Fire and Life Safety Report

Agricultural Sciences Building 11

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FPE Program

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Statement of Disclaimer

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Search Keywords

Fire, Life Safety, Analysis, Agricultural Sciences, Fire Protection Engineering

Executive Summary

The purpose of this fire and life safety analysis is to provide a conclusion on whether the Agricultural Sciences Building (ASB) meets fire safety goals. The primary fire safety goal is to provide building occupants a safe environment during fire conditions. This goal can be achieved by protecting the occupants not intimate with the initial fire development and improving survivability of those occupants intimate with the initial fire development.

A prescriptive-based design approach and a performance-based design approach are used to evaluate building safety. The prescriptive-based approach is used to evaluate the building's structural fire protection systems, fire detection and alarm systems, fire suppression systems and egress design.

The performance-based design approach is used to analyze how the building will perform in the event of a fire. The performance-based approach evaluates the building based on the required safe egress time (RSET) and available safe egress time (ASET) for occupants to evacuate the building safely in the event of a fire.

A Smoke Management Study was conducted to predict the effects of fire within the ASB using natural ventilation to control smoke. The study is evaluated in this report using hand calculation methods and two computer software programs, Fire Dynamics Simulator (FDS) and Pathfinder to determine if occupant safety is sufficient.

Recommendations to improve building fire safety are discussed based on the results of this fire and life safety analysis.

Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

AHJ	Authority Having Jurisdiction
AFF	Away From Floor
ANSI	American National Standards Institute
ARC	Alarm Receipt Capability
ASET	Available Safe Egress Time
ASFP	Association for Specialist Fire Protection
ASME	American Society of Mechanical Engineers
Cal Poly	California Polytechnic State University
IBC	International Building Code
IFC	International Fire Code
UBC	Uniform Building Code
NEC	National Electric Code
CPSU	California Polytechnic State University
ASB	Agricultural Sciences Building
EPSS	Emergency Power Supply System
FACP	Fire Alarm Control Panel
FATC	Fire Alarm Terminal Cabinet
FDS	Fire Dynamic Simulator
GPM	Gallons Per Minute
HRR	Heat Release Rate
ITM	Inspection, Testing and Maintenance
LSC	Life Safety Code
NAC	Notification Appliance Circuit
NFPA	National Fire Protection Association
NIST	National Institute of Technology
PSI	Pounds per Square Inch
RSET	Required Safe Egress Time
SFPE	Society of Fire Protection Engineers
SLC	Signal Line Circuit
PIV	Post-Indicator Valve
FDC	Fire Department Connection
DOT	Department of Transportation
PRV	Pressure Relief Valve
RTI	Response Time Index
NFPA	National Fire Protection Association
HB	Handbook
MRA	Most Remote Area

4. Introduction

The Agricultural Sciences Building (Building 11) was constructed in 1986 and is a three story building located in the northwest corner of Cal Poly, San Luis Obispo's campus core across the street from Engineering IV (Building 192). The building represents an open-air construction where most of the building is exposed to the outside environment. The first floor consists of two wings that connect at a 90-degree angle. The floor is lined with laboratories and lecture halls. The second floor can be described as on large rectangular corridor with a few branches. All corridors are lined with various faculty and administration offices. The third floor is one wing on the south side used for administration and storage purposes and a mechanical mezzanine on the north side.

The building has a footprint of 19,277 square feet. The entire building has a floor area of 47,311 square feet and is sprinklered. The exterior walls seem to be lined with textured concrete or plaster covered with paint. The interior walls are lined with drywall. The floors are also composed of concrete, but rooms also have tiles installed on top of the concrete. The building will be considered a business/mixed occupancy because the main use is for college education.

5. Codes and References

5.1. Codes During Construction

- Uniform Building Code (UBC), 1979 Edition
- Uniform Plumbing Code, 1979 Edition
- Uniform Mechanical Code, 1979 Edition
- National Electrical Code (NEC), 1978 Edition
- NFPA 13
- NFPA 72

5.2. Current Codes

- International Building Code (IBC), 2009 Edition
- NFPA 101: Life Safety Code (LSC), 2012 Edition
- NFPA 13: Standard for the Installation of Sprinkler Systems, 2013 Edition
- NFPA 72: National Fire Alarm and Signaling Code, 2010 Edition
- SFPE Handbook of Fire Protection Engineering, 4th Edition
- Fire Protection Handbook Volumes I & II, 20th Edition

This report focuses on the prescriptive-based and performance-based approaches to fire protection design as described in the Life Safety Code, (NFPA 101, 2012).

The following life safety goals are specified in NFPA 101:

> **Section 4.1:** The primary fire safety goal is to provide building occupants with an environment that is reasonably safe from fire by protecting the occupants not intimate with the initial fire

development and improving survivability of those occupants intimate with the initial fire development, (NFPA 101, 2012).

Section 4.2: The primary objectives used to achieve this goal include protecting occupants, maintaining structural integrity and maintaining system reliability for the time needed to evacuate, relocate, or defend in place. The Life Safety Code provides two compliance options to meet these goals and objectives: (1) Prescriptive-based and (2) Performance-based, (NFPA 101, 2012).

Section 4.4.2: A prescriptive-based approach to life safety design must be in accordance with Chapters 1-4, 6-11, 43 and the applicable occupancy chapter, chapters 12-42 of the Life Safety Code, (NFPA 101, 2012).

Section 4.4.3: A performance-based approach to life safety design must be in accordance with Chapters 1-5 of the Life Safety Code, (NFPA 101, 2012).

Specific code requirements pertaining to prescriptive-based and performance-based design will be discussed in their respective sections of this report.

6. Building Overview

6.1. Building Occupancy Classification

The ASB is classified as a Group B, Business Occupancy, defined as an occupancy used for the transaction of business other than mercantile, (NFPA 101, 2012, Section 6.1.11.1). There are also incidental occupancies within the ASB that have different uses along with occupant load factors assigned to each by the IBC. This thorough classification of occupancies will give a more accurate occupant load within the ASB. The different occupancy uses within the ASB are shown in Table 1. IBC definitions of the occupancies used are stated below:

Business: Section 304

- **Group B**. Facilities for **office, professional or service-type transactions**, including storage of records and accounts. Business occupancies include:
  - Banks
  - Civic administration
  - Educational occupancies for students above the 12th grade
  - Electronic data processing
  - Laboratories: testing, research *and [SFM] instruction*
  - Motor vehicle showrooms
  - Professional services (architects, attorneys, physicians, etc.)
  - Radio and television stations

Storage: Section 311

- **Group S**. Facilities used for **storage** and not classified as a hazardous occupancy.
  - **S-1** – Moderate hazard storage
    - Books / cardboard / clothing / furniture / lumber / etc.
  - **S-2** – Low hazard storage
    - Cement in bags / electric motors / food products / glass / gypsum board / metals / parking garages / stoves / washers / dryers / etc.

Utility: Section 312

- **Group U**. Structures of an **accessory character** and **miscellaneous structures not classified** in any specific occupancy.
  - Constructed, equipped and maintained for safety to be commensurate with the fire and life hazard incidental to their occupancy.
  - Examples: Agricultural buildings / Barns / Carports / Fences more than 6 feet high / Greenhouses / Livestock shelters / Private garages / Retaining walls / Sheds / Stables / Tanks / Towers.

Table 1 - Occupancy Classifications

Occupancy	Use	Occupant Load (sq ft/person)
Business	Office	100
	Lecture Hall	20
	Lab	50
Storage, S-2	Mech/Elec Room, Janitorial	300
Utility	Greenhouse	500

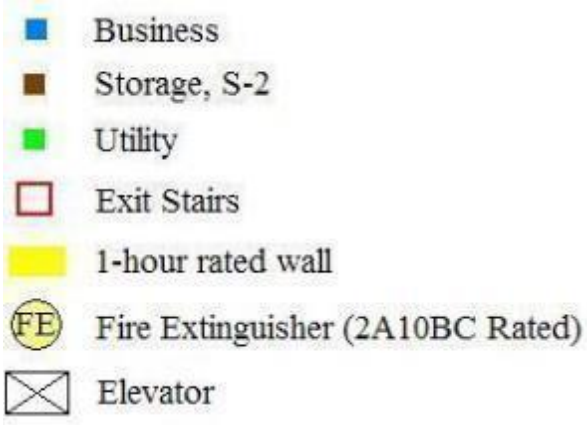


Figure 1 - ASB Legend

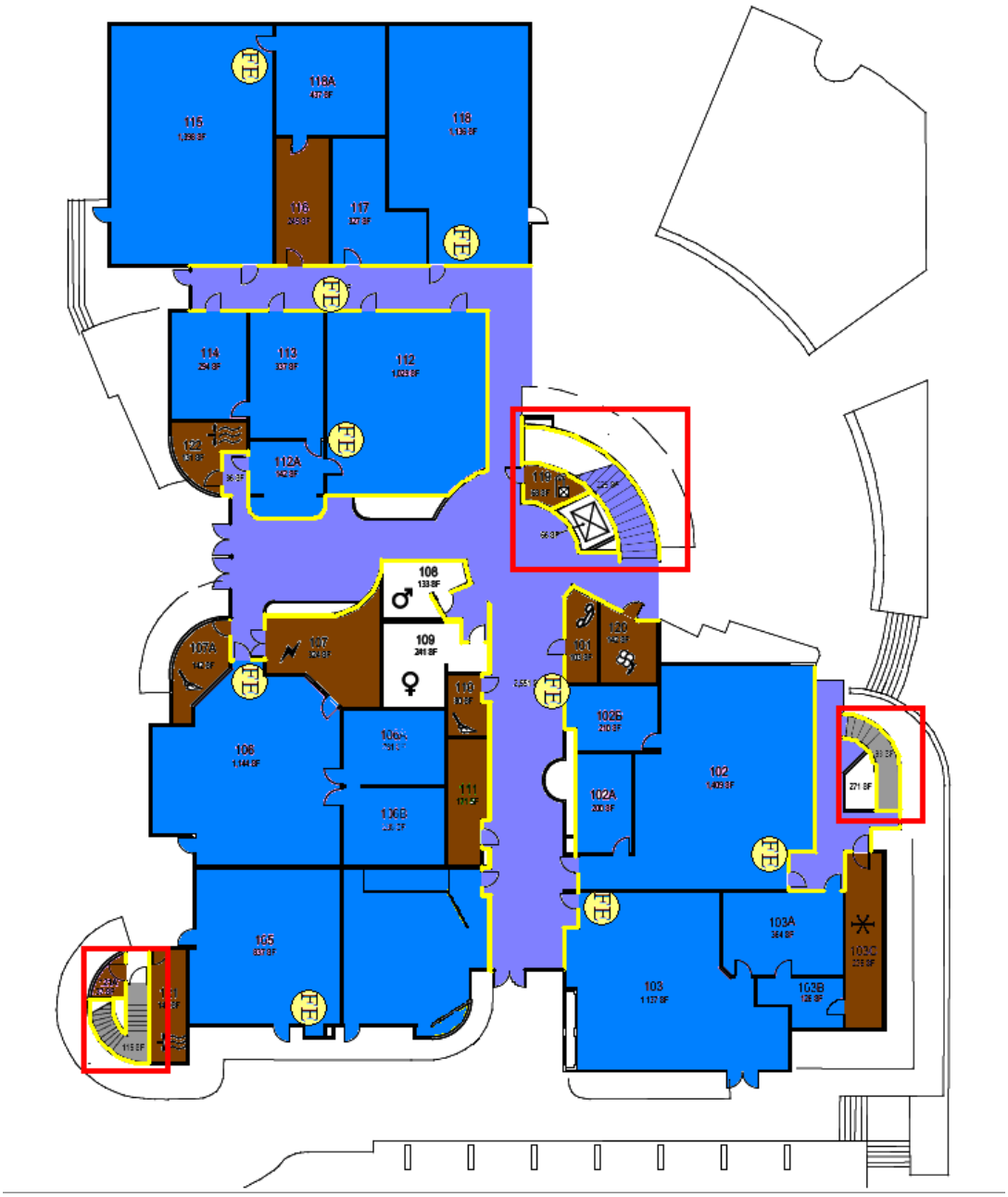


Figure 2 - ASB Occupancy Classification First Floor

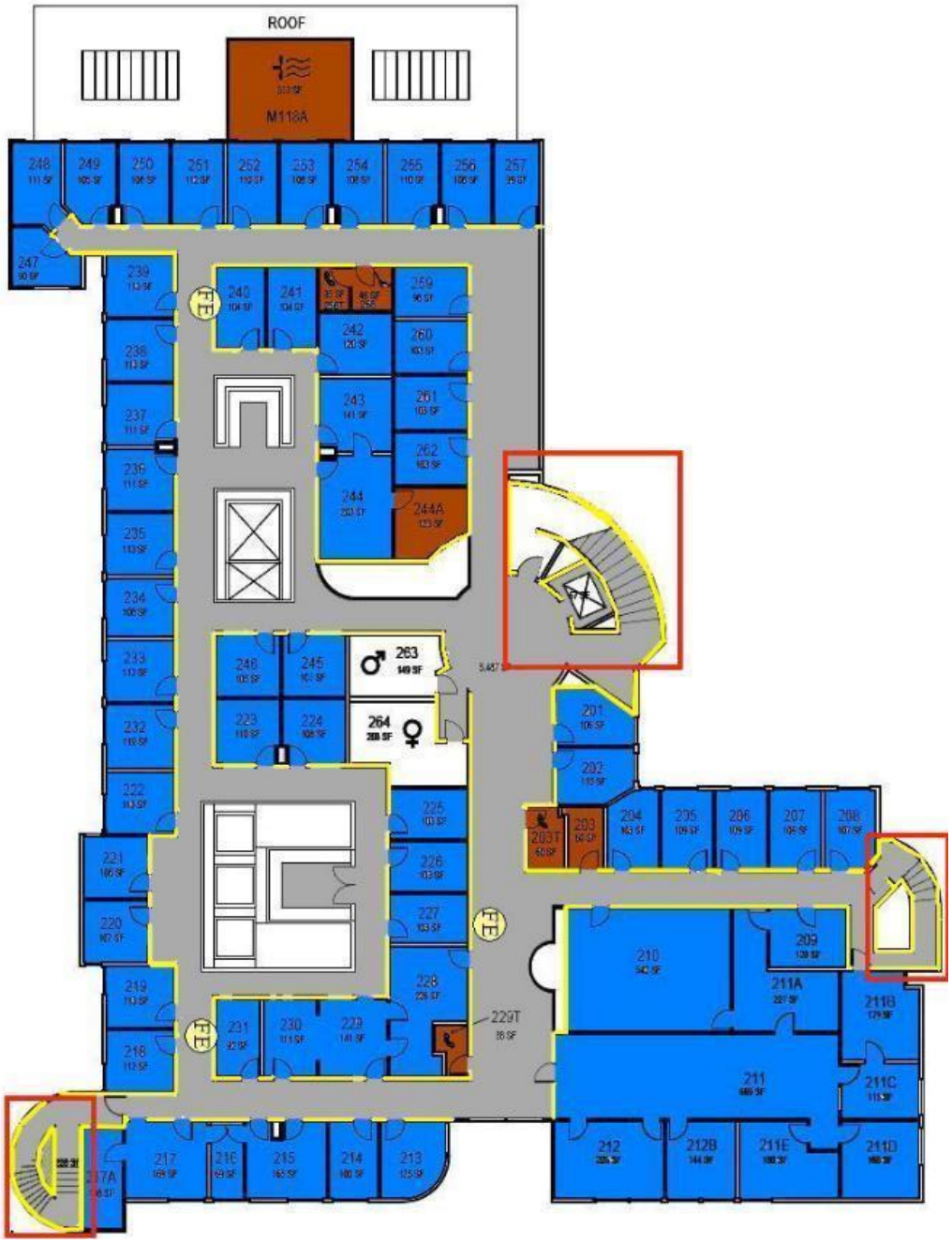


Figure 3 - ASB Occupancy Classification Second Floor

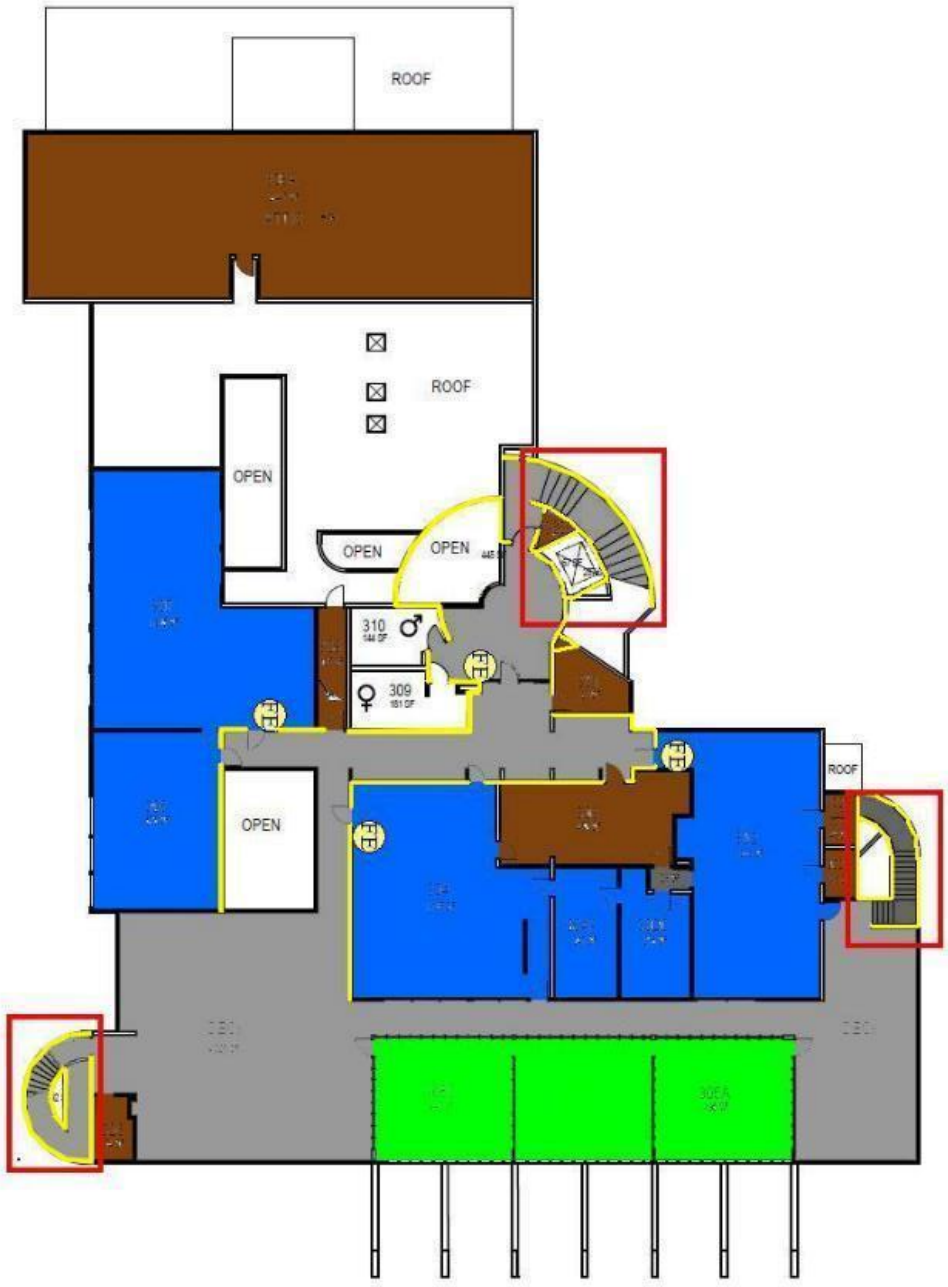


Figure 4 - ASB Occupancy Classification Third Floor

6.2. Construction Type

The construction type specified by the architecture plans is type III-N is from the UBC and is not recognized by the IBC, the construction type that is the most similar to III-N is construction type III-B in the IBC. The definition of construction type III is the type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of any material permitted by this

code. The buildings exoskeleton could be considered a type I or II construction, but is classified as type III because most rooms are lined with wood trim. In addition, some walls are lined with thermal and acoustical insulation panels having a flame spread index larger than 25.

6.3. Building Construction

The overall height of the building is 57 feet above the level of fire department vehicle access. The ASB largest gross floor area for one floor is 19,277. The allowable building height and floor area for construction type III-B classification Group B is 55 feet or 3 stories and 19,000 square feet per story, respectively, according to Table 503 in the IBC. It is allowed to increase the allowable building height and floor area to 75 feet or 4 stories and 61,750 square feet per story, respectively, for buildings equipped with an automatic fire sprinkler system and satisfies the frontage requirements according to Sections 504.2 and 506.1. The agriculture science building is within these standards to be classified as construction type III-B.

Table 2 - Exit Capacity

	Floor		
	Ground (+Second & Third)	Second (+Third)	Third
Net Floor Area	13,579 SF	9,868 SF	7,899 SF
Gross Floor Area	19,277 SF	16,542 SF	11,992 SF
Occupant Load	279 (622) persons	149 (264) persons	118 persons
Total Exit Width	784 in.	108 in.	108 in.
Exit Capacity	2613 persons	472 persons	472 persons

7. Prescriptive-Based Design

7.1. Structural Fire Protection

Foundation

The building is constructed on a reinforced concrete foundation on grade. The grade floor slab is 5" thick concrete with a minimum specified cover of 1 ½" of concrete over the reinforcing steel for unexposed slabs and 3" minimum for slabs exposed to the environment. The reinforcement is #3 bars at 24" on center each way over a 6" gravel capillary break. The concrete has a strength of f_c' = 3000 psi at 28 days.

Primary Structure Construction

The primary structure consists of steel wide-flange columns supporting steel wide-flange girders, beams, and joists. All exterior construction and most of the interior construction is comprised of non-combustible material so to satisfy the definition of construction type III. The letter B refers to the building classification of unprotected. Columns, beams, and joists required to have a 1-hour fire-resistant rating are protected by ½" gypsum sheathing and cement plaster on one side. All others have 5/8" gypsum board surrounding them.

Wall and Partition Construction

The exterior walls on the agriculture science building are nonbearing and have a fire separation distance of 10 feet or more in some places. The walls are constructed of 3 5/8" x 25 gauge at 24" on center, 6" x 25 gauge at 24" on center, 8" x 18 gauge at 24" on center steel studs and lined with 5/8" gypsum board on both sides. Walls are constructed with ½" gypsum sheathing and cement plaster on one side and 5/8" gypsum board on the other to provide a 1-hour fire-resistance rating.

Roof and Floor Construction

The roof and floors assemblies are 20 gauge composite metal deck with 2-1/2" lightweight concrete topping (5 ½ total thickness), with 6"x 6" 10/10 welded wire fabric reinforcement. Minimum topping cover on the WWF is specified to be 1" clear. The deck is supported by wide-flange steel joists with headed shear studs to join the joists to the deck compositely.

Paths of Egress Construction

Corridors in the Agriculture Science Building have minimum width of 48" and are separated from adjacent spaces by 1-hour fire-resistant rated walls. There are three stairways in the building. The main stairs (stair 3) are 6'-3" wide and stairs 2 and 1 both have a width of 48". All three are separated from adjacent spaces in the building by 1-hour fire-resistant rated walls. There is an elevator in the center of the building that is accessible on all three floors. The elevator shaft is separated from all adjacent spaces by 1-hour fire-resistant rated walls. The doors to the elevator shaft is a tight fitting smoke and draft assembly with a 20 minute fire-resistance rating.

Wall Openings Construction

The fire separation distance between the agriculture science building and the agriculture engineering building is greater than 30 feet. The food processing and market building is 10 to 15 feet from the agriculture science building, but the exterior wall facing the food processing and market building doesn't have any wall openings. The doors are typically 3'x 7' in size, 1 ¾" thick, and made out of wood with a solid core. The doors that open to the corridor are fire doors and have a typical fire-resistance rating of 20 minutes and are self-closing.

Special Features Construction

This section includes the atrium and shaft enclosures located in the Agriculture Science Building. There is an atrium in the building located near the elevator lobby that extends from the first floor to the third floor. The walls separating spaces adjacent to the atrium are all 1-hour fire-resistance rating. There are duct shafts located throughout the building are all separated by 1-hour fire-resistance rated walls.

7.1.1 Structural Fire Protection Requirements

The standards in the IBC for construction type IIIB will be used in this report's analysis since the IBC is the current code being used in the United States. The fire-resistance rating requirements for building elements is located in Table 601 and 602 of the IBC.

Primary Structure

The primary structural frame are required to have a fire-resistance rating of 0 hours according to Table 601 of the IBC. Joints in the structure are required to be in accordance with Section 714 of the IBC.

Walls and Partitions

Exterior bearing and non-bearing walls are required to have a fire-resistance rating of 2 and 1 hours, respectively, according to Tables 601 and 602 in the IBC. Interior bearing and nonbearing walls are required to have a fire-restance rating of 0 hours according to the IBC.

Roof and Floor

The roof and floors are required to have a fire-resistance rating of 0 hours according to the IBC.

Paths of Egress

Corridors that serve an occupant load larger than 30 in a business occupancy (Group B) are required to have a fire-resistance rating of 1-hour without a sprinkler system and 0-hour with a sprinkler system according to Table 1018.1 in the IBC.

