1.64	24.84	0.07
160	1203.2	34.5	1.66	24.98	0.07
162	1233.5	34.7	1.67	25.13	0.07
164	1264.1	35.0	1.68	25.28	0.08
166	1295.1	35.2	1.70	25.43	0.08
168	1326.5	35.4	1.71	25.58	0.08
170	1358.3	35.7	1.72	25.73	0.08
172	1390.4	35.9	1.74	25.89	0.08
174	1423.0	36.2	1.75	26.05	0.08
176	1455.9	36.4	1.76	26.21	0.08
178	1489.1	36.7	1.78	26.37	0.08
180	1522.8	36.9	1.79	26.54	0.08
182	1556.8	37.2	1.80	26.70	0.08

184	1591.2	37.4	1.82	26.87	0.09
186	1626.0	37.7	1.83	27.04	0.09
188	1661.2	37.9	1.84	27.22	0.09
190	1696.7	38.2	1.86	27.39	0.09
192	1732.6	38.5	1.87	27.57	0.09
194	1768.9	38.7	1.88	27.75	0.09
196	1805.6	39.0	1.90	27.93	0.09
198	1842.6	39.2	1.91	28.11	0.09
200	1880.0	39.5	1.92	28.29	0.09
202	1917.8	39.8	1.93	28.48	0.09
204	1956.0	40.0	1.95	28.67	0.09
206	1994.5	40.3	1.96	28.86	0.10
208	2033.4	40.5	1.97	29.05	0.10
210	2072.7	40.8	1.98	29.24	0.10
212	2112.4	41.1	2.00	29.43	0.10
214	2152.4	41.3	2.01	29.63	0.10
216	2192.8	41.6	2.02	29.83	0.10
218	2233.6	41.9	2.03	30.03	0.10
220	2274.8	42.1	2.05	30.23	0.10
222	2316.3	42.4	2.06	30.44	0.10
224	2358.3	42.7	2.07	30.64	0.10
226	2400.6	42.9	2.08	30.85	0.10
228	2443.2	43.2	2.10	31.06	0.11
230	2486.3	43.5	2.11	31.27	0.11
232	2529.7	43.8	2.12	31.48	0.11
234	2573.5	44.0	2.13	31.70	0.11
236	2617.7	44.3	2.15	31.91	0.11
238	2662.3	44.6	2.16	32.13	0.11
240	2707.2	44.9	2.17	32.35	0.11
242	2752.5	45.1	2.18	32.57	0.11
244	2798.2	45.4	2.19	32.79	0.11
246	2844.3	45.7	2.21	33.01	0.11
248	2890.7	46.0	2.22	33.24	0.11
250	2937.5	46.2	2.23	33.47	0.11
252	2984.7	46.5	2.24	33.70	0.12
254	3032.3	46.8	2.25	33.93	0.12
256	3080.2	47.1	2.26	34.16	0.12
258	3128.5	47.4	2.28	34.39	0.12
260	3177.2	47.7	2.29	34.62	0.12
262	3226.3	47.9	2.30	34.86	0.12
264	3275.7	48.2	2.31	35.10	0.12

266	3325.5	48.5	2.32	35.34	0.12
268	3375.7	48.8	2.33	35.58	0.12
270	3426.3	49.1	2.35	35.82	0.12
272	3477.2	49.4	2.36	36.06	0.12
274	3528.6	49.7	2.37	36.31	0.12
276	3580.3	49.9	2.38	36.55	0.12
278	3632.3	50.2	2.39	36.80	0.12
280	3684.8	50.5	2.40	37.05	0.13
282	3737.6	50.8	2.42	37.30	0.13
284	3790.8	51.1	2.43	37.55	0.13
286	3844.4	51.4	2.44	37.80	0.13
288	3898.4	51.7	2.45	38.06	0.13
290	3952.7	52.0	2.46	38.31	0.13
292	4007.4	52.3	2.47	38.57	0.13
294	4062.5	52.6	2.48	38.83	0.13
296	4118.0	52.9	2.49	39.09	0.13
298	4173.8	53.2	2.51	39.35	0.13
300	4230.0	53.5	2.52	39.61	0.13
302	4286.6	53.8	2.53	39.88	0.13
304	4343.6	54.1	2.54	40.14	0.13
306	4400.9	54.4	2.55	40.41	0.13
308	4458.6	54.7	2.56	40.67	0.13
310	4516.7	55.0	2.57	40.94	0.13
312	4575.2	55.3	2.58	41.21	0.14
314	4634.0	55.6	2.60	41.48	0.14
316	4693.2	55.9	2.61	41.75	0.14
318	4752.8	56.2	2.62	42.03	0.14
320	4812.8	56.5	2.63	42.30	0.14
322	4873.1	56.8	2.64	42.57	0.14
324	4933.9	57.1	2.65	42.85	0.14
326	4995.0	57.4	2.66	43.13	0.14
328	5056.4	57.7	2.67	43.41	0.14
330	5118.3	58.0	2.68	43.69	0.14
332	5180.5	58.3	2.69	43.97	0.14
334	5243.1	58.6	2.70	44.25	0.14
336	5306.1	58.9	2.71	44.53	0.14
338	5369.5	59.2	2.73	44.82	0.14
340	5433.2	59.5	2.74	45.10	0.14
342	5497.3	59.9	2.75	45.39	0.14
344	5561.8	60.2	2.76	45.67	0.14
346	5626.7	60.5	2.77	45.96	0.14