Wall Openings

The maximum area of exterior wall openings is not a required for walls with a fire separation distance of 30 feet or greater according to Table 705.8 in the IBC. The maximum allowable area of exterior wall openings is 45% for a protected exterior wall with a fire separation distance of 10 feet to less than 15 feet according to Table 705.8 in the IBC. Fire doors that open to a corridor or common means of egress are required to be installed with a minimum of a 20 minute fire-resistance rating and the ability to close automatically according to Table 715.4.8 and Section 1025.3 in the IBC. There are multiple penetrations of pipe, conduit, ducts and air transfer openings throughout the building and are required to be sealed in accordance with Sections 713 and 716 of the IBC.

Special Features

There are special detailed requirements for atriums contained in Section 404 of the IBC. These requirements include the enclosure of the atrium to be separated by a 1-hour barrier constructed in accordance with Section 707 or a horizontal assembly constructed in accordance with section 712, or both except the adjacent space of any three floors of the atrium where such spaces are accounted for in the design of the smoke control system. It is required for shaft enclosures connecting three stories or less to have a minimum fire-resistance rating of 1-hour according to the IBC.

7.1.2 Code Compliance Analysis

All of the Agriculture Science Building elements studied, both structural and non-structural, appear to comply with the IBC requirements for Type III-B construction, suitable for Group B occupancy. The SFRM-protected steel columns fall under the UL X40x-series of designs and it is assumed that the requisite coating thicknesses were applied and UL approved design construction details were complied with.

The roof and floor assemblies are of the UL N7xx- series of designs for restrained beams, exterior walls are of the UL U418 assembly types, and interior walls and partitions are of the UL U419 style. It is also assumed that all elements of the construction comply with UL-approved designs.

7.2. Fire Detection, Alarm and Communication Systems

7.2.1. Type of System

The structure has a proprietary supervising station alarm system installed on the premises. An installation of an alarm system that serves contiguous and noncontiguous properties, under one ownership, from a proprietary supervising station located at the protected premises, or at one of multiple non-contiguous protected premises, at which trained, competent personnel are in constant attendance. This includes the protected premises fire alarm system(s): proprietary supervising station; power supplies; signal-initiating devices; initiating device circuits; signal notification appliances; equipment for the automatic, permanent visual recording of signals; and equipment for initiating the operation of emergency building control services as defined in NFPA 72 **3.3.267.2**.

There are manual pull-stations and automatic tamper switches, fire sprinklers, smoke detectors, and flow switches installed in the building, which are initiating devices. The alarm notification devices are audible bells and visual strobe lights. When any of the initiating devices is activated, a signal is sent to the fire alarm control panel and is processed. Depending on the initiating device that's activated a supervisory or alarm signal will be sent out to either the supervising party or the alarm notifying devices or both.

7.3.2. Device Type and Locations

- The multi-sensor detectors in the building are Simplex TrueAlarm 2098-9508 Ionization Smoke Detectors.

Figure 5 - Simplex Smoke Detector

- The fire alarm control panel (FACP) is a Simplex TrueAlarm (model # not specified) fire alarm control panel.

Figure 6 - Simplex FACP

- The remote annunciator is a Simplex TrueAlarm 2601-8015 Remote Annunciator.

Figure 7 - Simplex Remote Annunciator

- Horn/Strobe Notification Devices

Figure 8 - Gentex Horn/Stobe Notification Appliance Model #GEC24-15/75WR

Figure 9 - Simplex Horn Notification Appliance

Figure 10 - Simplex Horn Notification Appliance Specs

- Simplex Manual Pull Station

Figure 11 - Simplex Manual Pull Station

- The sampling tubes from the duct detectors were provided by the mechanical engineer and connected to the FACP by the electrical engineer.

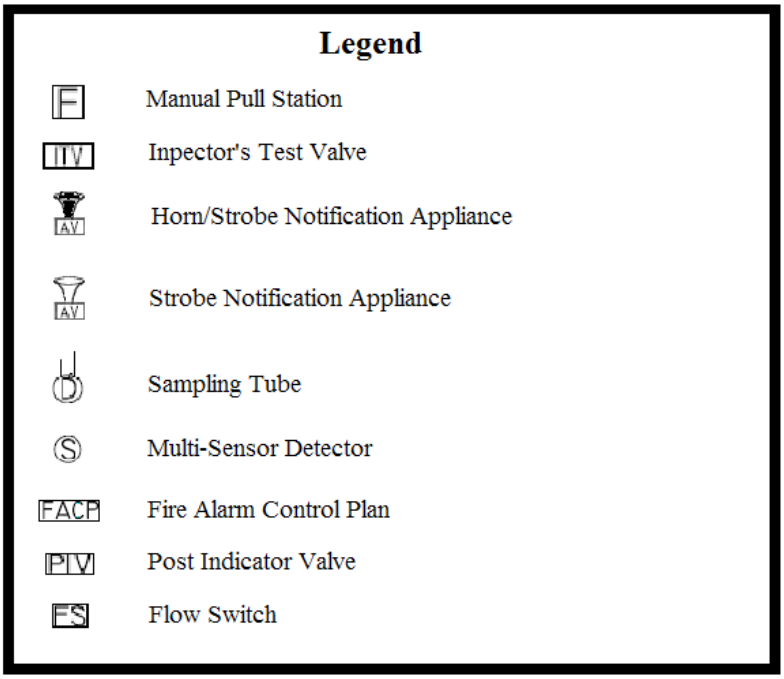


Figure 12 - Fire Alarm Legend

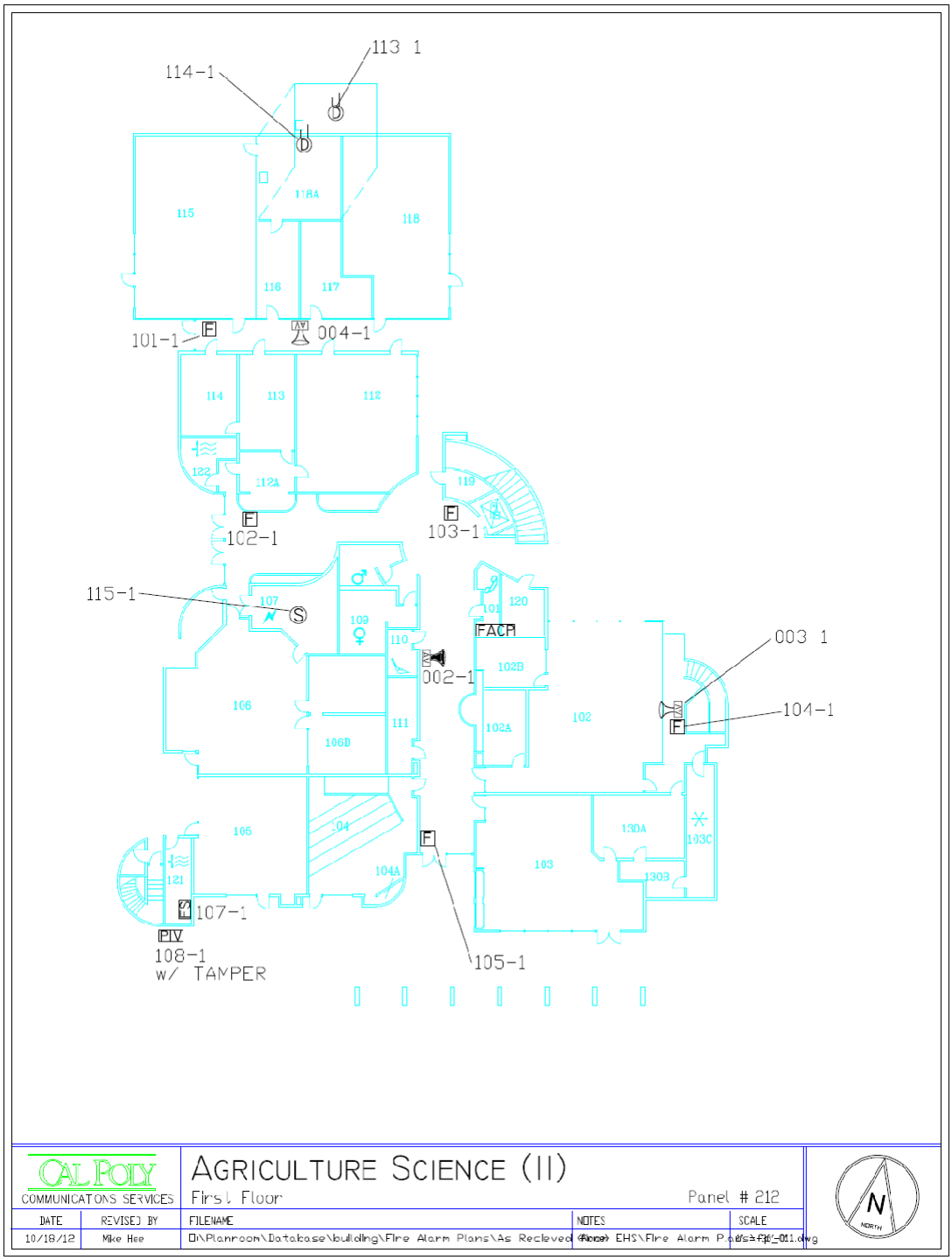


Figure 13 - First Floor Fire Alarm Device Locations

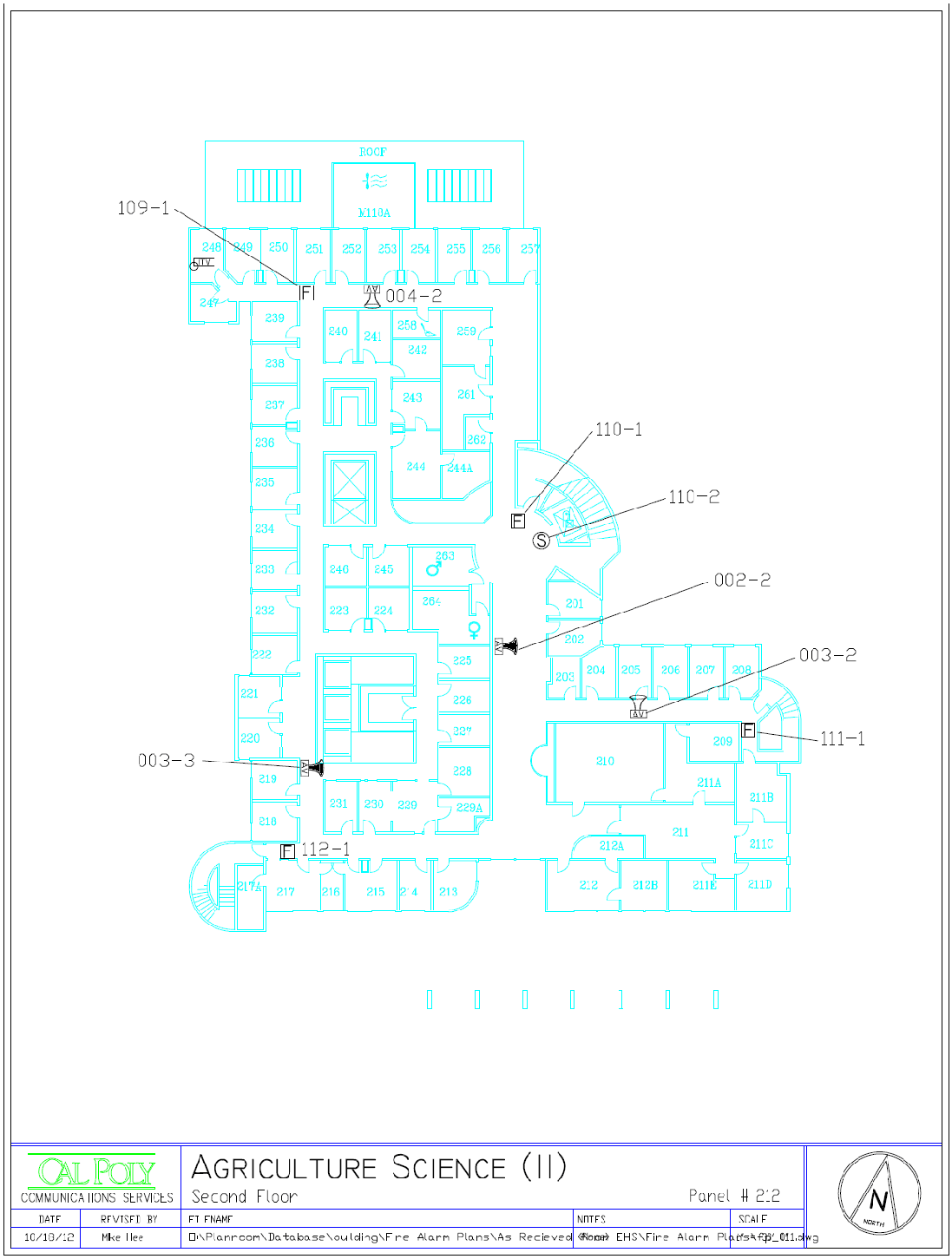


Figure 14 - Second Floor Fire Alarm Device Locations

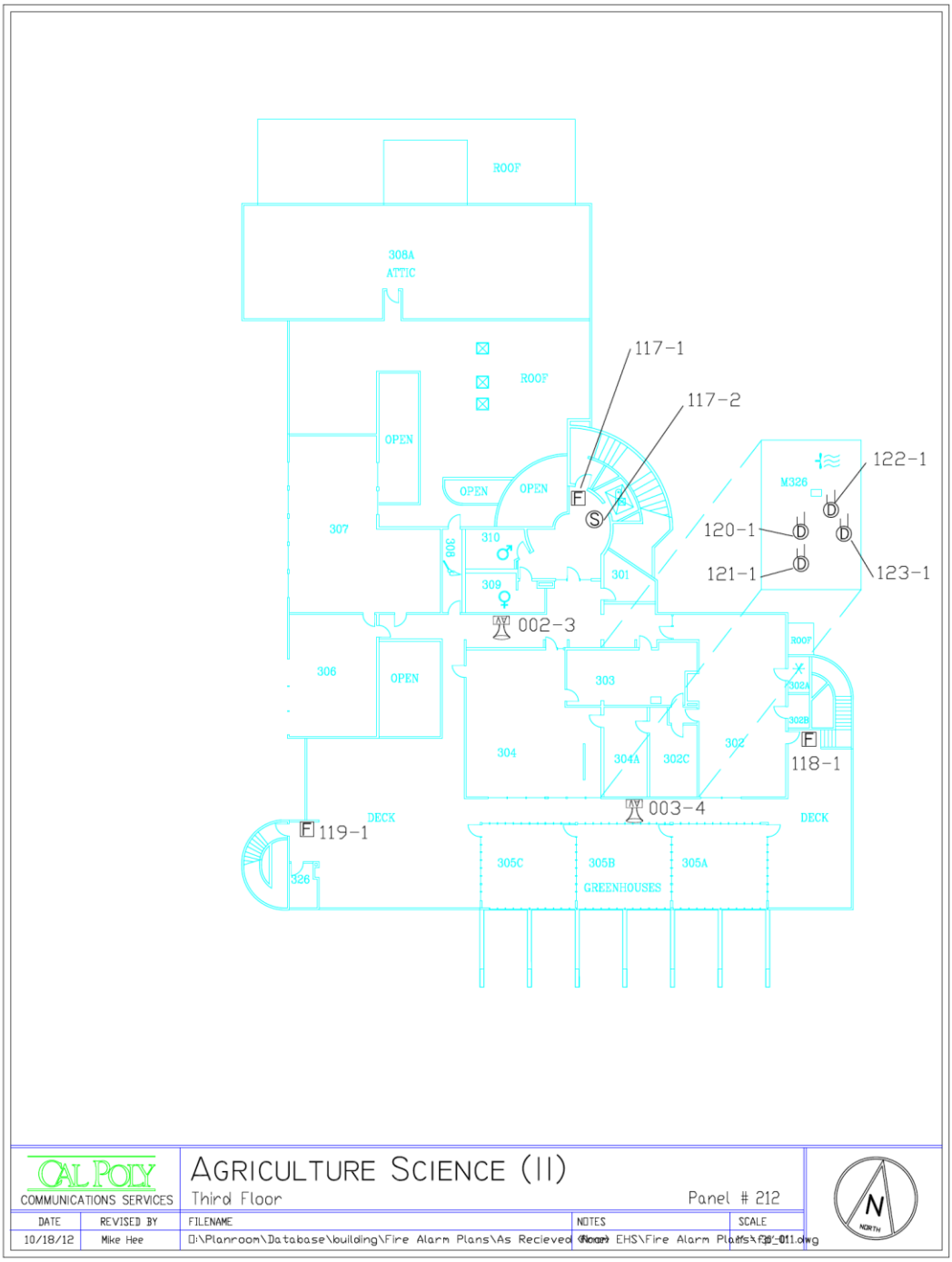


Figure 15 - Third Floor Fire Alarm Device Locations

7.3.3. Code Compliance

The Agriculture Science's Building has a partial coverage system installed on the premise and is based off of a prescriptive type design. A partially covered system is defined in NFPA 72 **code 17.5.3.2** where codes, standards, or laws require the protection of selected areas only, the specified areas shall be protected in accordance with this code. There are smoke detectors on the second and third story elevator

lobbies and one in an electrical storage room. Most of the detectors are fire sprinklers in the building and cover most space, but for design purposes, they are not considered part of the fire alarm system.

According to NFPA 72 **code 17.7.3.1.2,** the design must account for the contribution of the following factors in predicting detector response to the anticipated fires to which the system is intended to respond:

- Ceiling shape and surface
- Ceiling height
- Configuration of contents in the protected area
- Combustion characteristics and probable equivalence ratio of the anticipated fires involving the fuel loads within the protected area
- Compartment ventilation
- Ambient temperature, pressure, altitude, humidity, and atmosphere

7.3.4. Smoke Detectors

Relevant Codes

The spaces where the smoke detectors are located are on flat ceilings at a height of 10 feet. They are located there because of contents in the protected areas. The contents being potentially fire hazardous electrical equipment or mechanical equipment. NFPA 72 **code 17.7.3.1.4** also supports the location of the smoke detectors because it states that if the intent is to initiate action when smoke/fire threatens a specific object or space, the detector shall be permitted to be installed in close proximity to that object or space.

The IBC has a requirement for smoke detectors where **907.2.18.1** states a minimum of one smoke detector *listed* for the intended purpose shall be installed in the following areas:

1. Mechanical equipment, electrical, transformer, telephone equipment, elevator machine or similar rooms.
2. Elevator lobbies.
3. The main return and exhaust air plenum of each air-conditioning system serving more than one *story* and located in a serviceable area downstream of the last duct inlet.
4. Each connection to a vertical duct or riser serving two or more floors from return air ducts or plenums of heating, ventilating and air-conditioning systems, except that in Group R occupancies, a *listed* smoke detector is allowed to be used in each return air riser carrying not more than 5,000 cfm (2.4 m_3/s) and serving not more than 10 air-inlet openings.

Analysis

The fire sprinklers in the ASB count as heat detectors because the alarm system activates when the flow switch on the sprinkler riser senses water flow. Mechanical rooms and electrical rooms all have at least

one smoke detector on the ceiling or in the mechanical ducts supplying the room. From inspection of the plans, I can conclude that this code is satisfied.

7.3.5. Manual Pull Stations

Relevant Codes

For the manual pull stations located in the building NFPA 72 **code 17.14.5** states that manual fire alarm boxes shall be installed so that they are inconspicuous, unobstructed, and accessible. Surveying the Agriculture Sciences building, it is found that all pull stations meet this code requirement. **Code 17.14.6** states that manual fire alarm boxes shall be located within 60 in. of the exit doorway opening at each exit on each floor. It is shown in figures 13-15 that there is a pull station within 60 in. of every exit on every floor.

The LSC code **9.6.2.3** states a manual fire alarm box shall be provided as follows, unless modified by another section of this *Code*:

> (1) For new alarm system installations, the manual fire alarm box shall be located within 5 feet (1.5 m) of exit doorways.
> (2) For existing alarm system installations, the manual fire alarm box either shall be provided in the natural exit access path near each required exit or within 5 feet (1.5 m) of exit doorways.

And

Code **9.6.2.5*** states additional manual fire alarm boxes shall be located so that, on any given floor in any part of the building, no horizontal distance on that floor exceeding 200 ft (60 m) shall need to be traversed to reach a manual fire alarm box.

Analysis

Figures 13-15 indicate that there is manual pull station within 5 ft. of every common exit and spaced 200 ft. within the building. The codes for manual pull stations are satisfied.

7.3.6. Audible and Visual Devices

NFPA 72 **code 18.4.8.1** specifies that if ceiling heights allow, and unless otherwise permitted by 18.4.8.2 through 18.4.8.5, wall-mounted appliances shall have their tops above the finished floors at heights of not less than 90 in. and below the finished ceilings at distances of not less than 6 in. for audible notification devices and NFPA 72 **code 18.5.4.1** states for visual notification wall-mounted appliances shall be mounted such that the entire lens is not less than 80 in. and not greater than 96 in. above the finished floor. Visual inspection of all these appliances puts them all at code regulation distances on the wall.

There is a recommended corridor spacing code for visual notification appliances, but not necessarily required. NFPA 72 code **18.5.4.4.1** states that appliances in corridors 20 ft. or less in width should follow code **18.5.4.4**, which states that because occupants are usually alert and moving, and because their vision is focused by the narrowness of the space, corridor signaling is permitted to be by direct viewing of lower-intensity for visual notification appliances. That is, the alerting is intended to be seen directly and not by reflection on windows, etc. Note that it is acceptable to use 18.5.4.3 (Spacing in Rooms) to determine the number and location of strobes in corridors. If 18.5.4.3 is used, it is not necessary to have a corridor strobe within 15 ft (4.5 m) of the end of the corridor.

All appliances are mounted between their specified heights and meet NFPA 72 code requirements for mounting.

NFPA 72 18.5.4.4.5 - Visible appliances shall be within 15 feet of a corridor end.

NFPA 72 18.5.4.4.3 - In a corridor application, visible appliances shall be rated not less than 15 cd.

NFPA 72 18.4.4.2* Where approved by the authority having jurisdiction or other governing codes or standards, the requirements for audible signaling shall be permitted to be reduced or eliminated when visible signaling is provided in accordance with Section 18.5.

The only visual and audible devices in the building are in the corridors as shown in figures 13-15. The visible meet the standards according to code **18.5.4.4.1, 18.5.4.4,** and **18.5.4.4.3** because they provide at least 15 cd in a corridor smaller than 20 feet in width. Since the visual requirement is satisfied, the audible requirement may be reduced or eliminated by AHJ according to **NFPA 72 18.4.3.2**. Figure 16 depicts the audible capabilities where the minimum requirement is 60 dBA because the average ambient sound level in an educational occupancy is 45 dBA plus **NFPA 72 18.4.3.1** 15 dBA safety factor. The analysis assume an anechoic environment since the corridors are open. I did the analysis of the Simplex horn notification device because it provides less decibels at 10 feet than the Gentex horn/strobe notification device. From doing this analysis the maximum distance the audio device can reach is 62 dBA at 320 ft. This level of decibels is adequate to cover the length of each corridor throughout the building because the largest corridor is about 150 ft.

NFPA 72 18.4.3.1 To ensure that audible public mode signals are clearly heard, unless otherwise permitted by 18.4.3.2 through 18.4.3.5, they shall have a sound level at least 15 dB above the average ambient sound level or 5 dB above the maximum sound level having a duration of at

NFPA 72 18.4.3.2 Where approved by the authority having jurisdiction or other governing codes or standards, the requirements for audible signaling shall be permitted to be reduced or eliminated when visible signaling is provided in accordance with Section 18.5.

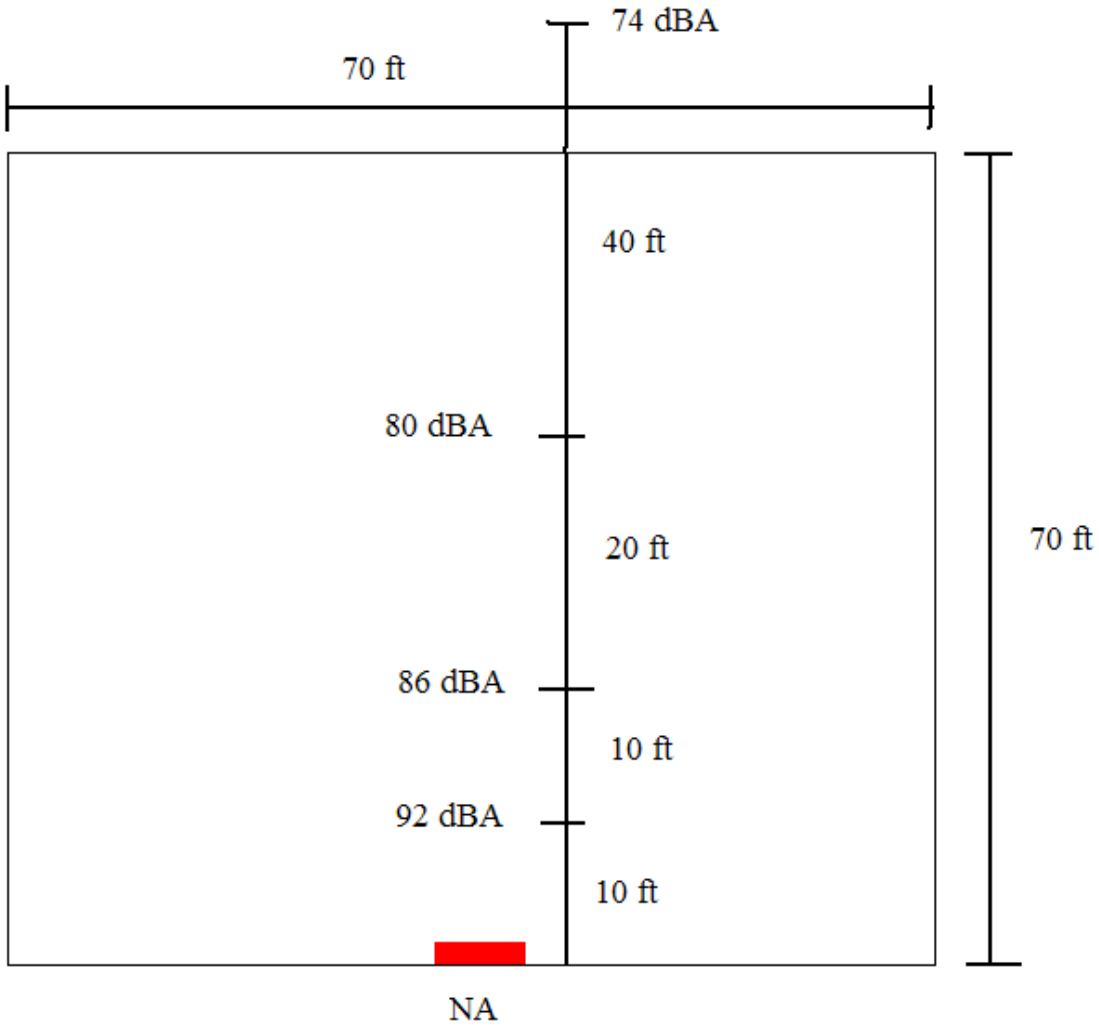


Figure 16 - Performance of Simplex Horn Notification Device

Analysis

The audible devices in the ASB are spaced correctly according to NFPA 72. However, the visual devices in the ASB are not spaced correctly. NFPA 72 requires visual devices be placed within 15 feet of each end of a corridor and clearly devices are not within 15 feet of each corridor's end. On top of that, the audible device in the north corridor doesn't meet the requirements to be considered to be labeled as a horn/strobe device, but they consider it one in the original set. More visual devices must be inserted in the ASB in order to be code compliant.

7.3.7. Sampling Tubes

Relevant Codes

NFPA 72 code 17.7.4.1 states that in spaces served by air-handling systems, detectors cannot be located where airflow prevents operation of the detectors. These detectors are the sampling tubes in figures 1 through 3 and should be located within proper specification.

Analysis

There are sampling tubes serving the air-conditioning system ducts, which satisfies code **907.2.13.1.2** in the IBC and states that duct smoke detectors complying with Section 907.3.1 shall be located as follows:
1. In the main return air and exhaust air plenum of each air-conditioning system having a capacity greater than 2,000 cubic feet per minute (cfm) (0.94 m /s). Such detectors shall be located in a serviceable area downstream of the last duct inlet.
2. At each connection to a vertical duct or riser serving two or more stories from a return air duct or plenum of an air-conditioning system. In Group R-1 and R-2 occupancies, a smoke detector is allowed to be used in each return air riser carrying not more than 5,000 cfm (2.4 m /s) and serving not more than 10 air-inlet openings.

Detectors are located in each applicable duct and therefore comply with NFPA 72.

7.2.9. Sequence of Operation

Fire alarm systems provide three types of signals:
(1) Alarm
- warning of fire danger that requires immediate action

(2) Supervisory
- action is needed in connection with the operation of other fire protection systems that are being monitored by the fire alarm system

(3) Trouble
- fault in a monitored circuit or component of the fire alarm system or the disarrangement of the primary or secondary power supply

According to code 26.3.7.1.1 in NFPA 72 alarm signals initiated by
- manual fire alarm boxes,
- automatic fire detectors,
- water flow from the automatic sprinkler system, or
- actuation of other fire suppression systems or equipment shall be treated as fire alarms.

SEQUENCE OF OPERATIONS MATRIX

DEVICE / ACTION	MANUAL PULL STATION	AREA SMOKE/ HEAT DETECTOR	DUCT SMOKE DETECTOR	ELEVATOR LOBBY DETECTOR	ELEVATOR SHAFT AND MACHINE ROOM SMOKE DETECTOR	SPRINKLER WATER FLOW SWITCH	SPRINKLER VALVE TAMPER SWITCH	SPECIAL EXTINGUISHING SYSTEMS	GENERATOR POWER FAILURE	ELEVATOR SHAFT AND MACHINE ROOM HEAT DETECTOR	CORRIDOR SMOKE DETECTOR
ANNUNCIATE AT FIRE CONTROL PANEL	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
ANNUNCIATE AT 24 HOURS ATTENDED REMOTE LOCATION	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
ACTIVATE AUDIBLE ALARM SIGNAL THROUGHOUT BUILDING	YES	YES	YES	YES	NO	YES	NO	YES	NO	NO	YES
SHUT DOWN ALL AIR HANDLING EQUIPMENT/CLOSE FSD	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO	YES
ELEVATOR SHUTDOWN	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	NO
RECALL ELEVATORS SERVING FIRE FLOOR	NO	NO	NO	YES	YES	NO	NO	NO	NO	NO	NO

Figure 17 - Sequence of Operations for the ASB

Signal initiation and deactivation is described in chapters 10.9 and 10.10, respectively, of NFPA 72. Chapter 10.6 describes the priority status of different signals that may occur. Take for instance, **10.6.2** states that fire alarm signals shall take precedence over all other signals, except as permitted by **10.6.1** or **10.6.3** and **10.6.5** states that supervisory signals shall take precedence over trouble signals. These are a few of the most pertinent codes from chapter 10.6 that concern the agriculture sciences building.

A.26.4.2.4 of NFPA 72 states for a proprietary supervising station alarm system, that building functions that should be initiated or controlled during a fire alarm condition include, but should not be limited to, the following:

(1) Elevator operation consistent with ANSI/ASME A17.1a/CSA B44a, *Safety Code for Elevators and Escalators*

(2) Unlocking of stairwell and exit doors *(see* NFPA 80, *Standard for Fire Doors and Other Opening Protectives, and* NFPA *101*, *Life Safety Code)*

(3) Release of fire and smoke dampers *(see* NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, and NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems)*

(4) Monitoring and initiating of self-contained automatic fire extinguishing system(s) or suppression system(s) and equipment *(see* NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*; NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*; NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems;* NFPA 13, *Standard for the Installation of Sprinkler Systems;* NFPA 14, *Standard for the Installation of Standpipe and Hose Systems;* NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection;* NFPA 17, *Standard for Dry Chemical Extinguishing Systems; and* NFPA 17A, *Standard for Wet Chemical Extinguishing Systems)*

(5) Lighting control necessary to provide essential illumination during alarm conditions *(see NFPA 70*, *National Electrical Code*, and NFPA *101*, *Life Safety Code)*

(6) Emergency shutoff of hazardous gas
(7) Control of building environmental heating, ventilating, and air-conditioning equipment to provide smoke control *(see* NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems)*
(8) Control of process, data processing, and similar equipment as necessary during alarm conditions

A.26.4.2.4 summarizes what is included in figure 17 for the sequence of operations.

7.2.10. Disposition of Signals

Proprietary Supervising Station Alarm System

The Agriculture Sciences building disposition of signals are as follows:

NFPA 72 26.4.5.6.1 Alarm Signals. Upon receipt of an alarm signal, the proprietary supervising station operator shall initiate action to perform the following:

(1) Immediately notify the fire department, the emergency response team, and such other parties as the authority having jurisdiction requires
(2) Dispatch a runner or technician to the alarm location to arrive within 2 hours after receipt of a signal
(3) Restore the system as soon as possible after disposition of the cause of the alarm signal

NFPA 72 26.4.5.6.3 Supervisory Signals. Upon receipt of sprinkler system and other supervisory signals, the proprietary supervising station operator shall initiate action to perform the following, if required:

(1) Communicate immediately with the designated person(s) to ascertain the reason for the signal
(2) Dispatch personnel to arrive within 2 hours to investigate, unless supervisory conditions are promptly restored
(3) Notify the fire department if required by the authority having jurisdiction
(4) Notify the authority having jurisdiction when sprinkler systems are wholly or partially out of service for 8 hours or more
(5) Provide written notice to the authority having jurisdiction as to the nature of the signal, time of occurrence, and restoration of service when equipment has been out of service for 8 hours or more

NFPA 72 26.4.5.6.4 Trouble Signals. Upon receipt of trouble signals or other signals pertaining solely to matters of equipment maintenance of the alarm system, the proprietary supervising station operator shall initiate action to perform the following, if required:

(1) Communicate immediately with the designated person(s) to ascertain reason for the signal
(2) Dispatch personnel to arrive within 4 hours to initiate maintenance, if necessary

(3) Notify the fire department if required by the authority having jurisdiction
(4) Notify the authority having jurisdiction when interruption of service exists for 4 hours or more
(5) When equipment has been out of service for 8 hours or more, provide written notice to the authority having jurisdiction as to the nature of the signal, time of occurrence, and restoration of service

7.2.11 Power Requirements

NFPA 72 10.5.6.3 - The secondary power supply shall have sufficient capacity to operate the system under quiescent load (system operating in a non-alarm condition) for a minimum of 24 hours and, at the end of that period, shall be capable of operating all alarm notification appliances used for evacuation or to direct aid to the location of an emergency for 5 minutes.

NFPA 72 10.5.6.3.2 - The secondary power supply capacity required shall include all power supply loads that are not automatically disconnected upon the transfer to secondary power supply. (10.5.6.3.2)

*** Table 3 - Secondary Battery Requirement**

Item	Desc.	Standby Current per Unit (Amps)	QTY	Total Standby current per unit (Amps)	Total Alarm Current Per Unit (Amps)	QTY	Total System Alarm Current (Amps)
A	FACU	0.13	1	0.13	3	1	3
B	Duct Det	0.0001	6	0.0006	0.086	6	0.516
C	Smoke Det	0.0001	3	0.0003	0.086	3	0.258
D	Horn	0	5	0	0.023	5	0.115
E	Horn/Strobe	0	4	0	0.091	4	0.364
F	Annunciator	0.065	1	0.065	0.14	1	0.14
				0		0	0
				0		0	0

Total System Standby Current (Amps)		0.1959	Total System Alarm Current (Amps)	4.393

Standyby 24 Hours Alarm: 5 min x 1/60 = 0.0833 Hours

Required Standby Time (Hours)	Total System Standby Current (Amps)	Required Standby Capacity (Amp-Hours)		Required Alarm Time (Hours)	Total System Alarm Current (Amps)	Required Alarm Current (Amp-Hours)
24	0.1959	4.7016		0.0833	4.393	0.3661

Required Standby Capacity (Amp-Hours)	Required Alarm Capacity (Amp-Hours)	Total Required Capacity (Amp-Hours)	Factor of Safety	Required Battery Capacity (Amp-Hours)
4.7016	0.366	5.068	1.2	6.081

* See Appendix C for all current ratings on devices

7.2.12. Inspection, Testing, and Maintenance (ITM)

Inspection

Table 4 - Inspection Frequency Requirements

	Inspection (NFPA 72 Table 14.3.1)
FACP (monitored)	Annual visual inspection of control equipment including fuses, interfaced equipment, lampps and LEDs, and primary power supply
Battery (nickel-cadmium)	Visual inspection of battery semiannually
Remote Annunciator	Visual inspection of remote annunciator semiannually to ensure obsticals are not blocking access.
Initiating Devices	Semiannual visual inspection of duct detectors, manual fire alarm boxes, and smoke detectors. Quarterly visual inspection of waterflow switch
Alarm Notification Appliances (supervised)	Semiannual visual inspection of both audible and visual notification devices

Testing

NFPA 72 14.4.2.2 – Test Methods

FACP

- Functions - At a minimum, control equipment shall be tested 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.
- Fuses – The rating and supervision shall be verified.
- Interfaced equipment - Integrity of single or multiple circuits providing interface between two or more control units shall be verified. Interfaced equipment connections shall be tested by operating or simulating operation of the equipment being supervised. Signals required to be transmitted shall be verified at the control unit.
- Lamps and LEDs – shall be illuminated

- Primary power supply - All secondary (standby) power shall be disconnected and tested under maximum load, including all alarm appliances requiring simultaneous operation. All secondary (standby) power shall be reconnected at end of test. For redundant power supplies, each shall be tested separately.

Secondary power supply

- All primary (main) power supplies shall be disconnected, and the occurrence of required trouble indication for loss of primary power shall be verified. The system's standby and alarm current demand shall be measured or verified, and, using manufacturer's data, the ability of batteries to meet standby and alarm requirements shall be verified. General alarm systems shall be operated for a minimum of 5 minutes, and emergency voice communications systems for a minimum of 15 minutes. Primary (main) power supply shall be reconnected at end of test.

Battery (Nickel-Cadmium)

- Battery replacement - Batteries shall be replaced in accordance with the recommendations of the alarm equipment manufacturer or when the recharged battery voltage or current falls below the manufacturer's recommendations.
- Discharge test - With the battery charger disconnected, the batteries shall be load tested following the manufacturer's recommendations. The voltage level shall not fall below the levels specified.
- Charger test - With the batteries fully charged and connected to the charger, an ampere meter shall be placed in series with the battery under charge. The charging current shall be in accordance with the manufacturer's recommendations for the type of battery used. In the absence of specific information, 1/30 to 1/25 of the battery rating shall be used.
- Load Voltage test - Under load, the float voltage for the entire battery shall be 1.42 volts per cell, nominal. If possible, cells shall be measured individually.

Fire alarm control unit trouble signals

- Audible and Visual - Operation of control unit trouble signals shall be verified, as well as ring-back feature for systems using a trouble-silencing switch that requires resetting.
- Disconnect Switches - If control unit has disconnect or isolating switches, performance of intended function of each switch shall be verified and receipt of trouble signal when a supervised function is disconnected shall also be verified.
- Ground-fault monitoring circuit - If the system has a ground detection feature, the occurrence of ground-fault indication shall be verified whenever any installation conductor is grounded.

- Transmission of signals to of-premises location - An initiating device shall be actuated and receipt of alarm signal at the off-premises premises location location shall be verified. A trouble condition shall be created and receipt of a trouble signal at the off-premises location shall be verified. A supervisory device shall be actuated and receipt of a supervisory signal at the off premises location shall be verified. If a transmission carrier is capable of operation under a single- or multiple-fault condition, an initiating device shall be activated during such fault condition and receipt of a trouble signal at the off-premises location shall be verified, in addition to the alarm signal.

Remote Annunciator

- The correct operation and identification of annunciators shall be verified. If provided, the correct operation of annunciator under a fault condition shall be verified.

Conductors

- Stray voltage - All installation conductors shall be tested with a volt/ohmmeter to verify that there are no stray (unwanted) voltages between installation conductors or between installation conductors and ground. Unless a different threshold is specified in the published manufacturer's instructions for the installed equipment, the maximum allowable stray voltage shall not exceed 1 volt ac/dc.
- Ground faults - All installation conductors, other than those intentionally and permanently grounded, shall be tested for isolation from ground per the installed equipment manufacturer's published instructions.
- Short-circuit faults - All installation conductors, other than those intentionally connected together, shall be tested for conductor-to-conductor isolation per the published manufacturer's instructions for the installed equipment. These same circuits also shall be tested conductor-to-ground.
- Loop resistance - With each initiating and indicating circuit installation conductor pair short-circuited at the far end, the resistance of each circuit shall be measured and recorded. It shall be verified that the loop resistance does not exceed the limits specified in the published manufacturer's instructions for the installed equipment.
- Supervision Introduction of a fault in any circuit monitored for integrity shall result in a trouble indication at the fire alarm control unit. One connection shall be opened 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.

Initiating devices

- Manual fire alarm boxes - Manual fire alarm boxes shall be operated per the manufacturer's published instructions. Key-operated pre-signal and general alarm manual fire alarm boxes shall both be tested.
- Smoke detectors (In other than one- and two- family dwellings, system detectors and single- or multiple- station smoke alarms) - Smoke detectors/smoke alarms shall be tested in place to ensure smoke entry into the sensing chamber and an alarm response. Testing with smoke or listed aerosol, acceptable to the manufacturer of the aerosol or the manufacturer of the smoke detector/smoke alarm and identified in their published instructions, shall be permitted as acceptable test methods. Other methods listed in the manufacturer's published instructions that ensure smoke entry from the protected area, through the vents, into the sensing chamber shall be permitted.
    - Any of the following tests shall be performed 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
(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

- Duct type - In addition to the testing required in Table 14.4.2.2(g)(1), duct smoke detectors utilizing sampling tubes shall be tested by verifying the correct pressure differential (within the manufacturer's published ranges) between the inlet and exhaust tubes using a method acceptable to the manufacturer to ensure that the device will properly sample the airstream. These tests shall be made in accordance with the manufacturer's published instructions for the device installed

Alarm notification appliances

- Audible
    (1) Initial and reacceptance testing shall comply with the following: Sound pressure levels for signals shall be measured with a sound level meter meeting ANSI S1.4a, *Specifications for Sound Level Meters*, Type 2 requirements. Sound pressure levels throughout the protected area shall be measured to confirm that they are in compliance with Chapter 18. The sound level meter shall be set in accordance with ANSI S3.41, *American National Standard Audible Evacuation Signal,* using the time weighted characteristic F (FAST).
    (2) Periodic testing shall comply with the following: Sound pressure levels for signals shall be measured with a sound level meter meeting ANSI S1.4a, *Specifications for Sound Level Meters*, Type 2 requirements. Sound pressure levels shall be measured for conformity to Chapter 18 where building, system, or occupancy changes have occurred. The sound level meter shall be set in accordance with ANSI S3.41, *American National Standard Audible Evacuation Signal,* using the time-weighted characteristic F (FAST).

- Visible - Test shall be performed in accordance with the manufacturer's published instructions. Appliance locations shall be verified to be per approved layout, and it shall be confirmed that no floor plan changes affect the approved layout. It shall be verified that the candela rating marking agrees with the approved drawing. It shall be confirmed that each appliance flashes.

Interface Equipment

- Interface equipment connections shall be tested by operating or simulating the equipment being supervised. Signals required to be transmitted shall be verified at the control unit. Test frequency for interface equipment shall be the same as the frequency required by the applicable NFPA standard(s) for the equipment being supervised.

Table 5 - Testing Frequency Requirements

	Testing (NFPA 72 Table 14.4.5)
FACP (monitored)	Annual test of control equipment including fuses, interfaced equipment, lamps and LEDs, transponders, and primary power supply
Battery (nickel-cadmium)	Charger test - Annually; Discharge test - Annually; Load Voltage test - semiannually
Remote Annunciator	Test Annually
Initiating Devices	Test duct detectors, manual fire alarm boxes, and smoke detectors annually; Test tamper switch semiannually
Alarm Notification Appliances (supervised)	Test audible and visual notification appliances annually

Maintenance

NFPA 72 14.5.1 System equipment shall be maintained in accordance with the manufacturer's published instructions.

NFPA 72 14.5.2 The frequency of maintenance of system equipment shall depend on the type of equipment and the local ambient conditions.

See data specs in Appendix C for device maintenance requirements

7.3. Automatic Fire Suppression System

7.3.1. Reference

The applicable sprinkler standard used to conduct this report is NFPA 13 (2013 Edition) and NFPA 25 (1998 Edition). The fire sprinkler system plans were obtained from Rex Wolf, architect and room planner on Cal Poly San Luis Obispo campus over in building 70.

7.3.2. Design Criteria

This is an ordinary building with moderate fire loads. The suppression system is not in any danger of freezing and nothing of great value will be stored in the building. A typical wet pipe system will satisfy the code and owner's needs in this building.

Table 6 – ASB Automatic Fire Suppression System Characteristics

Fire Suppression System		Reference
Type	Wet Pipe System	NFPA 13 7.1
Occupancy Class	Light Hazard	NFPA 13 A.5.2 (5)

The following is the design requirements for a hydraulic calculated light hazard building.

Table 7 - Hydraulic Requirements for ASB by Code

Hydraulic Requirements For Light Hazard		Reference
Hose Stream Allowance (gpm)	250	NFPA 13 Table 11.2.3.1.2
Duration (minutes)	30	NFPA 13 Table 11.2.3.1.2
Area of Sprinkler Operation (sq ft)	1500	NFPA 13 Figure 11.2.3.2
Density (gpm/sq ft)	0.1	NFPA 13 Figure 11.2.3.2

The building is fitted with high temperature sprinklers in some locations which is can be expected from a greenhouse and a mechanical room. Code 8.3.2.2 in NFPA 13 states that where maximum ceiling temperatures exceed 100°F, sprinklers with temperature ratings in accordance with the maximum ceiling temperatures of Table 6.2.5.1 shall be used and code 8.3.2.4 states sprinklers of intermediate- and high-temperature classifications shall be installed in specific locations as required by 8.3.2.5. This building is protected by intermediate temperature sprinklers in the indicated spots on the fire sprinkler plans.

Water Supply

Table 8 - Hydrant #29 Flow Information

Water Characteristics at Point of Connection (POC)		Flow (GPM)
Static Presure (psi)	80	0
Residual Pressure (psi)	60	1045

The point of connection (POC) to the city supply will be assumed to be at the POC "Boyance" indicated on the first page of the fire sprinkler plans section. The water flow information in table 8 was taken from hydrant #29 on campus. Figure 18 shows where hydrant #29 is by the blue star. Pressure readings were taken from the hydrant marked with the orange star. The flow test was performed on January 31, 2002.

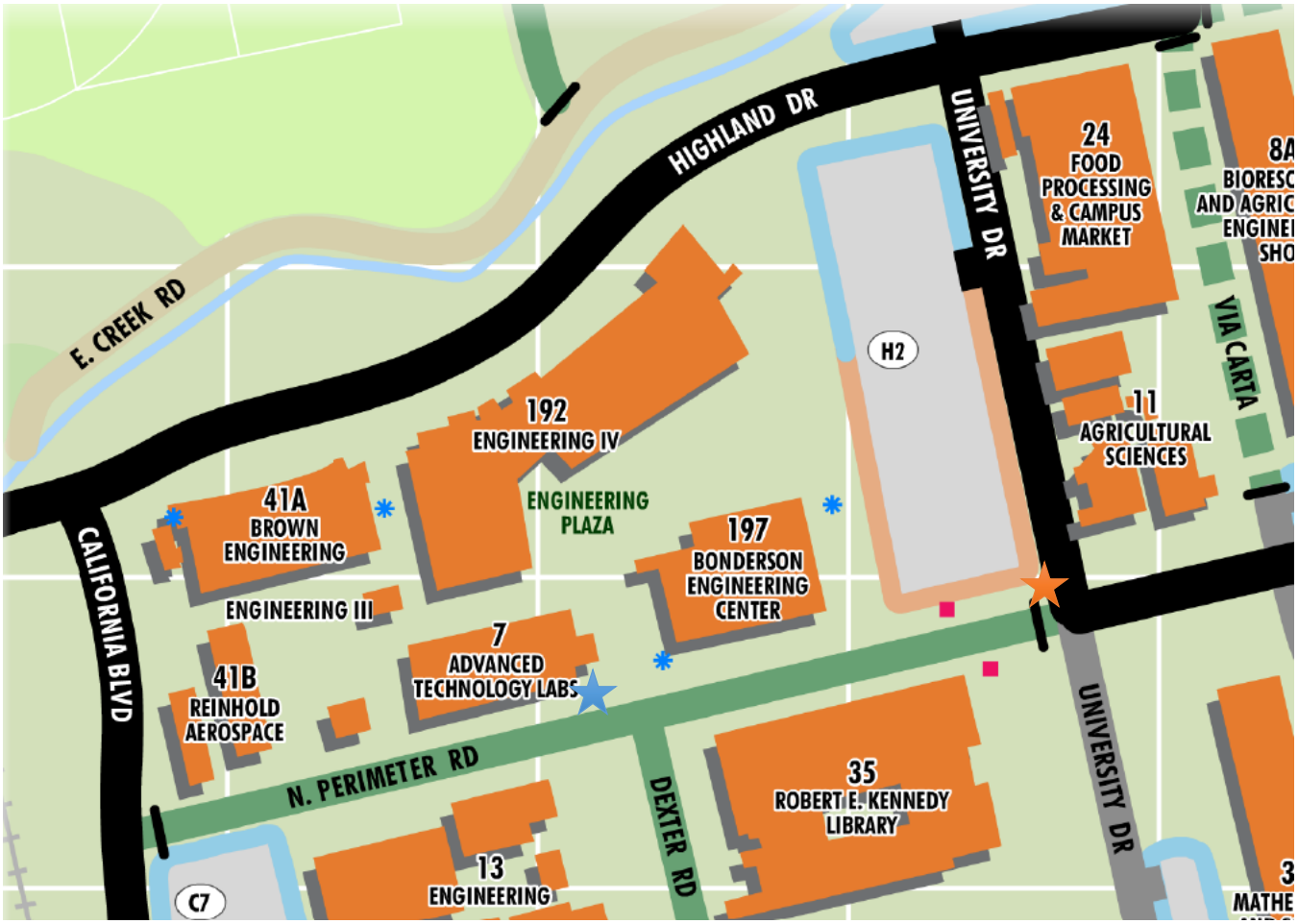


Figure 18 – Hydrant 29 Location

7.3.3. Fire Sprinkler Plans

The authority having jurisdiction in 1986 approved the plans in appendix G. The plans indicate all risers, mains, cross mains, and branch lines, complete with dimensions and nominal pipe sizes. It is assumed that the pipe is composed of schedule 40 black steel throughout the whole building. The plans indicate the point of connection at the base of the riser is in the southwest corner of the building.