348	5691.9	60.8	2.78	46.25	0.15
350	5757.5	61.1	2.79	46.54	0.15
352	5823.5	61.4	2.80	46.83	0.15
354	5889.9	61.7	2.81	47.13	0.15
356	5956.6	62.0	2.82	47.42	0.15
358	6023.7	62.4	2.83	47.71	0.15
360	6091.2	62.7	2.84	48.01	0.15
362	6159.1	63.0	2.85	48.30	0.15
364	6227.3	63.3	2.86	48.60	0.15
366	6295.9	63.6	2.87	48.90	0.15
368	6364.9	63.9	2.88	49.20	0.15
370	6434.3	64.3	2.90	49.50	0.15
372	6504.0	64.6	2.91	49.80	0.15
374	6574.2	64.9	2.92	50.10	0.15
376	6644.7	65.2	2.93	50.40	0.15
378	6715.5	65.5	2.94	50.71	0.15
380	6786.8	65.9	2.95	51.01	0.15
382	6858.4	66.2	2.96	51.32	0.15
384	6930.4	66.5	2.97	51.62	0.15
386	7002.8	66.8	2.98	51.93	0.15
388	7075.6	67.2	2.99	52.24	0.15
390	7148.7	67.5	3.00	52.55	0.15
392	7222.2	67.8	3.01	52.86	0.16
394	7296.1	68.1	3.02	53.17	0.16
396	7370.4	68.5	3.03	53.48	0.16
398	7445.0	68.8	3.04	53.79	0.16
400	7520.0	69.1	3.05	54.11	0.16
402	7595.4	69.4	3.06	54.42	0.16
404	7671.2	69.8	3.07	54.73	0.16
406	7747.3	70.1	3.08	55.05	0.16
408	7823.8	70.4	3.09	55.37	0.16
410	7900.7	70.8	3.10	55.68	0.16
412	7978.0	71.1	3.11	56.00	0.16
414	8055.6	71.4	3.12	56.32	0.16
416	8133.6	71.8	3.13	56.64	0.16
418	8212.0	72.1	3.14	56.96	0.16
420	8290.8	72.4	3.15	57.28	0.16
422	8369.9	72.7	3.16	57.60	0.16
424	8449.5	73.1	3.17	57.92	0.16
426	8529.4	73.4	3.18	58.25	0.16
428	8609.6	73.8	3.19	58.57	0.16

430	8690.3	74.1	3.20	58.90	0.16
432	8771.3	74.4	3.21	59.22	0.16
434	8852.7	74.8	3.22	59.55	0.16
436	8934.5	75.1	3.23	59.87	0.16
438	9016.7	75.4	3.24	60.20	0.16
440	9099.2	75.8	3.25	60.53	0.16
442	9182.1	76.1	3.26	60.86	0.16
444	9265.4	76.4	3.27	61.19	0.17
446	9349.1	76.8	3.28	61.52	0.17
448	9433.1	77.1	3.29	61.85	0.17
450	9517.5	77.5	3.30	62.18	0.17
452	9602.3	77.8	3.31	62.51	0.17
454	9687.5	78.1	3.32	62.85	0.17
456	9773.0	78.5	3.33	63.18	0.17
458	9858.9	78.8	3.34	63.52	0.17
460	9945.2	79.2	3.35	63.85	0.17
462	10031.9	79.5	3.36	64.19	0.17
464	10118.9	79.9	3.37	64.52	0.17
466	10206.3	80.2	3.38	64.86	0.17
468	10294.1	80.6	3.39	65.20	0.17
470	10382.3	80.9	3.40	65.54	0.17
472	10470.8	81.2	3.41	65.88	0.17
474	10559.8	81.6	3.41	66.21	0.17
476	10649.1	81.9	3.42	66.56	0.17
478	10738.7	82.3	3.43	66.90	0.17
480	10828.8	82.6	3.44	67.24	0.17
482	10919.2	83.0	3.45	67.58	0.17
484	11010.0	83.3	3.46	67.92	0.17
486	11101.2	83.7	3.47	68.27	0.17
488	11192.8	84.0	3.48	68.61	0.17
490	11284.7	84.4	3.49	68.95	0.17
492	11377.0	84.7	3.50	69.30	0.17
494	11469.7	85.1	3.51	69.64	0.17
496	11562.8	85.4	3.52	69.99	0.17
498	11656.2	85.8	3.53	70.34	0.17
500	11750.0	86.1	3.54	70.69	0.17
502	11844.2	86.5	3.55	71.03	0.17
504	11938.8	86.8	3.56	71.38	0.17
506	12033.7	87.2	3.57	71.73	0.17
508	12129.0	87.5	3.58	72.08	0.18
510	12224.7	87.9	3.59	72.43	0.18

512	12320.8	88.3	3.60	72.78	0.18
514	12417.2	88.6	3.60	73.13	0.18
516	12514.0	89.0	3.61	73.49	0.18
518	12611.2	89.3	3.62	73.84	0.18
520	12708.8	89.7	3.63	74.19	0.18