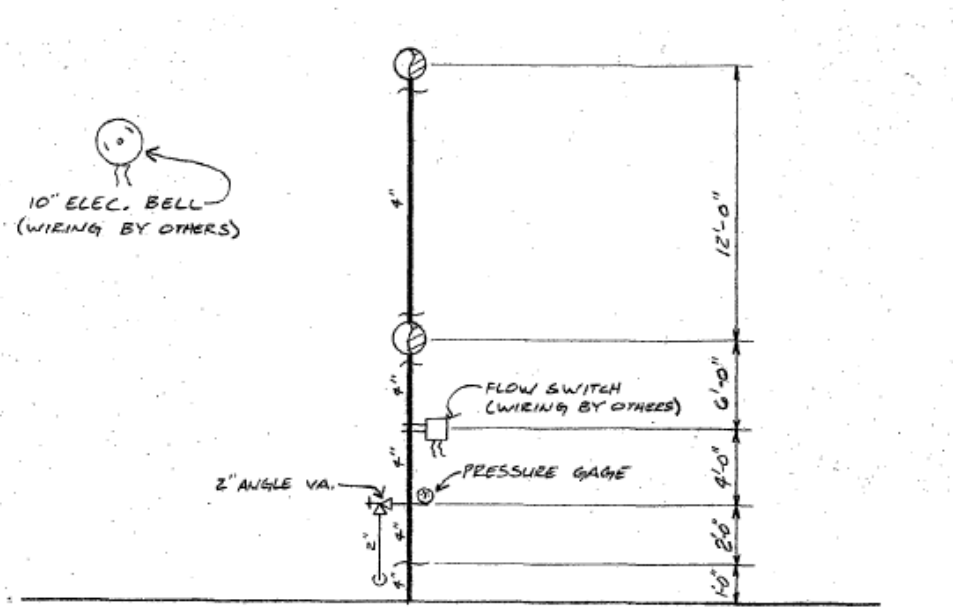


Figure 19 - ASB Riser Detail

NFPA 13 8.2.1 states the maximum floor area on any floor to be protected by sprinklers supplied by any one sprinkler system riser or combined system riser shall be 52,000 sq ft for light hazard class buildings. Since all floors are less than 1/3 the maximum floor space in the Agriculture Sciences Building, one riser is permitted to supply the sprinkler system in the building.

The riser reaches to the second floor and extends itself to the center of the building to another riser that feeds the third floor. The flow at sprinkler 169 suggests that the sprinkler has a K-factor of 5.6 in order to obtain the operating pressure of 7 psi or higher, but the main reason is probably to save on costs. Appendix G shows the original fire suppression system plans, which also shows that the ASB is up to code with codebook NFPA 13, code 8.3.4.2.

Fire Sprinklers

Table 9 - ASB Sprinkler Characteristics

Sprinkler Characteristics			
Orientation	Pendant (SSP)	Sidewall (HSW)	Upright (SSU)
Response	Standard	Standard	Standard
Temperature Ratings	165 F	212 F 286 F	165 F 212 F
Oriface Size	1/2"	1/2"	1/2"
Max. Coverage Per Sprinkler	225 sq ft	196 sq ft	225 sq ft
K Factor	5.6	5.6	5.6

Manufacturer	Viking	Viking	Viking
Type	Wet Dry	Wet	Wet

Hydraulic Calculation

The hydraulic calculations are from the area of operation to the base of the riser (BOR) or referred to as the point of connection (POC) in the plans.

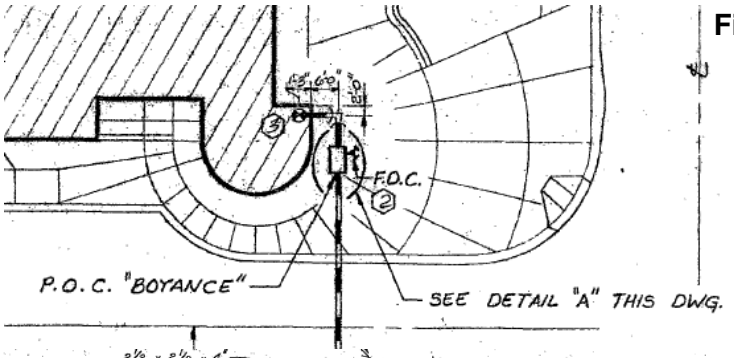


Figure 20 - ASB Point of Connection

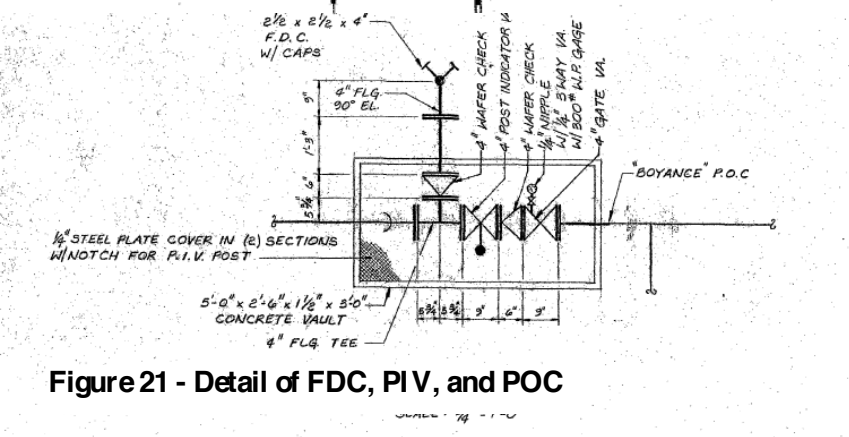


Figure 21 - Detail of FDC, PIV, and POC

There are two remote areas in the ASB. The first remote area in the agriculture sciences building is the room on the third floor on the west side as shown below. The maximum area of operation is 82 sq ft/sprink as seen in figure 22. This gives 19 sprinklers per 1500 sq ft of operation and working flow and pressure of 14.82 gpm and 7.0 psi, respectively.

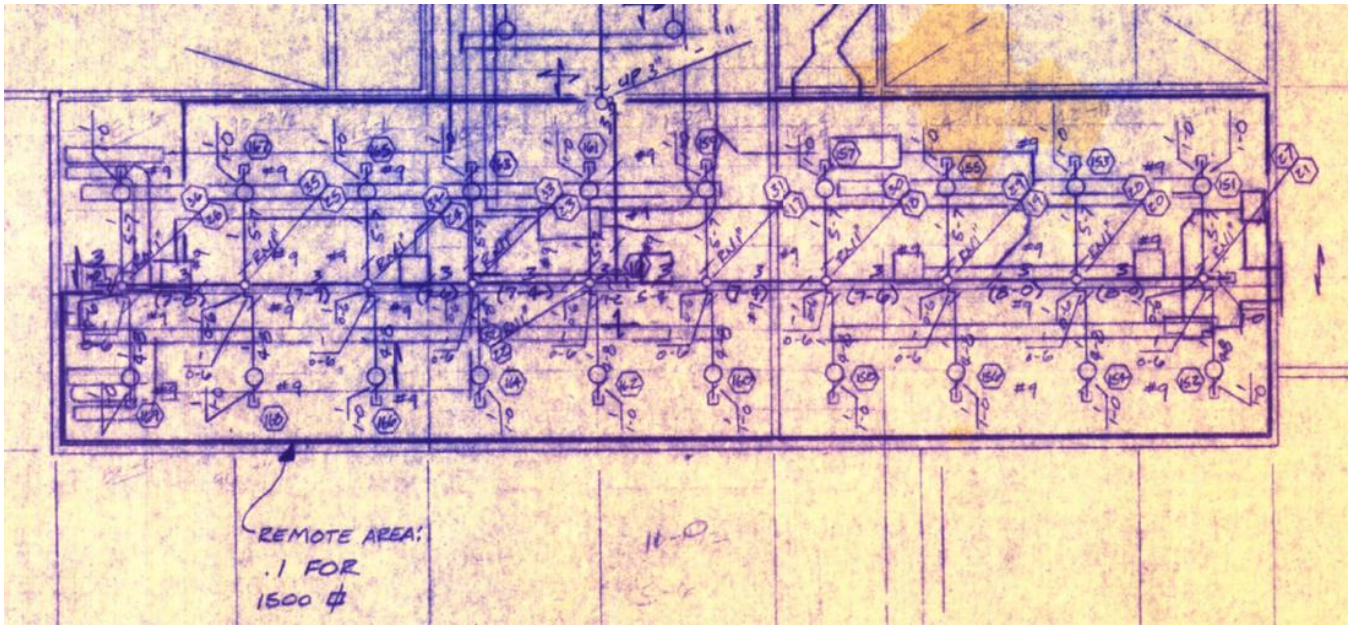


Figure 22 - First Most Remote Design Area

The second design area is located on the north-west side of the building on the second floor of the ASB. The sprinklers have a maximum spacing of 148 square feet as seen in figure 23. This gives 19 sprinklers per 1500 sq ft of operation and working flow and pressure of 14.82 gpm and 7.0 psi, respectively.

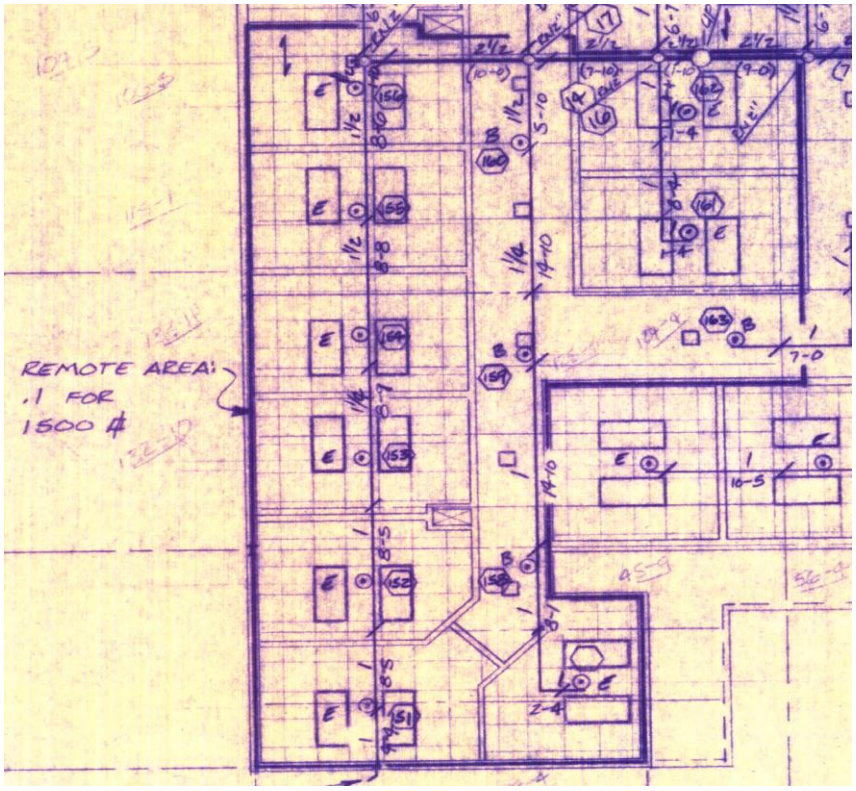


Figure 23 - Second Most Remote Area

The system demand for both design areas can be seen in table 10. When graphed on hydraulic paper and compared to each other and the city supply, it can be seen that the second design area is the most demanding.

Table 10 - Overall Design Area Demands

	First Design Area		Second Design Area	
	POC	Base of Riser	POC	Base of Riser
Pressure	49.6 psi	46.5 psi	77.52 psi	73.4 psi
Flow	286.7 gpm	286.7 gpm	320.31 gpm	320.31 gpm
Total Flow (w/ HSA)	536.7 gpm	536.7 gpm	570.31 gpm	570.31 gpm

Figure 24 shows the area graphed on hydraulic paper. The second design area's demand is just below the city supply but not under the 10% safety margin. This safety margin is taken to be the limit for the system because supplies tend to fluctuate depending on the city's water usage.

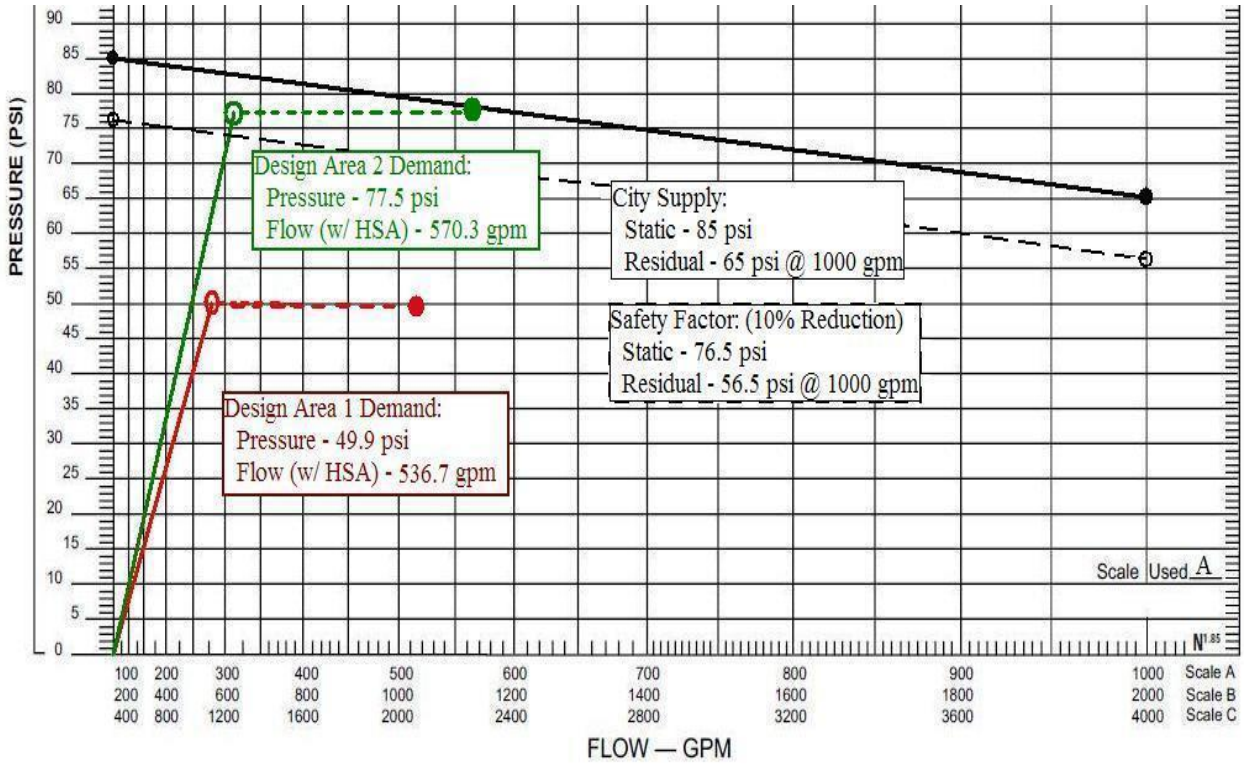


Figure 24 - System Demand

7.3.4. Inspection, Testing, Maintenance

The system in the agriculture sciences building consists of pressure gauges, control valves (or alarm valves), check valves, relief valves, sprinklers, pipe and fittings. The following is the specifications for inspecting, testing, and maintenance of such components in accordance with NFPA 13.

Components	Inspection	Testing	Maintenance
Pressure Gauges	NFPA 25 2-2.4.1 - Shall be inspected monthly to ensure that they are in good condition and that normal water supply pressure is being maintained	NFPA 25 2-3.2 - Gauges shall be tested or replaced every 5 years with a calibrated gauge. Gauges not accurate to within 3 percent of the full scale shall be recalibrated or replaced	NFPA 25 2-3.2 - Gauges shall be tested or replaced every 5 years with a calibrated gauge. Gauges not accurate to within 3 percent of the full scale shall be recalibrated or replaced
Control Valves	NFPA 25 9-3.3.2 - The inspection shall verify that the valves are in the following condition: (a) In the normal open or closed position. (b) Properly sealed, locked, or supervised. (c) Accessible (d) Provided with appropriate wrenches	NFPA 25 9-3.4 - Each control valve shall be operated annually through its full range and returned to its normal position.	NFPA 25 9-3.5 The operating stems of outside screw and yoke valves shall be lubricated annually. The valve then shall be closed and reopened to test its operation and distribute the lubricant.
Alarm Valve	NFPA 25 9-4.1.1 - Alarm valves shall be externally inspected monthly. The valve inspection shall verify the following: (a) The gauges indicate normal supply water is being maintained. (b) The valve is free of physical damage. (c) All valves are in the appropriate open or closed position. (d) There is no leakage from the retarding chamber or alarm drains. NFPA 25 9-4.1.2 - Alarm valves and their associated strainers, filters, and restriction orifices shall be inspected internally every 5 years unless tests indicate a greater frequency in required.	NFPA 25 2-3.3.1 - Testing the waterflow alarms on wet pipe systems shall be accomplished by opening the inspector's test connection on a quarterly interval.	NFPA 25 9-4.1.3.1 - Internal components shall be cleaned/repaired as necessary in accordance with the manufacturer's instructions.
Sprinklers	NFPA 25 2-2.1.1 - Sprinklers shall be	NFPA 25 2-3.1.1 - Where sprinklers have been in service for	NFPA 25 2-4.1.1 - Replacement sprinklers

	inspected from the floor level annually. Sprinklers shall be free of corrosion, foreign materials, paint, and physical damage and shall be installed in the proper orientation. Any sprinklershall be replaced that is painted, corroded, damaged, loaded, or in improper orientation. NFPA 25 2-2.1.2 - Unacceptable obstructions to spray patterns shall be corrected.	50 years, they shall be replaced or representative samples from one or more sample areas shall be submitted to a recognized testing laboratory acceptable the authority have jurisdiction for field service testing. Test procedures shall be repeated on a 10-year interval.	shall have the proper characteristics for the application intended. These include the following: (a) Style (b) Orifice size and K-factor (c) Temperature rating (d) Coating, if any (e) Deflector type (f) Design requirements.
Relief Valve	NFPA 25 9-5.1.1 - All valves shall be inspected quarterly. The inspection shall verify that the valves are in the following condition: (a) In the open position (b) Not leaking (c) Maintaining downstream pressures in accordance with the design criteria (d) In good condition, with hand-wheels installed and unbroken.	NFPA 25 9-5.1.2 - A full flow test shall be conducted on each valve at 5-year intervals and shall be compared to previous tests results. If adjustments are necessary, they shall be in accordance with the manufacturer's instructions. NFPA 25 9-5.1.3 - A partial flow test adequate to move the valve from its seat shall be conducted annually.	All damaged or missing components noted during the inspections shall be repaired or replaced in accordance with the manufacturer's instructions.
Pipe and Fittings	NFPA 25 2-2.2 - Sprinkler pipe and fittings shall be inspected annually from the floor level. Pipe and fittings shall be in good condition and free of mechanical damage, corrosion, leakage, loading, and misalignment. (Exception: Pipe and fittings installed in concealed spaces shall not be required to be inspected.)		All damaged or missing components noted during the inspections shall be repaired or replaced in accordance with the manufacturer's instructions and design criteria.

Since the building is located in central California where the climate stays temperate, this system will not need seasonal inspecting, testing, and maintenance.

7.3.5. Analysis

The fire suppression system is code compliant in every aspect of the IBC and NFPA 13. Although it is not required by code for the system to be designed below the 10% safety margin, it is good practice to follow due to the uncertainty in the supply at any given moment. The best and most inexpensive way to fix this problem is to up size the main feeding the area. It can be seen in the fire suppression system plans that the main transitions from a 4" main to 2 ½" main half way through the ASB. Changing the 2 ½" main to a 4" main would significantly reduce the pressure drop in the system and reduce the system demand to below the 10% safety margin.

7.4. Egress Analysis

7.4.1. Occupants Characteristics

The majority of occupants that will be in the Agricultural Sciences Building at Cal Poly will be adults (18 and older) because this is a college campus where students, professors and other faculty go for educational purposes. This indicates that the occupants will have a high capacity for cognitive thinking due to their mature age. The majority will have the physical ability to self-rescue, but occupants unable to use stairs may need additional assistance to exit the premise if elevators are unavailable. The building accounts for this dilemma and provides an emergency evacuation device as shown in Figure 1.

Figure 25 - Emergency Evacuation Device

The number of occupants and density of the occupancy was determined previously. It is determined that the occupancy will not be a highly dense occupancy because the number of occupants is relatively spread out compared to the floor area. The floors at the bottom of the building have a higher density of

occupants because this is where all the classrooms are located. Furthermore, the only activities that will be happening are lecturing, lab-work, and office work. The students and faculty that occupy this building will be there multiple times per week so they will be familiar with their surroundings. Also, because of their mature state of mind, they will be alert to any indication of a fire. Professors and other faculty will assume the responsibilities and role of caretakers to the students in the event of an emergency. It will be their responsibility to provide instruction to those in need of assistance, but doesn't mean that students are unable to assume these roles either, but for the purposes of simplifying the staff will be solely responsible for assuming these responsibilities. Furthermore, all occupants will be perceptive to the warning signs to an imminent emergency. For example, the sound of a fire alarm will commit occupants to a higher state of awareness although nothing may be done about it because the possibility of a false alarm is the first excuse if no other signs of an emergency are present. Typically after hearing an alarm for 5-10 minutes will occupants find it necessary to investigate the cause of the alarm. Only physical evidence or relayed information will make an occupant commit to exiting the building in most cases. This evidence or information could take up to 10-15 minutes to reach the occupants. After that, an occupant will be committed to exiting the building. That's 25 minutes of pre-movement at the most.

7.4.2. Fire Resistive Ratings/Horizontal Exits

Relevant Codes

L**SC 3.3.81.1 - Horizontal Exit.** A way of passage from one building to an area of refuge in another building on approximately the same level, or a way of passage through or around a fire barrier to an area of refuge on approximately the same level in the same building that affords safety from fire and smoke originating from the area of incidence and areas communicating therewith.

LSC 7.1.3.1 - Exit Access Corridors. Corridors used as exit access and serving an area having an occupant load exceeding 30 shall be separated from other parts of the building by walls having not less than a 1-hour fire resistance rating in accordance with Section 8.3, unless otherwise permitted by one of the following:

(1) This requirement shall not apply to existing buildings, provided that the occupancy classification does not change.

(2) This requirement shall not apply where otherwise provided in Chapters 11 through 43.

LSC 7.1.3.2.1 – Exits. Where this *Code* requires an exit to be separated from other parts of the building, the separating construction shall meet the requirements of Section 8.2 and the following:

(1) *The separation shall have a minimum 1-hour fire resistance rating where the exit connects three or fewer stories.

(2) The separation specified in 7.1.3.2.1(1), other than an existing separation, shall be supported by construction having not less than a 1-hour fire resistance rating.

(3) *The separation shall have a minimum 2-hour fire resistance rating where the exit connects four or more stories,

LSC 8.6.5 - Required Fire Resistance Rating - The minimum fire resistance rating for the enclosure of floor openings shall be as follows *(see 7.1.3.2.1 for enclosure of exits):*

(1) Enclosures connecting four or more stories in new construction — 2-hour fire barriers

(2) Other enclosures in new construction: 1-hour fire barriers

Analysis

The areas marked as a corridor are all considered horizontal exits because they are enclosed and protected by fire resistant walls. Elevators are enclosed in shafts and are susceptible to codes for shafts. LSC 8.6.5 requires a three floor enclosure of floor openings to be protected by 1-hour fire barriers/walls. The LSC also requires the agricultural sciences building to have vertical exits and corridors used for evacuation to be protected by 1-hour barriers/walls as well. There are a few storage occupancies adjacent to business occupancies, which require a 2-hour barrier by the LSC.

7.4.3. Illumination

Relevant Codes

LSC 7.8.1.1 - Illumination of means of egress shall be provided in accordance with Section 7.8 for every building and structure where required in Chapters 11 through 43. For the purposes of this requirement, exit access shall include only designated stairs, aisles, corridors, ramps, escalators, and passageways leading to an exit. For the purposes of this requirement, exit discharge shall include only designated stairs, aisles, corridors, ramps, escalators, walkways, and exit passageways leading to a public way.

Analysis

The only recommended exit sign labeled for this building is on the 2nd floor. It is listed because a corridor connecting the east exit stairway begins in that area. The following passage from the LSC enforces this recommendation.

7.4.4. Wall and Ceiling Finish

Relevant Codes

LSC 10.3.5 - Furnishings or decorations of an explosive or highly flammable character shall not be used.
LSC 39.3.3.2.1 - Interior wall and ceiling finish materials complying with Section 10.2 shall be Class A or Class B in exits and in exit access corridors.

Analysis

The ASB doesn't utilize any furnishings or decorations of an explosive or highly flammable character. The interior wall and ceiling finish materials utilized in the exit access corridors are made of cement plaster and comply with section 10.2 of the LSC.

7.4.5. Exit Capacity

Relevant Codes

LSC 7.3.1.1.1 - The total capacity of the means of egress for any story, balcony, tier, or other occupied space shall be sufficient for the occupant load thereof.
LSC 7.3.1.1.2 - … where more than one means of egress is required, the loss of **any one** means of egress (shall) leave available not less than 50 percent of the required capacity.
LSC 7.3.3.2 - For **stairways wider than 44 in.** and subject to the **0.3 in. width per person capacity factor**, the capacity shall be permitted to be increased using the following equation:

$$C = 146.7 + \left(\frac{Wn - 44}{0.218}\right) \qquad \textbf{Equation 1}$$

Where:

- C = exit capacity (people)
- W_n = nominal stairway width (in.)

LSC 7.3.4.1 - The width of any means of egress, unless otherwise provided in 7.3.4.1.1 through 7.3.4.1.3, shall be as follows:

- (1) Not less than that required for a given egress component in this chapter or Chapters 11 through 43
- (2) **Not less than 36 in**. (915 mm)

LSC 9.4.1 - An elevator, other than an elevator in accordance with 7.2.13, shall not be considered a component in a required means of egress but shall be permitted as a component in an accessible means of egress.

Minimum Width Requirements

Minimum door width – 36 in. LSC **7.3.4.1 (2)**
Minimum stair width – 44 in. LSC **7.2.2.2.1.2**
Minimum corridor width – 44 in. LSC **A.18.2.3.4 (1)**

Table 11 - First Floor Exit Capacity

Exit Capacity for 1st Floor			
Total Sum of Door Widths (in)	Capacity Factor	Exit Capacity	Required
784	0.3 in/person	2613 people	517 people

The 1st stairway's exit capacity shall be governed by the equation in LSC 7.3.3.2.

Table 12 - Second and Third Floor Exit Capacities

Exit Capacity for 2nd and 3rd Floors						
Stair Width (in.)	Capacity Factor	Exit Capacity	Door Width (in.)	Capacity Factor	Exit Capacity	Limiting Factor
78	0.3 in./person	302 people	36	0.2 in./person	180 people	180 people
44	0.3 in./person	146 people	36	0.2 in./person	180 people	146 people
44	0.3 in./person	146 people	36	0.2 in./person	180 people	146 people
					Total Exit Capacity:	472 people
					Required Exit Capacity	
					2nd Floor	149
					3rd Floor	118

Analysis

The total sum of door widths is only doors discharging from the corridors on the first floor. None of the room exits that discharge out of the building are included. The greatest loss of exit capacity is 43% when any one exit is rendered useless on the first floor. The first floor's exit capacity is sufficient since the exit capacity, 2613 people, is greater than the occupant load, 517 people. Only 38% of exit capacity is lost at the most when one of the stairways is taken out. The 2nd and 3rd floor's exit capacity satisfies both codes 7.3.1.1.1 and 7.3.1.1.2 from the LSC.

7.4.6. Exit Arrangement

Relevant Codes

LSC 7.5.1.3.2 - Where two exits, exit accesses, or exit discharges are required, they shall be located at a distance from one another not less than one-half the length of the maximum overall diagonal dimension of the building or area to be served, measured in a straight line between the nearest edge of the exits, exit accesses, or exit discharges.
LSC 7.4.1.2 - The number of means of egress from any story or portion thereof… shall be as follows:

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

Analysis

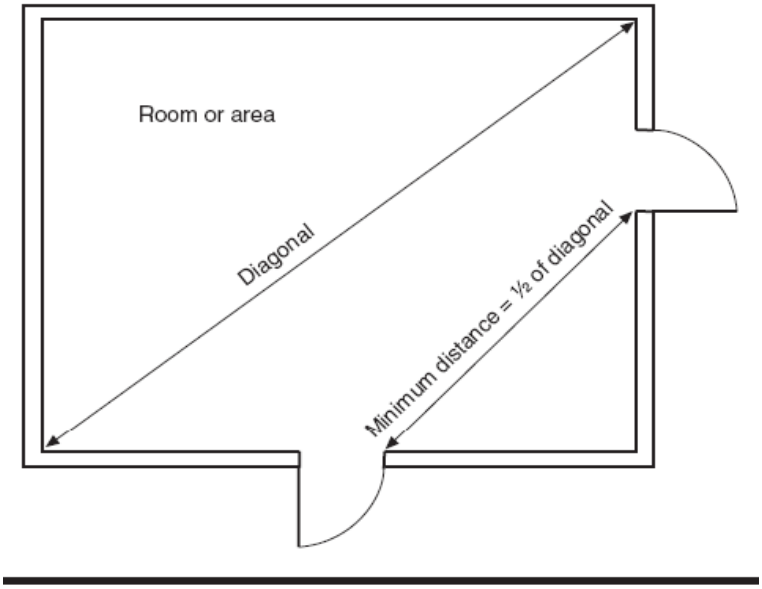


Figure A.7.5.1.3.2(a) Diagonal Rule for Exit Remoteness.

Figure 26 - Exit Remoteness Rule

The building satisfies the LSC requirement 7.5.1.3.2 as demonstrated in the following figures:

Figure 27 - First Floor Exit Remoteness

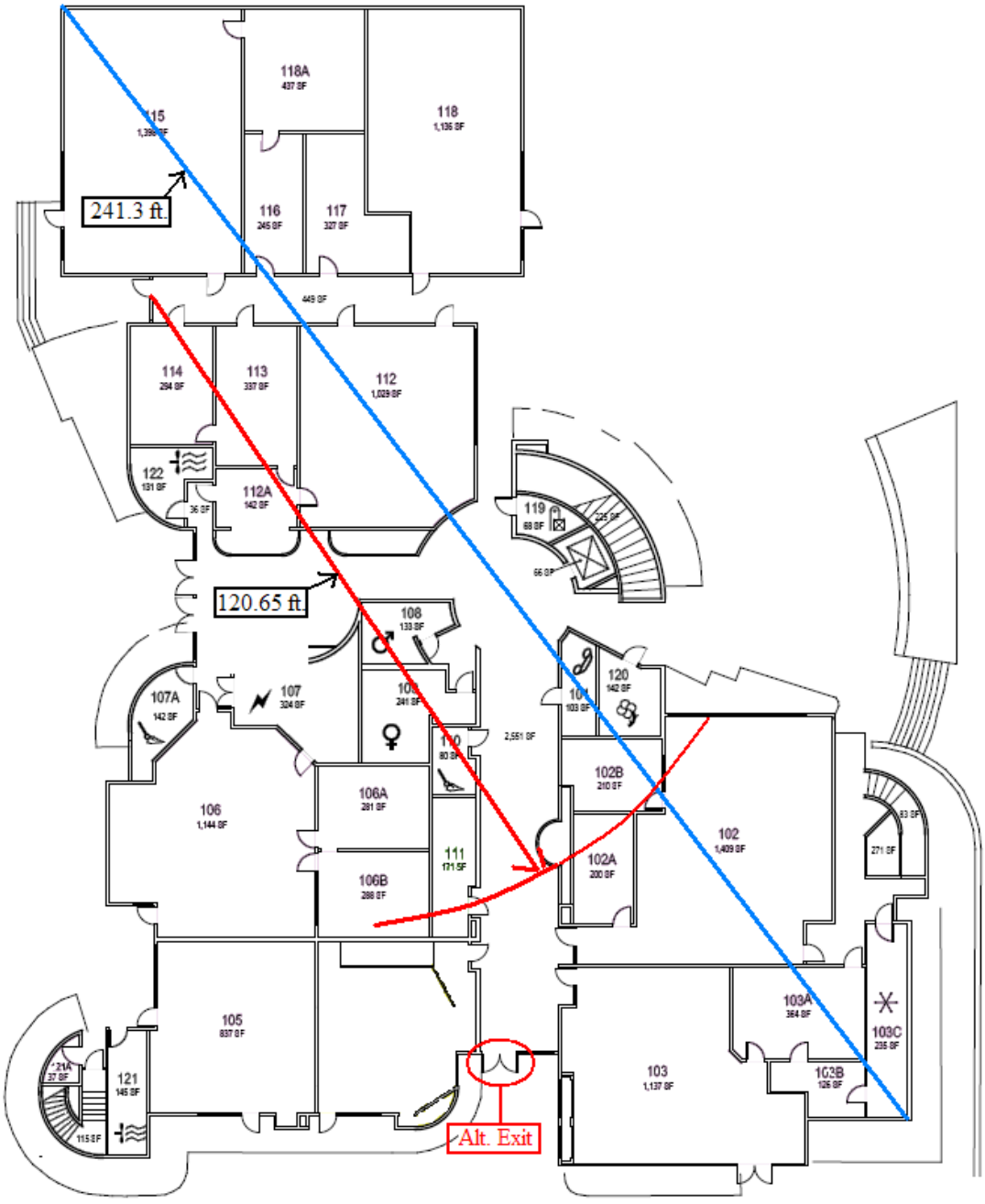


Figure 28 - Second Floor Exit Remoteness

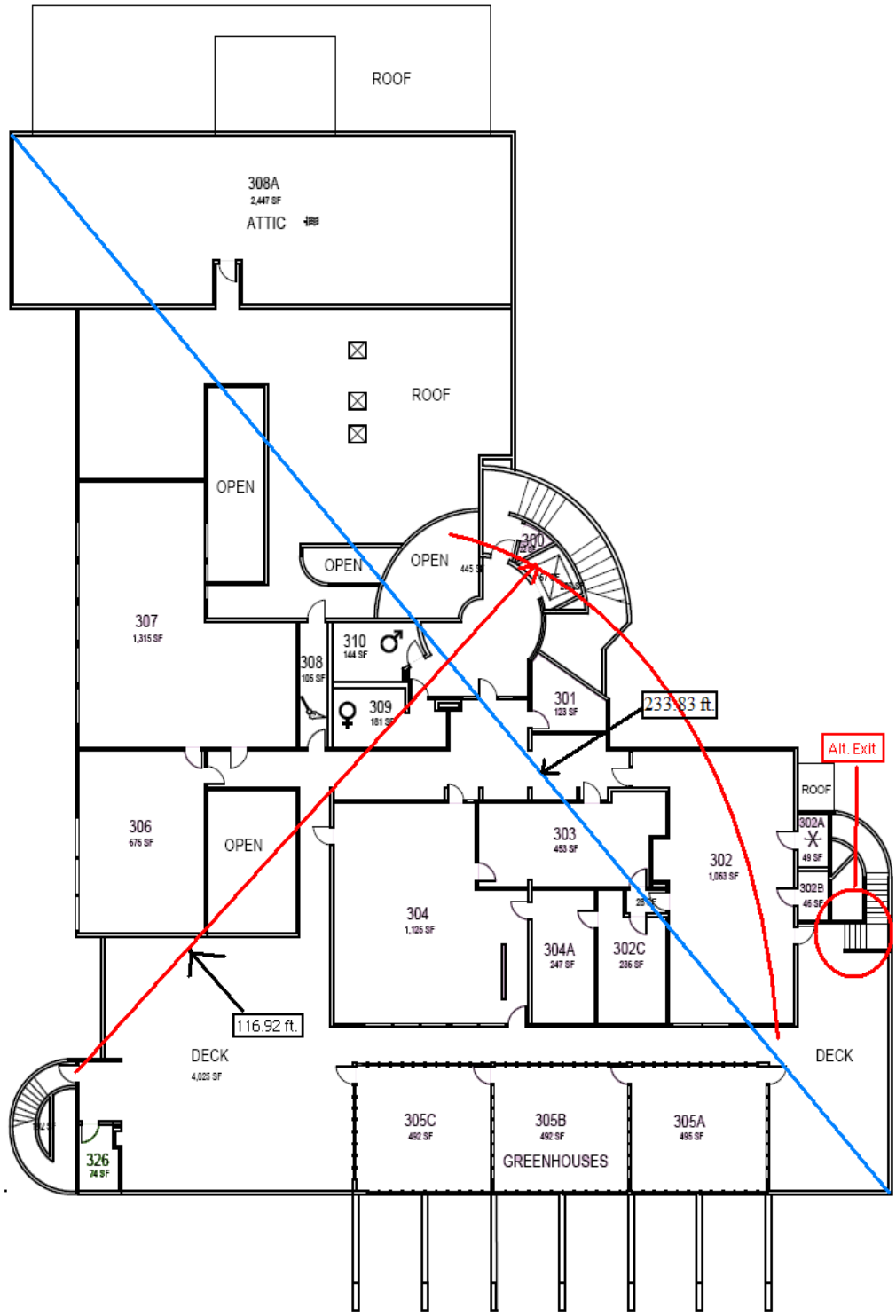


Figure 29 - Third Floor Exit Remoteness

The building has an occupant load of 850 people and the building has a total of three exits located throughout the structure. The building therefore complies with the requirements in LSC 7.4.1.2. The remoteness of exits makes it harder for a hazard to render an exit useless. The agricultural sciences building exits are considered remote enough to comply to LSC 7.5.1.3.2.

7.4.7. Marking of Egress

Relevant Codes

LSC 7.10.8.5. Evacuation Diagram - Where a posted floor evacuation diagram is required in Chapters 11 through 43, floor evacuation diagrams reflecting the actual floor arrangement and exit locations shall be posted and oriented in a location and manner acceptable to the authority having jurisdiction.

Analysis

All floors have an evacuation plan/diagram posted throughout the building including marked exits, fire alarms, etc.

Figure 30 - ASB Evacuation Plan

8. Performance-Based Design

A performance-based design method complies with the IBC because it is considered an alternate design method. The AHJ is required to review the design for compliance with the intent of the IBC (IBC, 2009, Section 104.11).

For purposes of this report, the Life Safety Code (2012 Edition) is used as a guideline for a performance-based approach. A performance-based approach to life safety design must be in accordance with Chapters 1-5 of the Life Safety Code, (NFPA 101, 2012, Section 4.4.3). Chapter 5 focuses on the performance-based approach to life safety design.

Performance Criteria

A performance-based design must prevent any occupant who is not intimate with ignition from being exposed to instantaneous or cumulative untenable conditions. The primary objectives used to achieve this goal include protecting occupants, maintaining structural integrity and maintaining system reliability for the time needed to evacuate, relocate, or defend in place, (NFPA 101, 2012, Section 5.2.2 and Section 4.2).

Retained Prescriptive Requirements

A performance-based design has certain requirements retained from the prescriptive requirements of the Life Safety Code. These requirements pertain to means of egress and are listed in Section 5.3.2 of the Life Safety Code. The relevant requirements to the ASB are covered in Section 4.4 of this report, (NFPA 101, 2012, Section 5.3).

Design Specifications

Design specifications and other conditions used in the performance-based design must be clearly stated and shown to be realistic and sustainable.

- Assumptions must be accurately translated into input data specifications, as appropriate for the calculation method or model. Assumptions that are not addressed or that are modified in the input data because of limitations in test methods must be identified and a sensitivity analysis of the consequences must be performed.
- Building characteristics that affect occupant behavior or the rate of hazard development must be identified.

- The selection of occupant characteristics must provide an accurate reflection of the expected population of building users and be approved by the AHJ.
- The basic occupant response characteristics of sensibility, reactivity, mobility and susceptibility must be evaluated.
- It should be assumed that in every normally occupied room, at least one person is located at the most remote point from the exits.
- The design must be based on the maximum number of people that every occupied room is expected to contain.

Design Fire Scenarios

The Life Safety Code specifies a minimum of eight fire design scenarios to be included in the performance-based analysis. These scenarios are described in detail in Section 5.5.3 of the Life Safety Code, 2012 edition. This report analyzes four fire scenarios that were developed in a Smoke Management Study for the atrium of the CSM and follows the guidance of the SFPE Engineering Guide to Performance-based Fire Protection Analysis and Design of Buildings.

Evaluation of Proposed Designs

The AHJ must approve the choice of assessment methods used in the performance-based approach. The design professional must use the assessment methods to demonstrate that the proposed design will achieve the goals and objectives, as measured by the performance criteria in light of the safety margins and uncertainty analysis, for each scenario, given the assumptions.

Input data for computer fire models must be obtained in accordance with ASTM E 1591, Standard Guide for Obtaining Data for Deterministic Fire Models. Data for use in analytical models that are not computer-based fire models must be obtained using appropriate measurement, recording, and storage techniques to ensure the applicability of the data to the analytical method being used.

Uncertainty in input data must be analyzed and, as determined appropriate by the AHJ, addressed through the use of conservative values. Evidence must be provided to confirm that the assessment methods are valid and appropriate for the proposed building, use, and conditions.

Approved safety factors must be included in the design methods and calculation to reflect uncertainty in the assumptions, data, and other factors associated with the performance-based design.

8.1. Design Fires

8.1.1. Scenario 1

Summary

The first scenario addresses the hazardous materials in the plant physiology classroom (room 115) on the north-west side of the first floor as seen in figure 31. The classroom is mostly used for storage of equipment now. This classroom also has compressed hydrogen stored in aluminum cylinders in it, they are stored at the end of a desk in the room. The cylinders are specifically made out of 6061-T6 grade aluminum and properties for this material was taken from EES. For more details on the compressed hydrogen and aluminum, please see appendix I and H, respectively. Amongst the equipment being stored in the classroom there is a computer located right next to one of the cylinders containing the compressed hydrogen stored at about 2400 psi. This computer has been chosen to be the source of failure resulting in a fire. Since this classroom is mainly used as storage, it is usually unoccupied for the most part and will stay this way for the analysis.

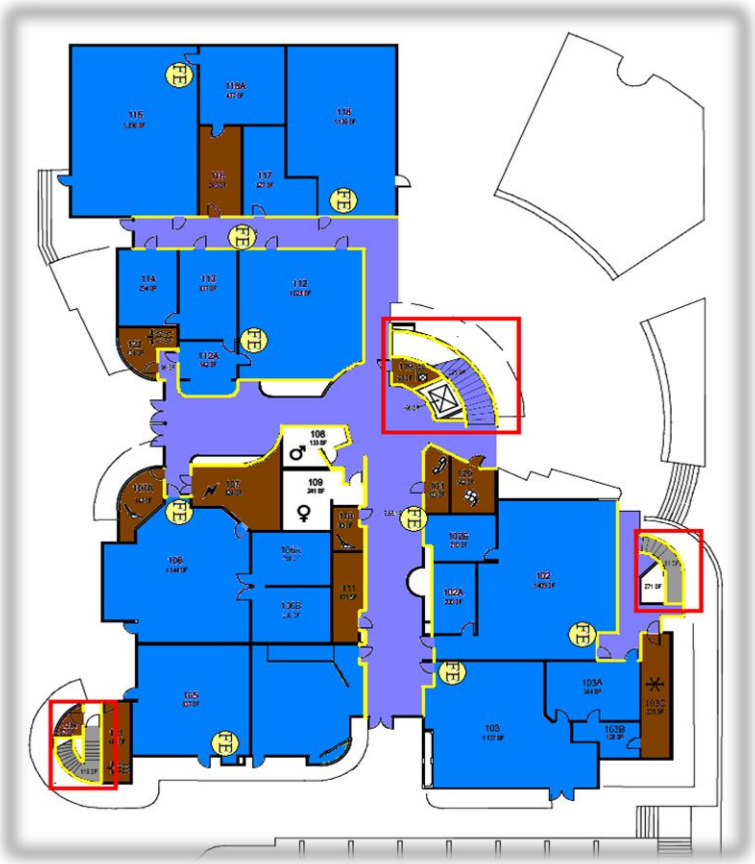


Figure 31 - First Design Scenario Location

Model Development

The model will be laid out just like in figure 32. The hydrogen cylinder is on the left side in figure _ and right behind it is the personal computer as described before. The fire is set to take place during the day

when the ASB would be occupied. The room is unoccupied by anyone so the sprinkler system will be what detects the fire and activates the alarm system. The analysis will concentrate on the temperature the cylinder reaches in fire conditions and how it may affect the fire because of hydrogen's flammability. The cylinder is equipped with a type CG-4 pressure relief valve (PRV) as required by DOT regulations. The PRV has two devices built into it that allow it to function properly. These two devices are a rupture disk and a fusible temperature link. Simple PRV are equipped with one or the other, but the reason why this PRV is equipped with both is to prevent activation due to momentarily over-pressurization. The fusible temperature link, if not melted, will not allow the PRV to activate. In this analysis, both devices will need to be initiated to activate the PRV. The fusible temperature link has a temperature rating of 165 C and the rupture disk's burst pressure is not to exceed the DOT-required test pressure of the cylinder, which is 4000 psi in this case. A safety factor will be applied to prevent temporarily exceeding the test pressure and risk rupture of the cylinder. The rupture disk will be set to go off at 3750 psi in the analysis, which correlates to a temperature of 184 C using EES with the assumption of constant volume. When the PRV is activated, it is designed to release all contents within the cylinder.

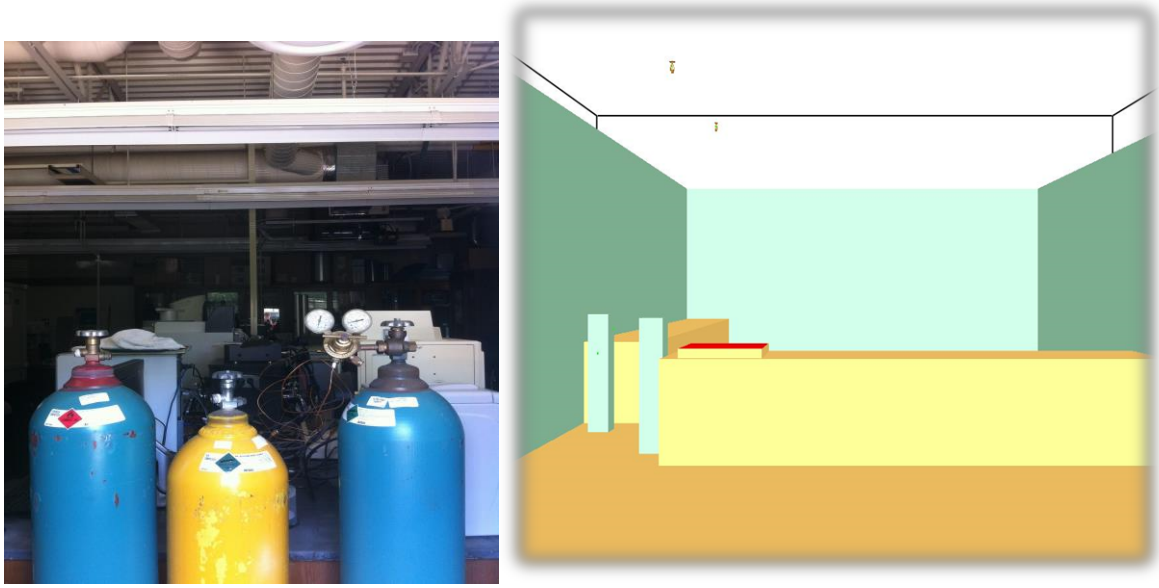


Figure 32 - First Design Scenario Model Setup

The cylinder has a height/length of 60 inches. Also, the cylinder has an outside diameter of 10 inches and a wall thickness of 1 inch. This wall thickness is dictated by an equation given in the DOT regulations for pressure cylinders. These regulations can be found in appendix J.

The goal of the analysis is to calculate whether the fire sprinklers will go off before the PRV releases hydrogen into the room causing an explosion. There are sprinklers in the space and are characterized in table 13. Since the sprinkler has a standard response time, the RTI in the analysis was taken to be 100 $(m\text{-}s)^{0.5}$ because it is an average value for a standard response type sprinkler.

Table 13 - Sprinkler Characteristics in Scenario 1

Sprinkler Characteristics	
Orientation	Upright (SSU)
Response	Standard
Temperature Rating	212 F
Oriface Size	1/2"
Max. Coverage Per Sprinkler	225 sq ft
K Factor	5.6
Manufacturer	Viking
Type	Wet
RTI	100 $(m\text{-}s)^{0.5}$

Design Fire

The design fire is modeled from data taken out of the SFPE HB. This data is from burning workstations that would be typically found in an office in a calorimeter. These workstations included a desk, personal computer, trash bin and other miscellaneous things. Some tests included partitions and some didn't, the data for without partitions is used for this design fire because there is not a cubicle located in the classroom. The design fire is modeled as a workstation because of all the equipment that lies around the

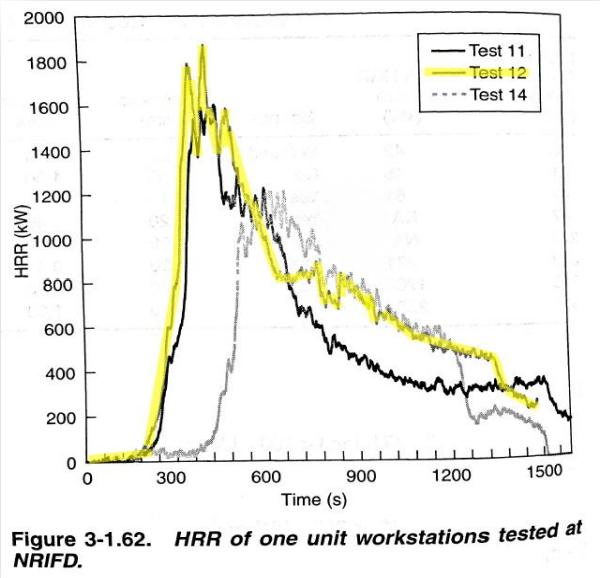


Figure 3-1.62. *HRR of one unit workstations tested at NRIFD.*

Figure 33 -- Design Fire Data for Scenario 1

computer simulating the same fuel load as an office workstation. The data is shown in figure 33 below as test 12.

The peak HRR of the design fire in the analysis is 1870 kW and has a growth rate of Q_{tau} = -400 s. The negative signifies a t^2 fire growth curve. This follows the curve in figure 33 conservatively. For more details on the FDS input, see appendix H.

Tenability Criteria

Since the discharge of the hydrogen tank has the potential to create in explosive hazard, the untenable criteria will be set to be when the cylinder temperature reaches 160 C because that is when the PRV will activate. The potential of the hazard is the pressure wave created from the explosion. The pressure wave has the potential to damage occupant's internal organs ending in death. It also has the potential of structural damage to the room, which could result in the collapse of the floor on the second story.

Analysis

Fire Dynamics Simulator

The only room modeled in the simulation is the plant physiology room. Figure 34 shows the setup in smokeview. The cuboids on the left side are the hydrogen cylinders and are specified as cylinders and are only shown as cuboids in smokeview. The hydrogen is stored at approximately 2400 psi and will be treated as a real gas. Using a program called engineering equations solver, values for thermal conductivity and specific heat with respect to temperature were extracted. Since the cylinders are closed, the density is assumed to be constant. To see more specifics please fds file hydclass3.fds in appendix H.

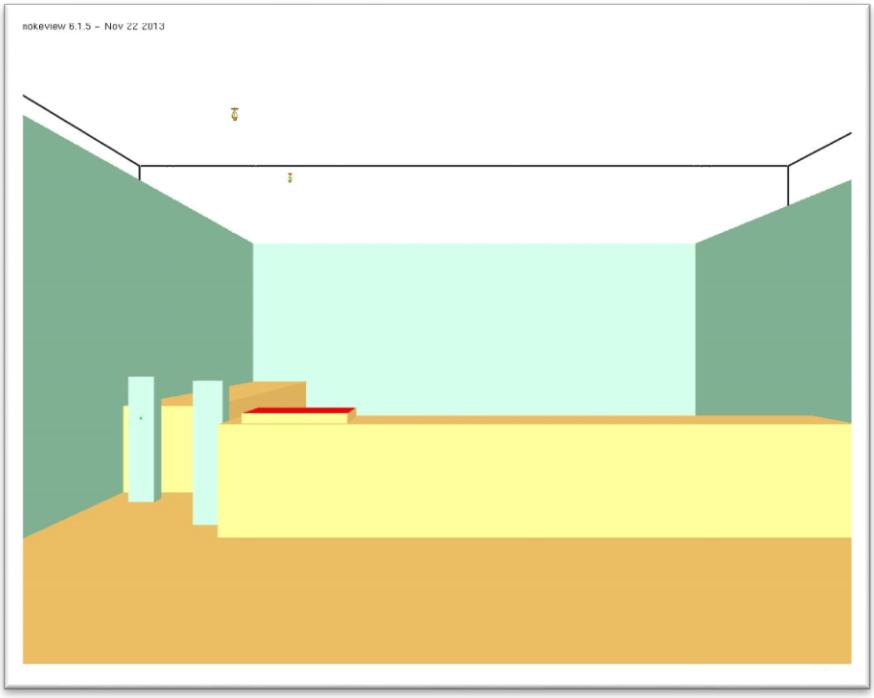


Figure 34 – FDS Model for Scenario 1

Figures 35 illustrate the development of the fire and shows the temperature of the cylinder with respect to time.

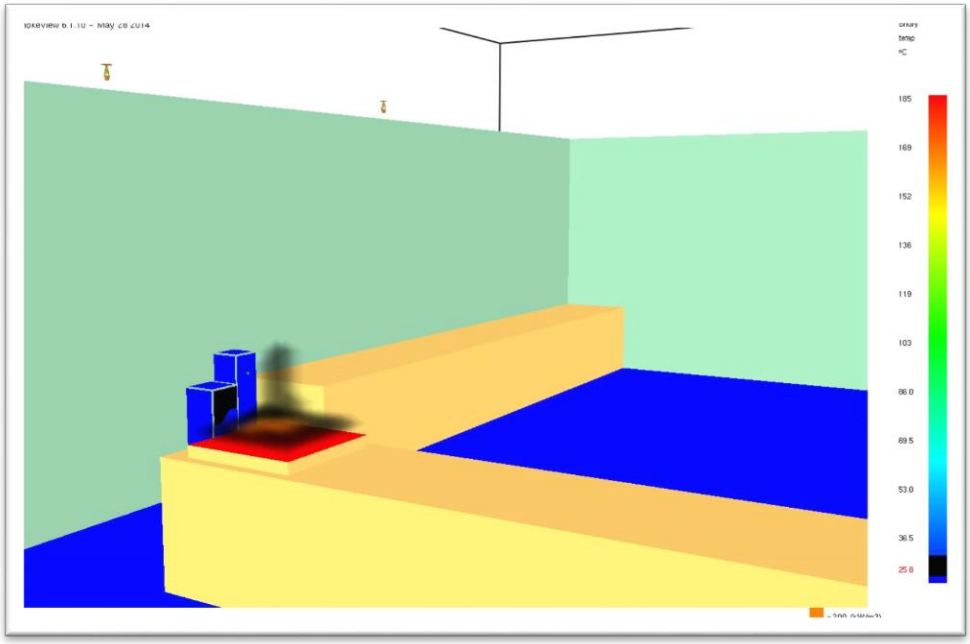


Figure 35 - FDS Model Scenario 1 at 50 seconds

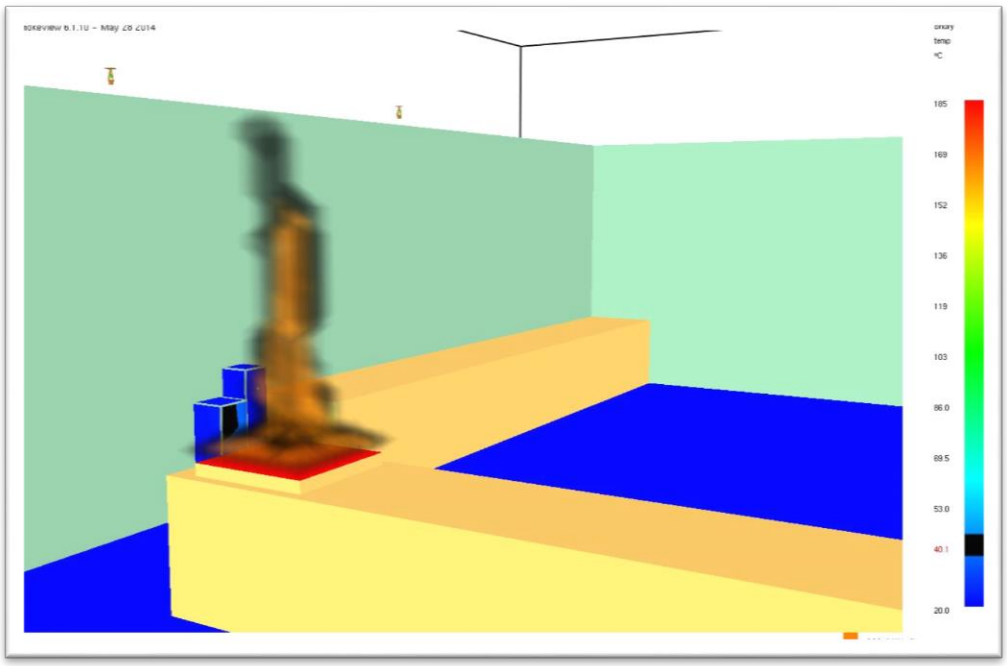


Figure 36 - FDS Model Scenario 1 at 100 seconds

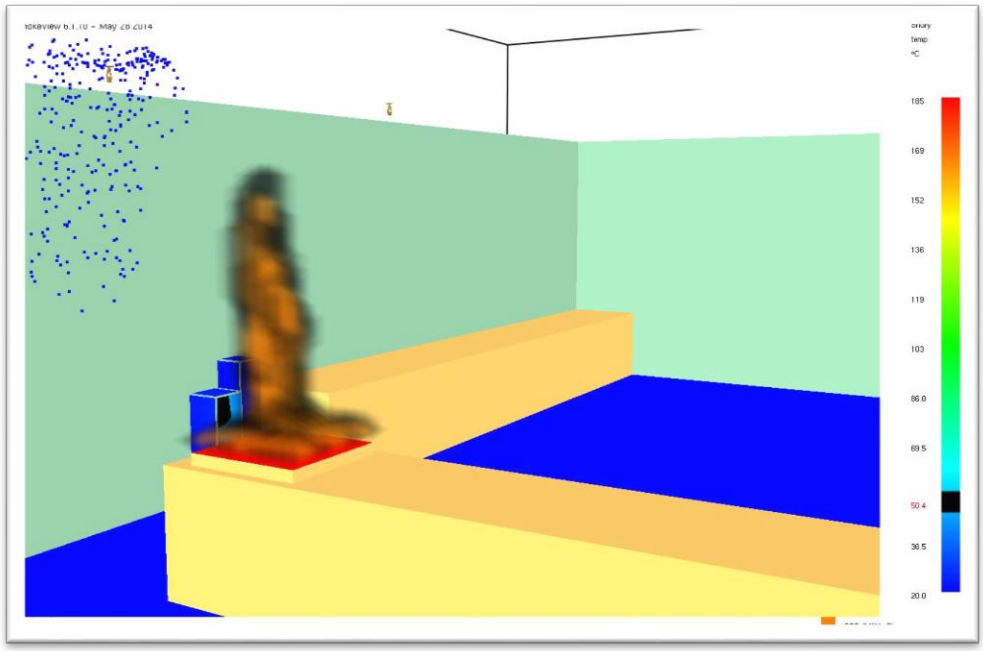


Figure 37 - FDS Model Scenario 1 at First Sprinkler Activation

The first sprinkler activations happens at 236.8 seconds as seen in figure 37 and the second sprinkler activation happens at 255 seconds as seen in figure 38.

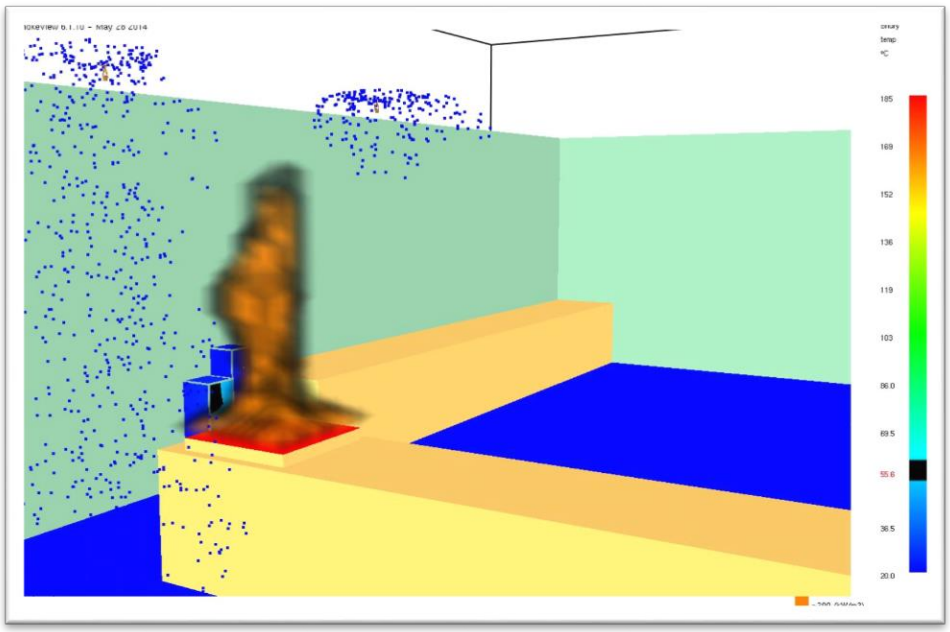


Figure 38 - FDS Model Scenario 1 at Second Sprinkler Activation

After the sprinklers activate, the fire continues to grow. This is because the model doesn't account for the suppression provided by the sprinklers. It is assumed that the sprinklers will be sufficient in keeping the hydrogen cylinders temperature from rising any further. It is out of the programs capabilities to account for the cooling effect from the water on the environment.

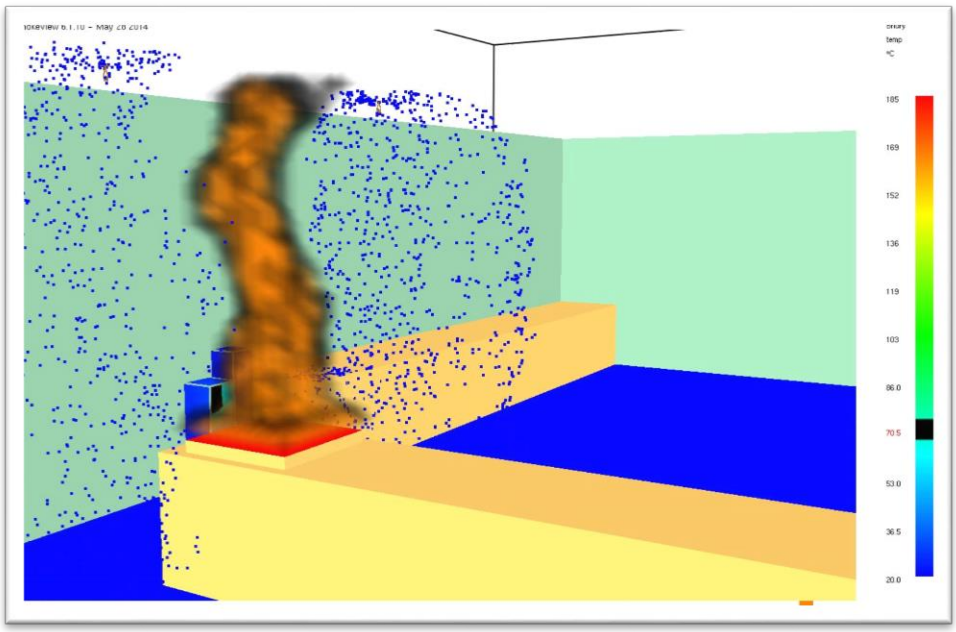


Figure 39 - FDS Model Scenario 1 at 300 seconds

When the first sprinkler activates the cylinder's wall temperature is at approximately 50 C. With the assumption that the water will cool the cylinder sufficiently to keep the temperature of the cylinder from

rising any further, it is likely that the building will remain tenable for the occupants to evacuate. Even if the temperature did continue to rise, another sprinkler next to the cylinders activates to help cool them. At the five minute mark the wall temperature of the closest cylinder has only reached 70 C without any cooling effects to help it. This helps confirm that the cylinders will not reach 184 C.

8.1.2. Design Scenario 2

Summary

The second scenario takes place in the corridor on the first floor of the ASB in figure 40. There are recycling cans placed in a line there that act as a collection area for the rest of the ASB as seen in figure 40. The janitors collect the recycling from all the recycling cans in the ASB and bring the recycling back to these cans before the waste gets picked up to be delivered to the recycling center. These recycling cans will be the source of the design fire as a result of arson by a disgruntled student.

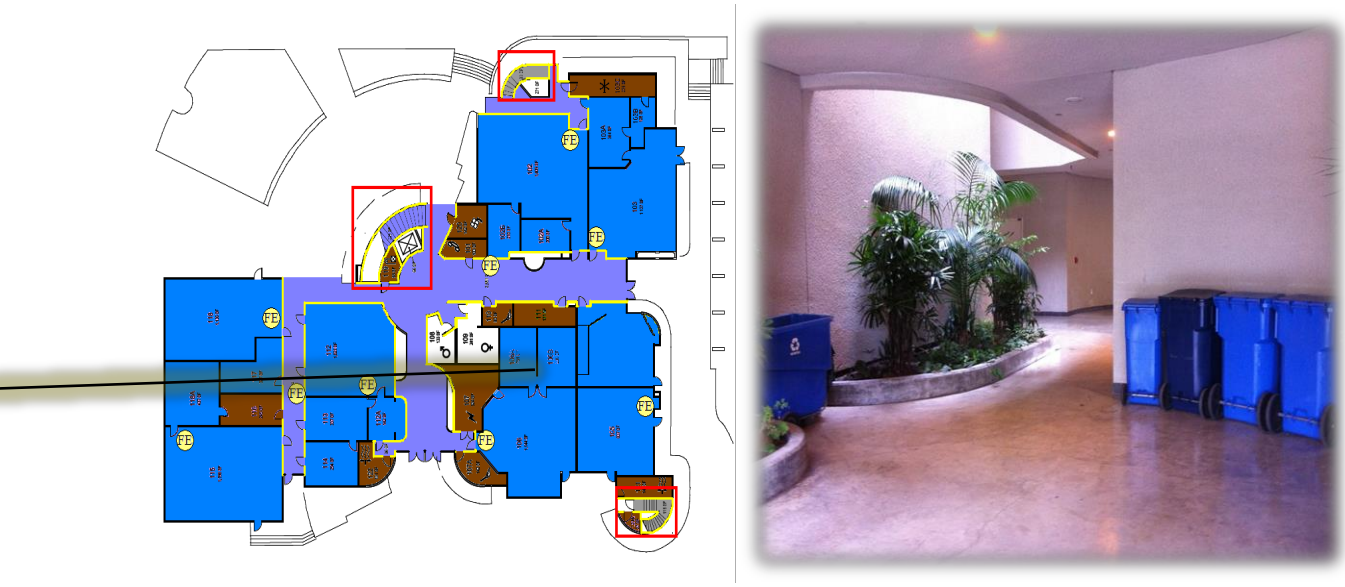


Figure 40 - Design Scenario 2 Setup

Model Development

There are at most four recycling bins at any given time in the corridor and are in the same location every day. The fire is modeled as one burner four and half feet tall with a one square meter section, placed where the bins are normally placed as seen in figure 40. The fire will take place mid-day in-between classes when traffic is less common in the halls. The assumption that no one will come across the development of the fire is applied so that the alarm system will be activated by the activation of a fire sprinkler making for a conservative detection time. The analysis will concentrate on the visibility

throughout the corridors of the ASB because this characteristic is most likely to fail first in the open mall ASB.

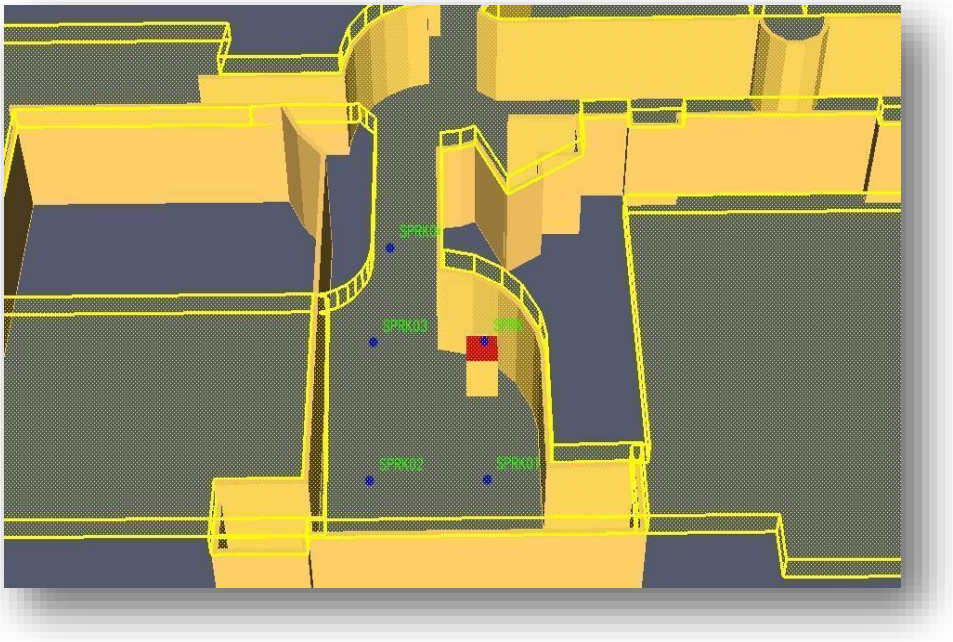


Figure 41 - Scenario 2 FDS Model Setup

The sprinklers in the corridor are at a height of 11.5 feet AFF and have a fusible link. More characteristics are listed in Table 14. Since the sprinkler has a standard response time, the RTI in the analysis was taken to be 100 $(m\text{-}s)^{0.5}$ because it is an average value for a standard response type sprinkler. The model was ran once to establish what time fire sprinklers started firing and at what HRR the fire is upon activation.

Table 14 - Sprinkler Characteristics in Scenario 2

Sprinkler Characteristics	
Orientation	Pendant (SSP)
Response	Standard
Temperature Rating	165 F
Oriface Size	1/2"
Max. Coverage Per Sprinkler	225 sq ft
K Factor	5.6
Manufacturer	Viking
Type	Wet
RTI	100 $(m\text{-}s)^{0.5}$

Design Fire

The design fire is modeled from data taken out of the SFPE HB. This data is from burning polyethylene packaged fruit/berry baskets in a calorimeter. These packaged baskets do not include the fruit/berries in the tests. The packaging is loaded onto a single pallet. I chose test F because the volume of packaging most closely matched the volume capacity of the recycling bins.

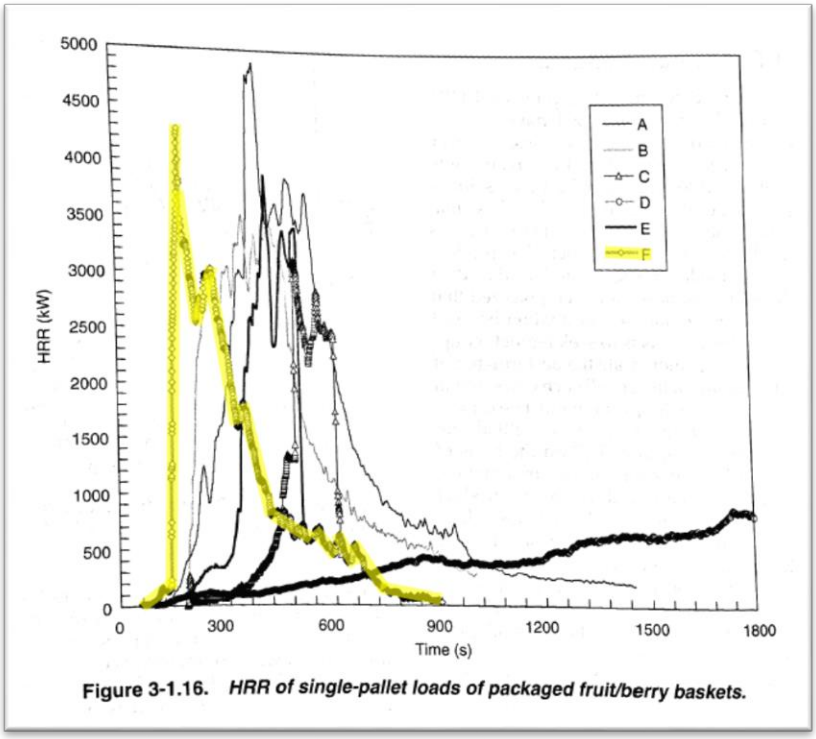


Figure 42 - Design Fire Data in Scenario 2

The peak HRR of the design fire in the model is 4280 kW with a soot yield of 0.06 g/g, which is as mentioned before the soot yield of polyethylene from table 3-4.16 in the SFPE handbook. The fire is modeled characteristically with a t^2 growth rate that will reach the peak HRR rate of 4280 kW in 400 s. This will conservatively match the data set F in figure 42. Like mentioned before, a test run was initiated to establish sprinkler activation times and the fires HRR at that time. The fire was then remodeled to a user inputted ramp function that would match the HRR growth rate in the test run, but plateau at the time of sprinkler activation (see figure 43). The HRR recorded at sprinkler activation is 33% of the peak HRR or 1,412.4 kW as seen in figure 43. This simulates the most demanding situation because the sprinkler is only suppressing the fire but not extinguishing it.

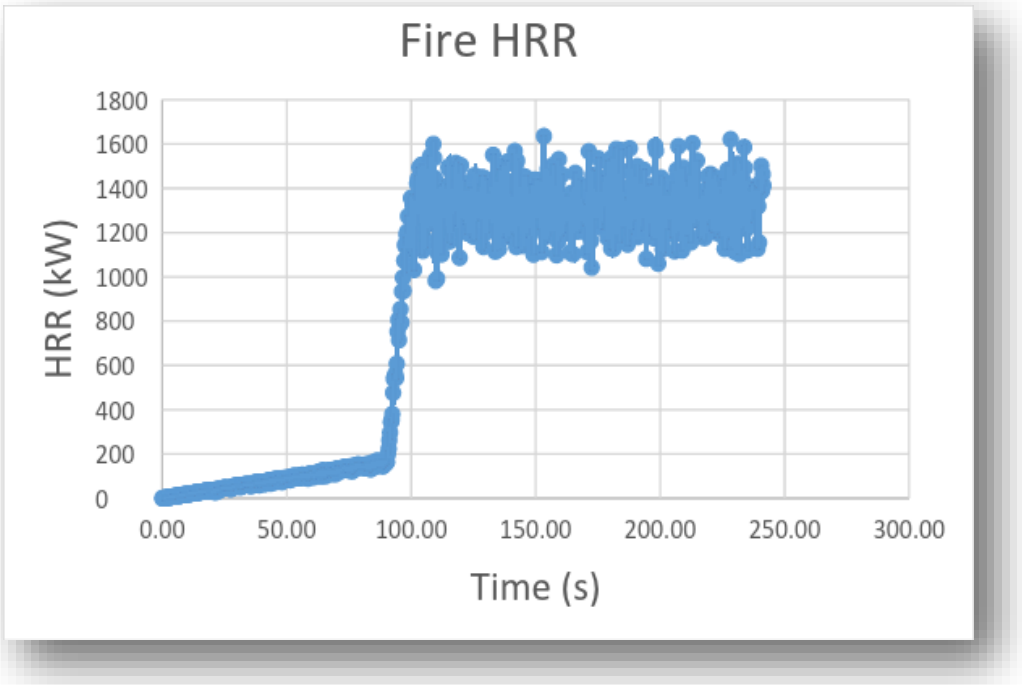


Figure 43 – Scenario 2 Design Fire HRR

Tenability Criteria

In this scenario the limiting tenability criteria is taken to be visibility of 10 meters. Visibility is usually always the first tenability criteria to fail and one tenable condition is usually used when analyzing a space so this is what this scenario will use as its tenability criteria.

Analysis

Available Safe Egress Time

Using FDS, it was determined that the available safe egress time (ASET) was at least four minutes from the analysis performed by FDS. All the corridors are modeled in the simulation to see if the smoke would travel to any other part. Figure 44 depicts the rendering of the model in smokeview. The model is being viewed from the plan view and the third floor's roof is hidden from view which reveals the open corridors in the elevator lobby.

Figure 44 - Overview of Scenario 2 FDS Model

Figures 45-52 is a view of the fire from the right side and plan view of the ASB in relation to the view in figure 44. The slice file in the plan view figures is 1.8 m (6 feet) off the surface of the floor in the first floor. All slice files in the figures are set to show the visibility in the y- or z-plane. In the first 50 seconds of the simulation it is apparent that most of the smoke is funneled through the open ceilings of the ASB as seen in figure 45. Even the space with the fire is in is still tenable. The visibility barely falls beneath 10 meters in the smoke layer and is well above the 6 feet marker.

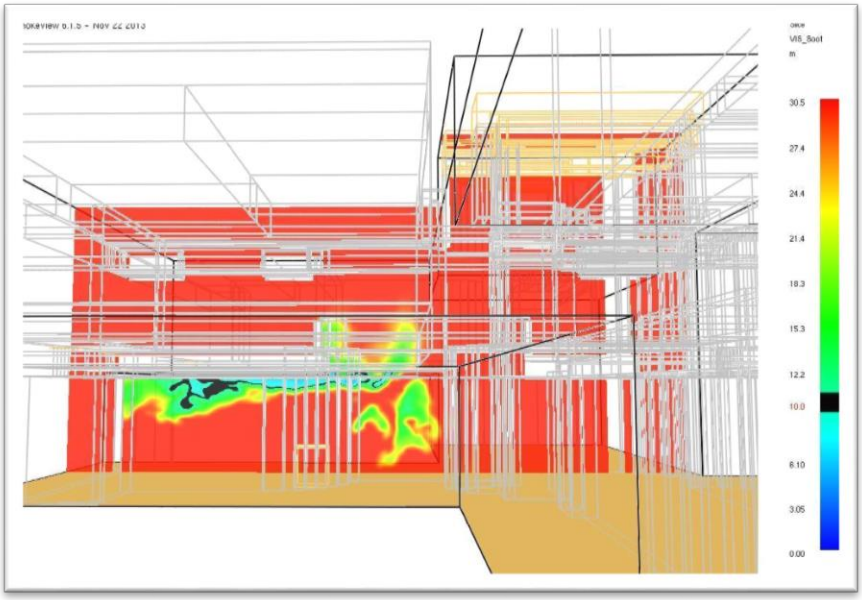


Figure 45 – Side View of FDS Model Scenario 2 at 50 seconds

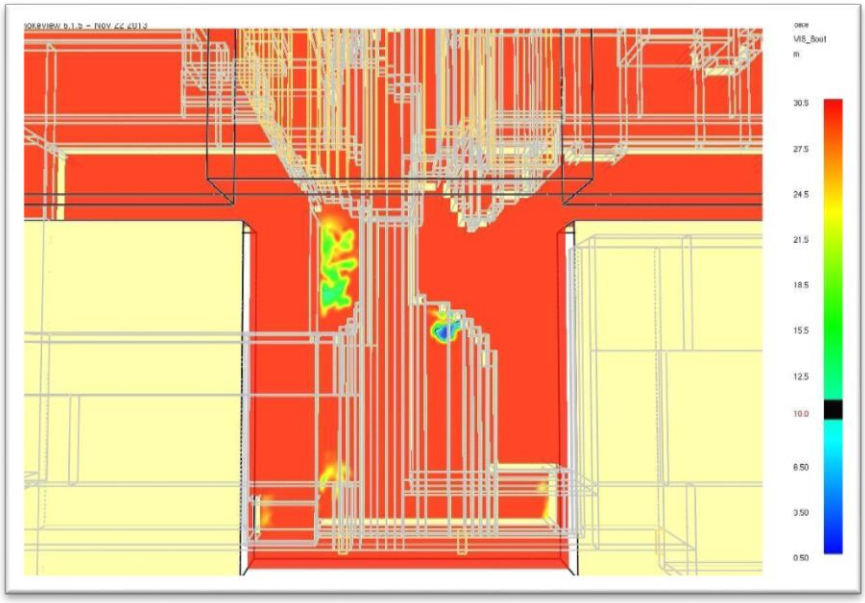


Figure 46 – Plan View of FDS Model Scenario 2 at 50 seconds

After 100 seconds in the simulation the first sprinkler is activated at 98.4 seconds and halts the fire growth to a steady HRR of 1,412.4 kW as seen in figure 43. Remember, this simulates suppression of the fire by the sprinkler but is not extinguishing the fire. At this point the visibility is finally reaching the tenability threshold of 10 meters at 1.8 meters (6 feet) above the floor in the space. This doesn't fail the tenability criteria though as this space is considered to have been intimate with the fire when it first started.

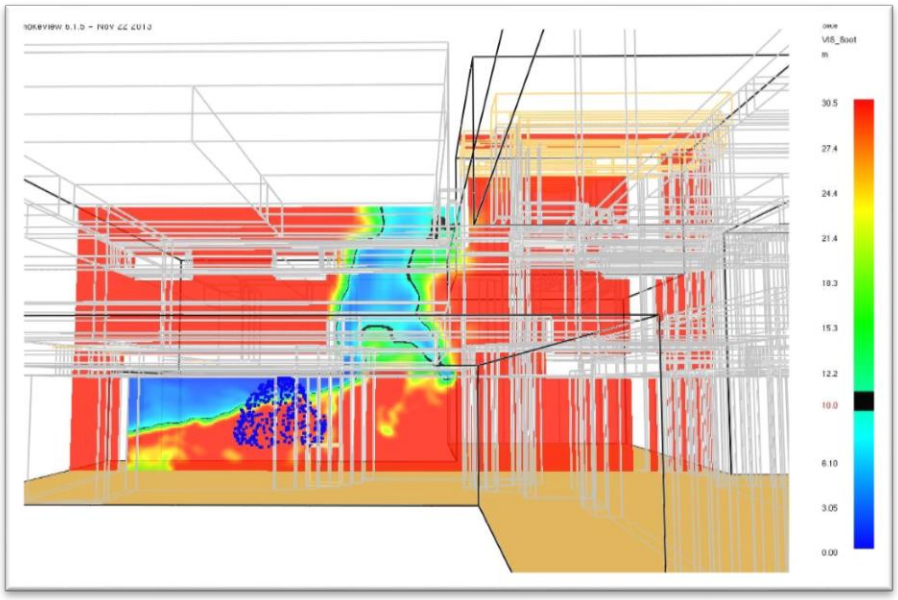


Figure 47 – Side View of FDS Model Scenario 2 at 100 seconds

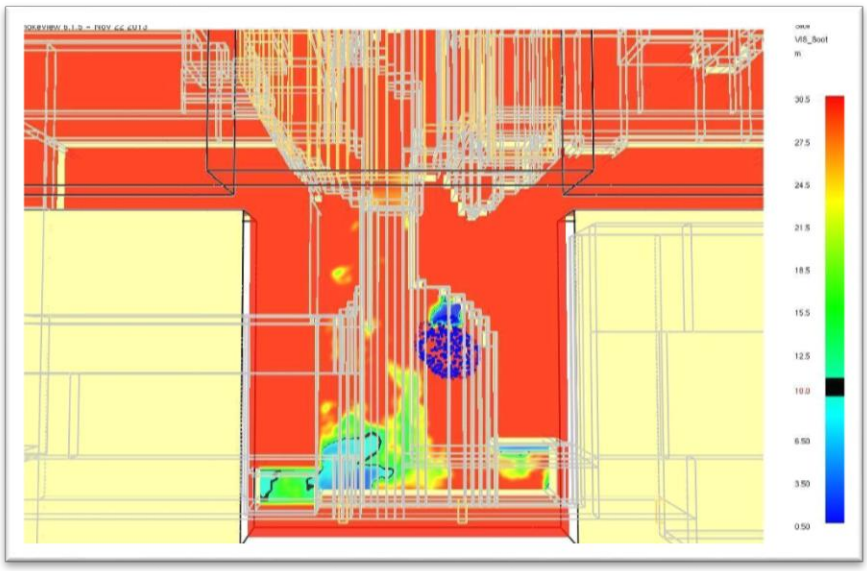


Figure 48 - Plan View of FDS Model Scenario 2 at 100 seconds

Figure 49 shows the simulation when it has reached 150 seconds. After 150 seconds three more sprinklers have been activated in the simulation by now even though the HRR has plateaued. This isn't unexpected because the simulation isn't accounting for the cooling effects of water from the first sprinkler. It is seen in the simulation that the space with the fire remains untenable, but most, if not all, smoke is being funneled out of the corridor through the openings in the roof leaving the rest of the corridors tenable.

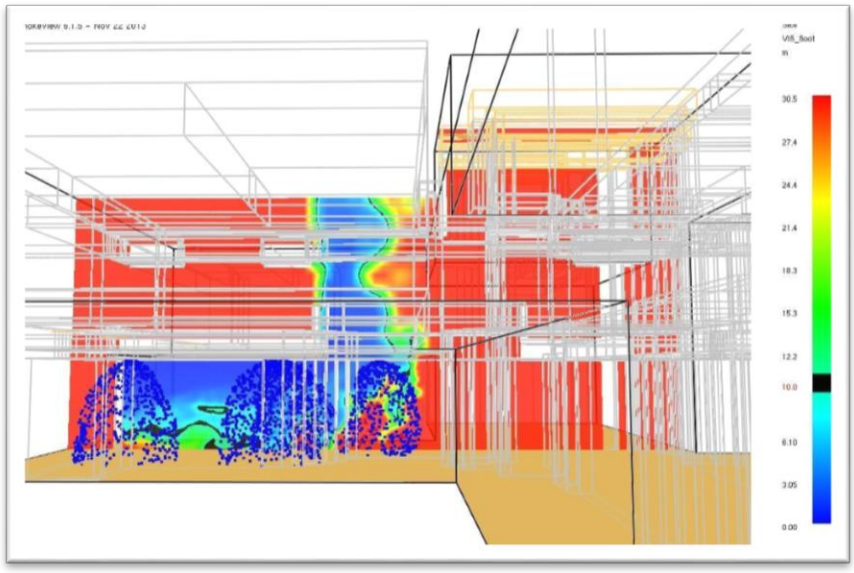


Figure 49 - Side View of FDS Model Scenario 2 at 150 seconds

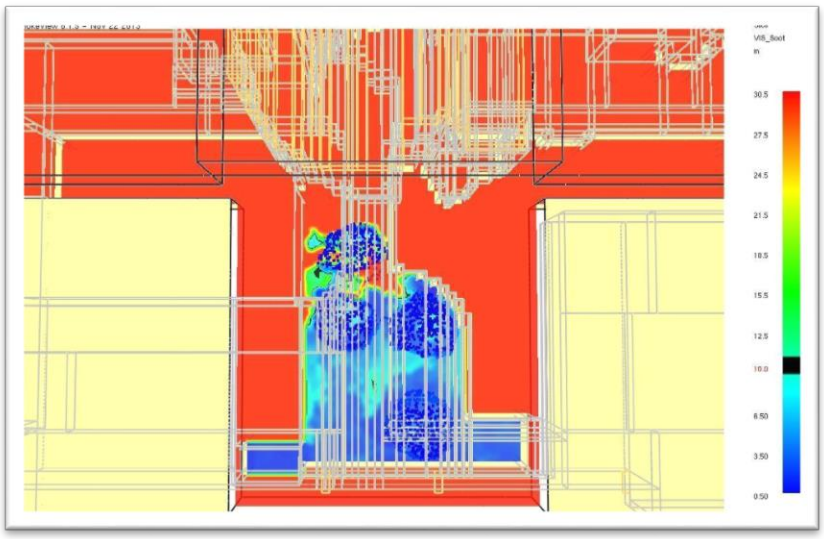


Figure 50 - Plan View of FDS Model Scenario 2 at 150 seconds

After four minutes of the simulation has gone by, the conditions of the space has changed. It can be seen in figure 50 that the majority of the smoke is still being funneled out through the openings in the ASB. In addition, it is seen in figure 51 that some smoke is starting to make its way into the elevator lobby, but the lobby still remains tenable at the four-minute marker. This is the end of the simulation, but if it were to continue I would predict more smoke to make its way into the elevator lobby only to flow out the openings at the end of the corridor. Since the fires HRR has plateaued due to sprinkler activation, it would be reasonable to say that the corridors would remain tenable for quite some time after four minutes.

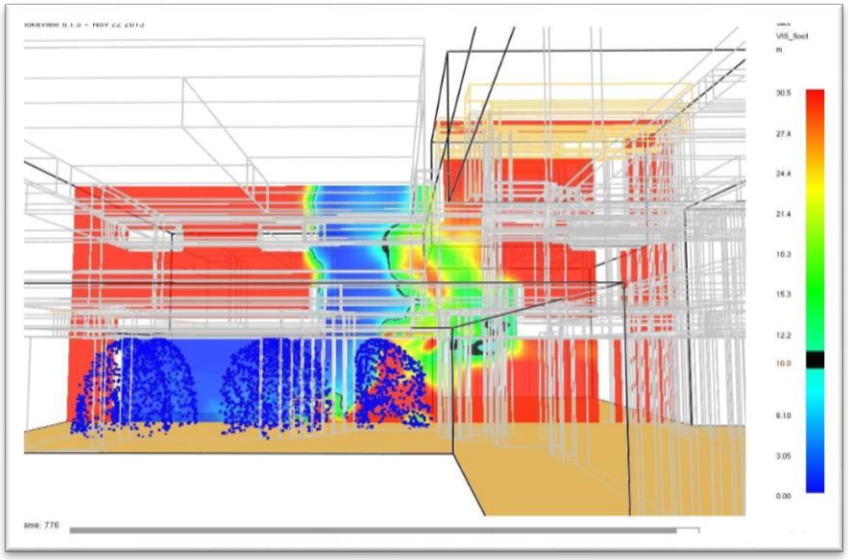


Figure 51 - Side View of FDS Model Scenario 2 at 232 seconds

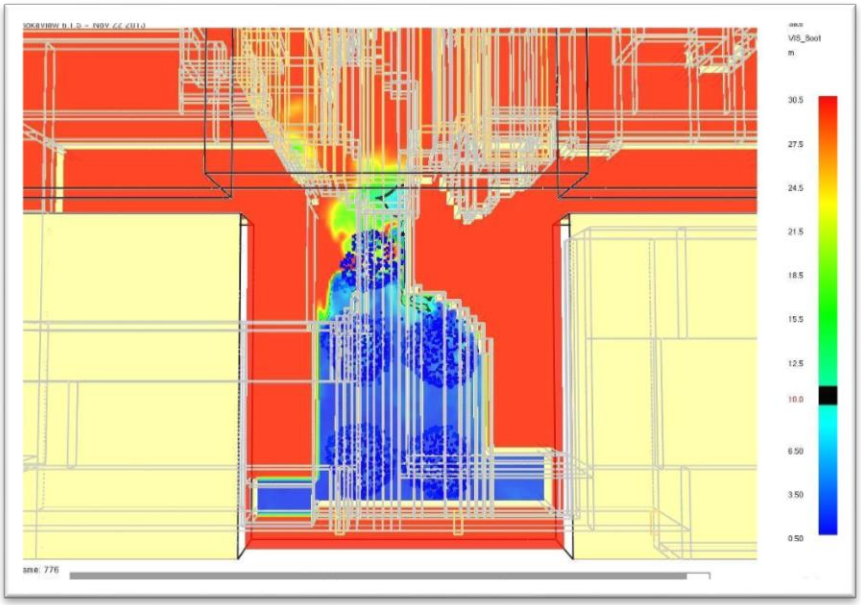


Figure 52 - Plan View of FDS Model Scenario 2 at 232 seconds

Figures 53 and 54 shows a visibility slice file on the z-plane at 1.8 m (6 feet) off the second and third floor, respectively. As depicted in the figures, there isn't much smoke spread in the second floor and none in the third floor at four minutes. Given the performance of the simulation under fire conditions, the ASET for this scenario is at least four minutes.

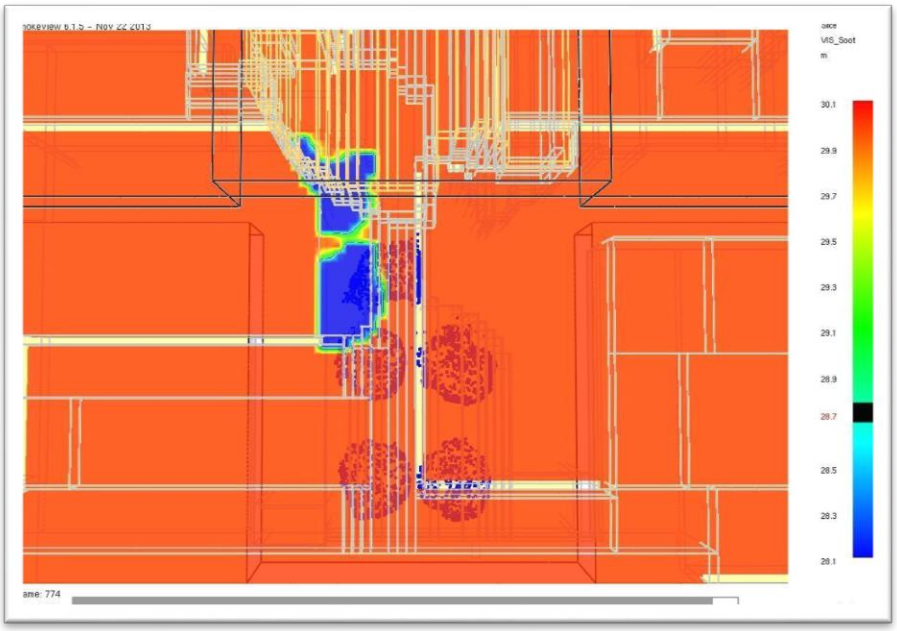


Figure 53 - Plan View of FDS Model Scenario 2 at 232 seconds

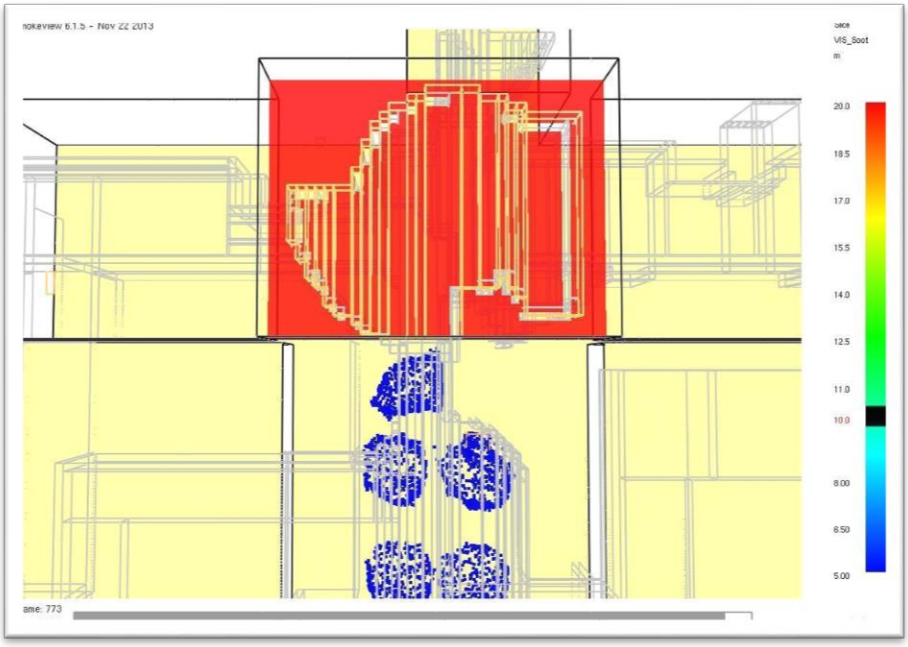


Figure 54 - Plan View of FDS Model Scenario 2 at 232 seconds

Required Safe Egress Time

Detection Time

The worst case scenario for the detection time is detection by sprinkler. In the FDS model, the first sprinkler activates at 98.4 seconds, but there is also a 30 second delay in the flow switch that sends a signal to the alarm system. So the combined delay and activation times comes out to be 128.4 seconds for the detection time.

Pre-movement Time

Given the nature of the occupants, college students, a pre-movement time is assumed to be 45 seconds because of the college students' demeanor towards fire alarms. More often than not a fire alarm is a false alarm or nothing major throughout their childhood. Students will most likely not leave their belongings in the building if they do decide to evacuate. The pre-movement time takes into account the time to take for the student to investigate and decide to leave and the time it takes them to pack up all of their belongings.

Travel Time - Hand Calculation

Building Characteristics:

- 7 in. risers and 11 in. threads; Spiral Stairs
- Floor-to-floor height is 12 ft.

- There are three stairs, no dead ends
- 3 Floors

Assumptions:

- Occupants all start evacuating simultaneously.
- Since the stairways discharge into the open and there isn't a constricting door, the populous in this calculation will be taken to be the top two floors because that is where the choke points are.
- Spiral stairs are modeled as standard stairs.
- The prime controlling factor will either be the stairways or the door discharging from them.
- The population will use all facilities optimally.
- Queuing will occur, so the specific flow equals the maximum flow.
- Occupant flow will not involve any interruptions caused by decisions of the individuals involved.
- All or most of the persons involved are free of disabilities that would significantly impede their ability to keep up with the movement of a group.

Total Population: 267 people

Evacuation Time for Building								
Stair W_e (ft)		Flow		Door W_e (ft)	Flow			
		Specific (P/min/ft)	Calculated (P/min)		Specific (P/min/ft)	Calculated (P/min)	Limiting	
	5.5	18.5	101.75	2.0	24	48	48	
	2.7	18.5	49.33	2.0	24	48	48	
	2.7	18.5	49.33	2.0	24	48	48	
Total:	10.8	18.5	200.42	6.0	24	144	144	
		SFPE	Evacuation Time (min):		1.85	With stair:	5.65	
		Paul's Method	Evacuation Time (min):		2.47			

SFPE Method:

The SFPE method comes from the SFPE Handbook of Fire Protection Engineers. This method can be influenced by the stairs or doorways, whichever one has the smaller calculated flow (= specific flow x eff. Width) will have the limiting flow and this is the flow we need to take in account. The evacuation time of the populous to the exits on each floor is:

Total population / Sum of the limiting flows = Evacuation Time

The specific flow can be found in Table 4.2.8. The evacuation time to get down the stairs is the travel distance of stair divided by the travel speed. The travel distance is:

(Stair Height x Conversion Factor) + Platform widths = Travel Distance

Where the conversion factor can be found in Table 4.2.6 of the NFPA Handbook. The travel speed is calculated from the equation:

SFPE Handbook:
- S = travel speed (m/s)
- a = constant (0.266 m²/p)
- D = density (p/m²)
- k = egress constant

$$S = k - akD$$
$$= k(1 - aD)$$

Equation 2

where k can be found in Table 4.2.5 in the NFPA HB:

Table 15 – Boundary Layer Widths, Table 4.2.4 in NFPA HB

	Boundary Layer	
Exit Route Element	*in.*	*cm*
Stairways—walls or side of tread	6.0	15
Railings, handrails*	3.5	9
Theater chairs, stadium benches	0.0	0
Corridor, ramp walls	8.0	20
Obstacles	4.0	10
Wide concourses, passageways	Up to 18	46
Door, archways	6.0	15

*Where handrails are present, use the value if it results in a lesser effective width.

Table 16 – Constants for Equation 2 Evacuation Speed, Table 4.2.5 in NFPA HB

Exit Route Element		k_1	k_2
Corridor, Aisle, Ramp, Doorway		275	1.40
Stairs Riser (in.)	Tread (in.)		
7.5	10	196	1.00
7.0	11	212	1.08
6.5	12	229	1.16
6.5	13	242	1.23
		English units (ft /min) a = 2.86	Metric units (m/s) a = 0.266

Table 17 – Maximum Specific Flow, Table 4.2.8 in NFPA HB

TABLE 4.2.8 Maximum Specific Flow, F_{sm}

Exit Route Element	Riser (in.)	Riser (mm)	Tread (in.)	Tread (mm)	Maximum Specific Flow: *Persons/ min/ft of Effective Width*	Maximum Specific Flow: *Persons/ sec/m of Effective Width*
Corridor, Aisle, Ramp, Doorway					24.0	1.30
Stairs						
	7.5	(190)	10	(254)	17.1	0.94
	7.0	(178)	11	(279)	18.5	1.01
	6.5	(165)	12	(305)	20.0	1.09
	6.5	(165)	13	(330)	21.2	1.16

Source: Table 3-14.5, *SFPE Handbook of Fire Protection Engineering*, 3rd edition, 2002. Courtesy Society of Fire Protection Engineers.

Paul's Method:

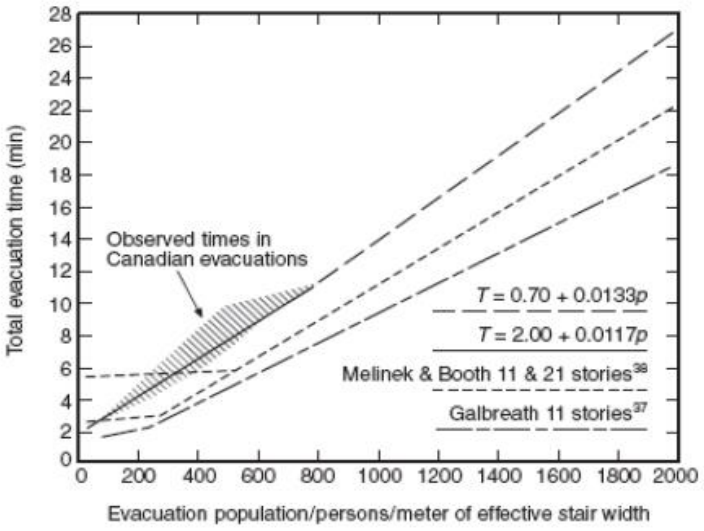


Figure 55 - Paul's Correlation

where:

- First equation applies to situations with total population using stairs of > 800 P/m of eff. Width

$$t(\min) = 0.70 + 0.0133(P / w_e)(people / m)$$

- Second equation applies to situation with total population using stairs of < 800 P/m of eff. Width.

$$t(\min) = 2.0 + 0.0117(P / w_e)(people / m)$$

The agricultural science building has a P/m of eff. Width below 800, so the calculation uses the second equation. The effective width used in this analysis is taken to be from all three of the stairway's widths minus each of their boundary layers. The boundary layer can be determined from LSC Table 4.2.4 and is demonstrated below.

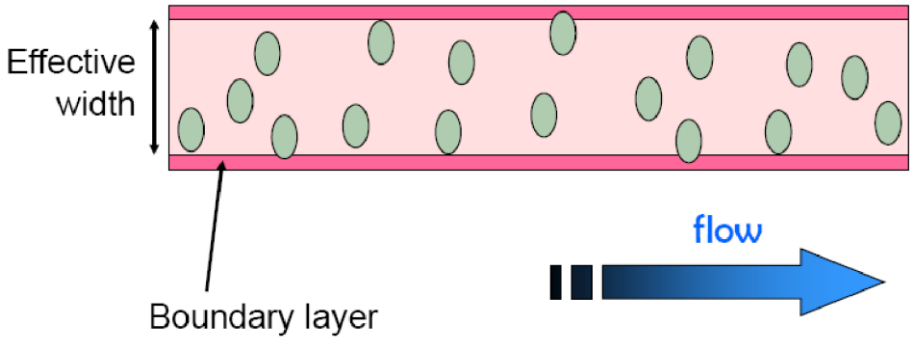


Figure 56 - Definition of Effective Width and Boundary Layer

Travel Time - Pathfinder

The following assumptions are taken to be true in the simulation done by the computer program called pathfinder.

Assumptions:

- All occupant loads in each room will be rounded up so the occupant load may be larger than previously stated. LSC **7.3.1.3.1** states the occupant load in any building or portion thereof shall be permitted to be increased from the occupant load established for the given use in accordance with 7.3.1.2 where all other requirements of this *Code* are also met, based on such increased occupant load.
- Occupant flow will not involve any interruptions caused by decisions of the individuals involved.
- All or most of the persons involved are free of disabilities that would significantly impede their ability to keep up with the movement of a group.
- Occupants will be considered evacuated once they have reached a stairway. (2nd and 3rd floor only)
- Occupants all start evacuating simultaneously.
- The population will use all facilities optimally.
- Occupants behavior will be homogeneous.
    - Go to any exit
    - Speed – 4 feet./s
    - Priority

Figure 57 - Pathfinder Simulation of ASB at 0 seconds

The ASB does not host any events in the building so the corridors will not have occupants in them initially and rooms will not see more occupants than what they are classified for. In the simulation, most of the building is occupied. On the first floor and third floor, most of the lecture halls are full, but the adjoining tech labs are partially occupied because they are meant to serve the classroom it is adjacent to. Meaning students will only perform work in the room during class time and are not available to unenrolled students during class time. Every other office has been occupied, typically with a student and professor, on the second floor because professors will hold office hours in their office space. Every other office is empty because professors also have lecture to attend, which is going on throughout the building in this scenario. At the start of the simulation students, professors, and administrative personnel immediately head for the closest exit.

Figure 58 - Pathfinder Simulation of ASB at 5 seconds

I included an occupant in the mechanical room on the north side of the third floor to simulate a repairman doing work at the time of the fire. He is the most remote occupant and he must travel through a janitorial closet to get the common path. I also used the occupant as a reference for how long it may take someone with a disability to egress from a closer room. Queuing begins at the classroom doors at around the five second mark as seen in figure 58. Once in the corridor, which is a horizontal exit, occupants make their way to the nearest stair/common exit as seen in figure 59.

Figure 59 - Pathfinder Simulation of ASB at 25 seconds

At 40 seconds into the simulation, all occupants on the first and second floor have evacuated while the last occupants are finally reaching the stairs as seen in figure 60. This may be due to the fact that most of the occupancies on the third floor are located near the main stair of the ASB. The door that leads to the

main stair is much narrower than the stairs themselves and restricts the flow of people to one person through the door at a time.

Figure 60 - Pathfinder Simulation of ASB at 40 seconds

Overall, the total time it takes for everyone to evacuate the ASB is 48.8 seconds. Figure _ illustrates the number of occupants still in the ASB in relation to time.

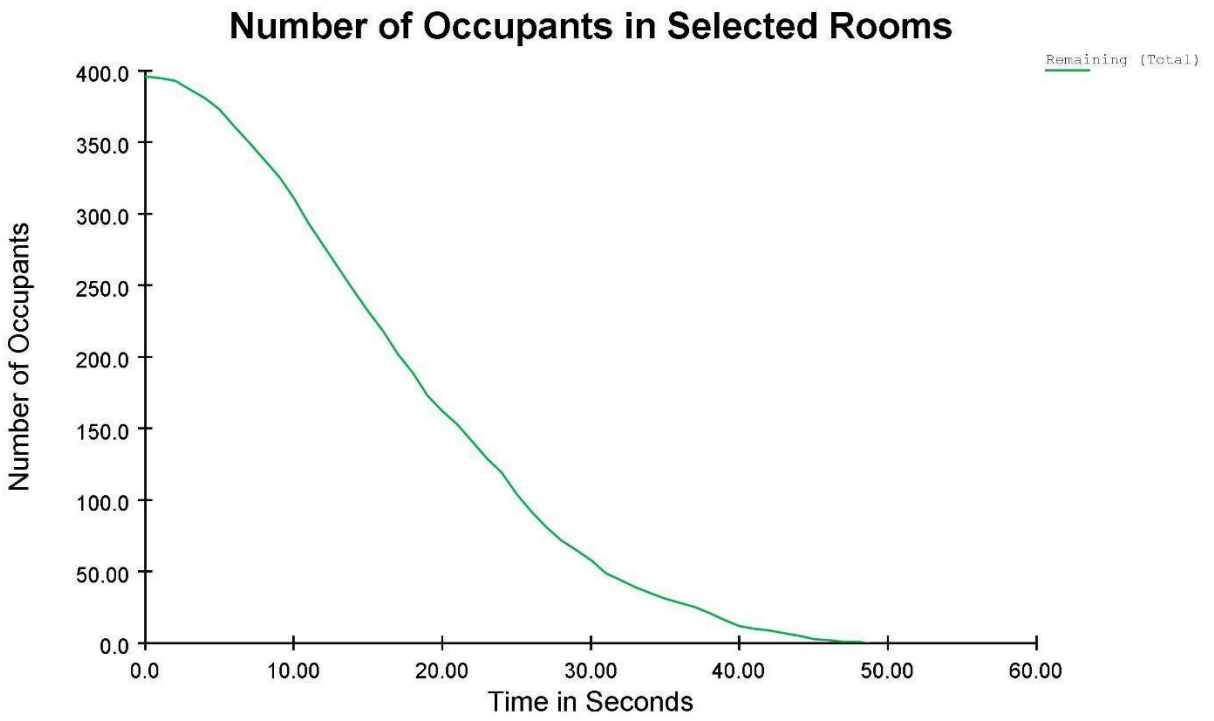


Figure 61 – Plot of People in ASB vs. Time

RSET vs ASET

The design objective is to have ASET larger than RSET. This means that everyone should have enough time to evacuate from the ASB without experiencing untenable conditions.

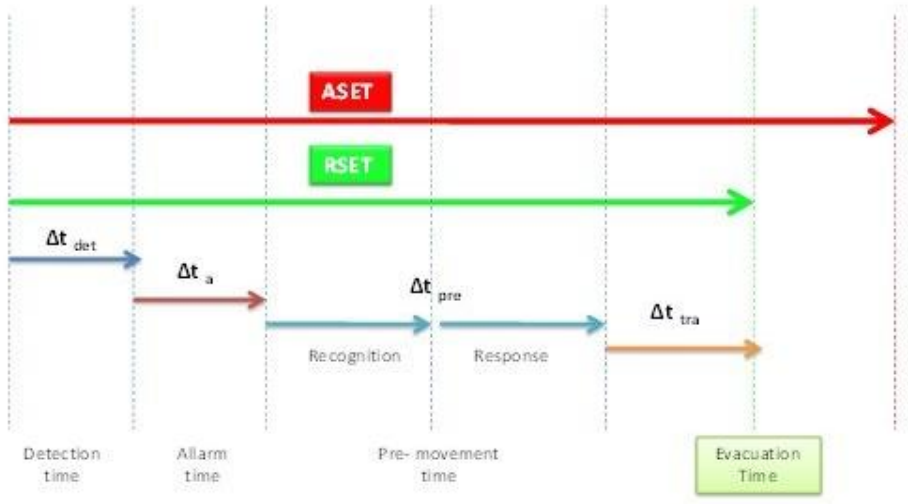


Figure 62 - Visual Break Down of RSET Composition

The RSET is the combination of the detection, alarm delay, pre-movement and travel times. These times are listed in table 18 and add up to equal the RSET. In this scenario, the RSET is calculated to be 222.2 seconds, which comes out to be about 3 minutes and 42.2 seconds.

Table 18 – Time of Each RSET Component

RSET	Time
Detection Time	98.4 s
Alarm (Flow Switch delay)	30.0 s
Pre-Movement Time	45.0 s
Evacuation Time	48.8 s

Comparing the two simulations performed and values taken from them for ASET and RSET, it is clear that the ASET is larger than the RSET, thus complying with the LSC.

9. Recommendations

Automatic Fire Alarm System

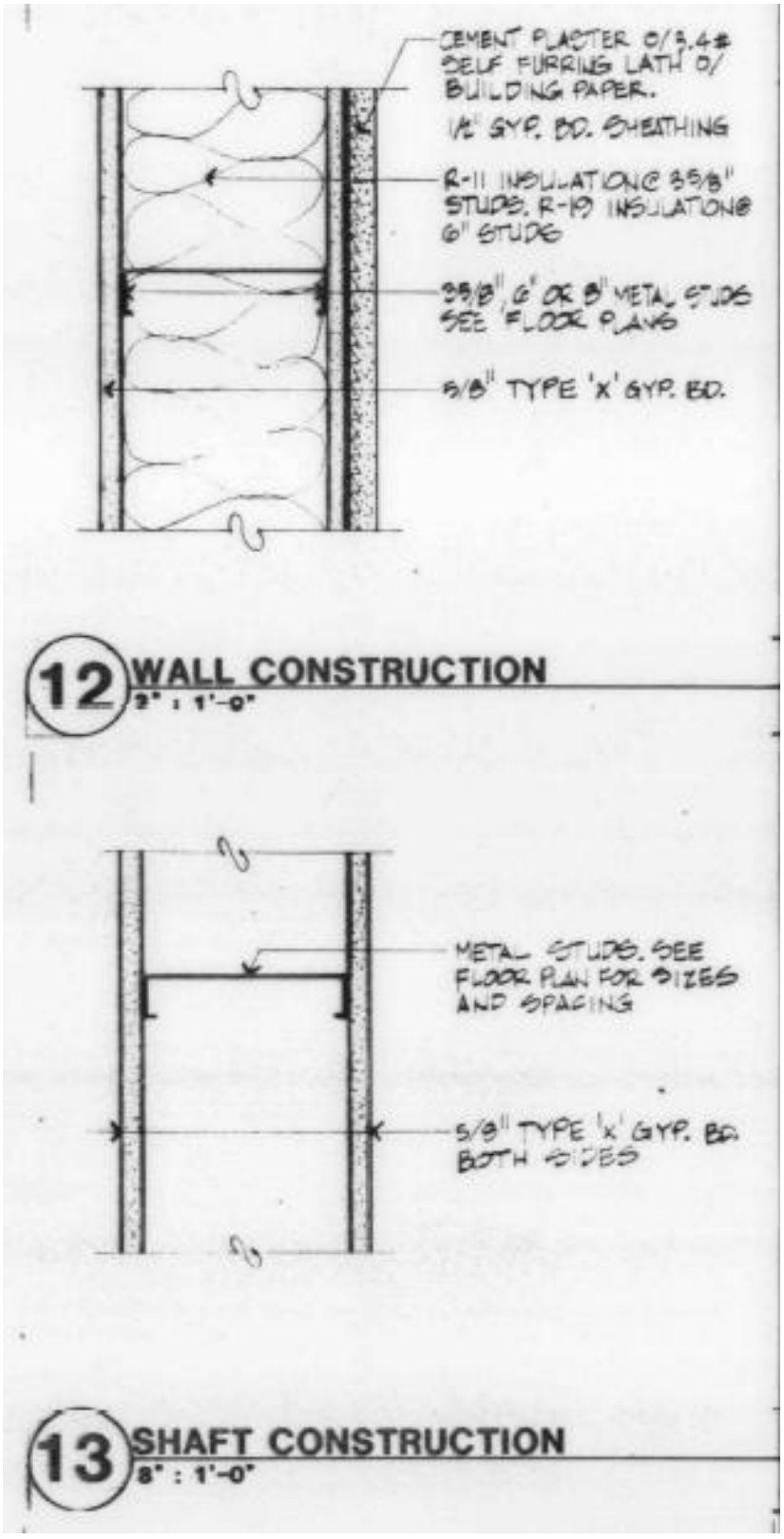
For the automatic fire alarm system in the ASB, I would recommend placing a visual device at the end of each corridor and one on the ceiling of the elevator lobby on each floor. This would provide adequate coverage in accordance with NFPA 72. Another recommendation for the automatic fire alarm system in the ASB is to replace the horn devices in the northern corridor on floors 1 and 2 to a horn/strobe device.

Automatic Fire Suppression System

For the automatic fire suppression system in the ASB, I would recommend increasing the safety margin between the supply and the second most remote area because it is dangerously close to the supply curve. There are two ways to go about doing this. One method would be to install a pump for the system to increase the supply to the system, but this method is expensive. The second method, the recommended and most cost effective method, would to increase the 2 ½" mains to 4" mains to significantly lower the pressure losses in the system and therefore lowering the demand of the second MRA.

10. Appendices

Appendix A: Fire Resistance Ratings


CEMENT PLASTER O/ 3.4# SELF FURRING LATH O/ BUILDING PAPER.
1/2" GYP. BD. SHEATHING
R-11 INSULATION @ 3 5/8" STUDS. R-19 INSULATION @ 6" STUDS
3 5/8", 6" OR 8" METAL STUDS SEE FLOOR PLANS
5/8" TYPE 'X' GYP. BD.
12 WALL CONSTRUCTION
3" : 1'-0"
METAL STUDS. SEE FLOOR PLAN FOR SIZES AND SPACING
5/8" TYPE 'X' GYP. BD. BOTH SIDES
13 SHAFT CONSTRUCTION
3" : 1'-0"

Appendix B: Occupancy Classifications

First Floor							
Room	Room_Type	Area	OLF	Occupant Load Factor	Occupant Load	Occupant Classification	Color
		Sq. Ft.		Sq. ft/Person	People		
0	Corridor	3000	Unoccupied				
0102-00	UpDiv Teach Lab	1409	Educational	Fixed	25	Business	
0102-A0	Tch Lab Serv	199	Lab	100	2	Business	
0102-B0	Tch Lab Serv	209	Lab	100	3	Business	
0103-00	UpDiv Teach Lab	1136	Educational	Fixed	25	Business	
0103-A0	Tch Lab Serv	363	Lab	100	4	Business	
0103-B0	Tch Lab Serv	125	Lab	100	2	Business	
0103-C0	Tch Lab Serv	234	Lab	100	3	Business	
0104-00	Lecture	753	Educational	20	47	Business	
0104-A0	Lecture Serv	24	Lab	100	1	Business	
0105-00	UpDiv Teach Lab	837	Educational	Fixed	25	Business	
0106-00	UpDiv Teach Lab	1143	Educational	Fixed	25	Business	
0106-A0	Tch Lab Serv	281	Lab	100	3	Business	
0106-B0	Tch Lab Serv	287	Lab	100	3	Business	
0107-00	Mechanical/Elect	323	Storage	300	2	Storage	
0107-A0	Custodial	141	Storage	300	1	Storage	
0108-00	Restroom	133	Unoccupied	0	0	Unoccupied	
0109-00	Restroom	240	Unoccupied	0	0	Unoccupied	
0110-00	Custodial	80	Storage	300	1	Storage	
0111-00	Gen Storage	170	Storage	300	1	Storage	
0112-00	LwDiv Teach Lab	1028	Educational	Fixed	25	Business	
0112-A0	Tch Lab Serv	142	Lab	100	2	Business	
0113-00	Tch Lab Serv	337	Lab	100	4	Business	
0114-00	Tch Lab Serv	293	Lab	100	3	Business	
0115-00	UpDiv Teach Lab	1397	Educational	Fixed	25	Business	
0116-00	Tch Lab Serv	245	Lab	50	5	Business	
0117-00	Tch Lab Serv	327	Lab	50	7	Business	
0118-00	LwDiv Teach Lab	1136	Educational	Fixed	25	Business	
0118-A0	Tch Lab Serv	437	Lab	100	5	Business	
0119-00	Mechanical/Elect	68	Storage	300	1	Storage	
0120-00	Custodial	142	Storage	300	1	Storage	
0121-00	Mechanical/Elect	145	Storage	300	1	Storage	
0121-A0	Gen Storage	37	Storage	300	1	Storage	
0122-00	Mechanical/Elect	131	Storage	300	1	Storage	
E101-00	Circulation	66	Unoccupied		0	Unoccupied	
	Net Area	13579		Net Total:	279		

Second Floor							
0	Corridor	5487					
0201-00	Faculty Office	106	Business	100	2	Business	
0202-00	Faculty Office	110	Business	100	2	Business	
0203-00	Gen Storage	60	Storage	300	1	Storage	
0203-T0	Mechanical/Elect	60	Storage	300	1	Storage	
0204-00	Faculty Office	102	Business	100	2	Business	
0205-00	Faculty Office	109	Business	100	2	Business	
0206-00	Faculty Office	109	Business	100	2	Business	
0207-00	Faculty Office	109	Business	100	2	Business	
0208-00	Faculty Office	107	Business	100	2	Business	
0209-00	Support Office	123	Business	100	2	Business	
0210-00	Conf Room	541	Business	100	6	Business	
0211-00	Staff Office	665	Business	100	7	Business	
0211-A0	Support Office	227	Business	100	3	Business	
0211-B0	Admin Office	178	Business	100	2	Business	
0211-C0	Staff Office	115	Business	100	2	Business	
0211-D0	Staff Office	160	Business	100	2	Business	
0211-E0	Admin Office	180	Business	100	2	Business	
0212-00	Staff Office	225	Business	100	3	Business	
0212-B0	Admin Office	143	Business	100	2	Business	
0213-00	Faculty Office	124	Business	100	2	Business	
0214-00	Faculty Office	99	Business	100	1	Business	
0215-00	Admin Office	164	Business	100	2	Business	
0216-00	Staff Office	68	Business	100	1	Business	
0217-00	Staff Office	168	Business	100	2	Business	
0217-A0	Support Office	108	Business	100	2	Business	
0218-00	Faculty Office	113	Business	100	2	Business	
0219-00	Faculty Office	113	Business	100	2	Business	
0220-00	Faculty Office	106	Business	100	2	Business	
0221-00	Faculty Office	105	Business	100	2	Business	
0222-00	Faculty Office	113	Business	100	2	Business	
0223-00	Faculty Office	110	Business	100	2	Business	
0224-00	Faculty Office	108	Business	100	2	Business	
0225-00	Faculty Office	102	Business	100	2	Business	
0226-00	Faculty Office	102	Business	100	2	Business	
0227-00	Faculty Office	102	Business	100	2	Business	
0228-00	Admin Office	225	Business	100	3	Business	
0229-00	Staff Office	141	Business	100	2	Business	
0229-T0	Mechanical/Elect	37	Storage	300	1	Storage	
0230-00	Support Office	110	Business	100	2	Business	
0231-00	Faculty Office	91	Business	100	1	Business	
0232-00	Faculty Office	118	Business	100	2	Business	
0233-00	Faculty Office	113	Business	100	2	Business	
0234-00	Faculty Office	107	Business	100	2	Business	
0235-00	Faculty Office	113	Business	100	2	Business	
0236-00	Faculty Office	111	Business	100	2	Business	

0237-00	Faculty Office	111	Business	100	2	Business	
0238-00	Faculty Office	113	Business	100	2	Business	
0239-00	Faculty Office	113	Business	100	2	Business	
0240-00	Faculty Office	103	Business	100	2	Business	
0241-00	Faculty Office	103	Business	100	2	Business	
0242-00	Support Office	119	Business	100	2	Business	
0243-00	Admin Office	141	Business	100	2	Business	
0244-00	Staff Office	202	Business	100	3	Business	
0244-A0	Gen Storage	122	Storage	300	1	Storage	
0245-00	Faculty Office	103	Business	100	2	Business	
0246-00	Faculty Office	104	Business	100	2	Business	
0247-00	Faculty Office	90	Business	100	1	Business	
0248-00	Faculty Office	110	Business	100	2	Business	
0249-00	Faculty Office	105	Business	100	2	Business	
0250-00	Faculty Office	107	Business	100	2	Business	
0251-00	Faculty Office	111	Business	100	2	Business	
0252-00	Faculty Office	109	Business	100	2	Business	
0253-00	Faculty Office	107	Business	100	2	Business	
0254-00	Faculty Office	107	Business	100	2	Business	
0255-00	Faculty Office	109	Business	100	2	Business	
0256-00	Faculty Office	107	Business	100	2	Business	
0257-00	Faculty Office	98	Business	100	1	Business	
0258-00	Custodial	45	Storage	300	1	Storage	
0258-T0	Mechanical/Elect	34	Storage	300	1	Storage	
0259-00	Faculty Office	97	Business	100	1	Business	
0260-00	Faculty Office	103	Business	100	2	Business	
0261-00	Faculty Office	103	Business	100	2	Business	
0262-00	Faculty Office	103	Business	100	2	Business	
0263-00	Restroom	148	Unoccupied	0	0	Unoccupied	
0264-00	Restroom	208	Unoccupied	0	0	Unoccupied	
0M11-80	Mechanical/Elect	333	Storage	300	2	Storage	
E201-00	Circulation	67	Unoccupied	0	0	Unoccupied	
	Net Area	10068		Net Total:	149		

Third Floor							
0	Corridor/Deck	4025					
0300-00	Gen Storage	21	Storage	300	1	Storage	
0301-00	Gen Storage	123	Storage	300	1	Storage	
0302-00	UpDiv Teach Lab	1062	Educational	Fixed	25	Business	
0302-A0	Tch Lab Serv	49	Lab	50	1	Business	
0302-B0	Tch Lab Serv	46	Lab	50	1	Business	
0302-C0	Tch Lab Serv	236	Lab	50	5	Business	
0303-00	Gen Storage	452	Educational	300	2	Business	
0304-00	UpDiv Teach Lab	1125	Educational	Fixed	25	Business	
0304-A0	Tch Lab Serv	247	Lab	50	5	Business	
0305-A0	Greenhouse	495	Storage	300	2	Storage	
0305-B0	Greenhouse	492	Storage	300	2	Storage	
0305-C0	Greenhouse	491	Storage	300	2	Storage	
0306-00	Tch Lab Serv	674	Lab	100	7	Business	
0307-00	UpDiv Teach Lab	1315	Educational	Fixed	25	Business	
0308-00	Custodial	104	Storage	300	1	Storage	
0308-A0	Mechanical/Elect	2447	Storage	300	9	Storage	
0309-00	Restroom	180	Unoccupied	0	0	Unoccupied	
0310-00	Restroom	144	Unoccupied	0	0	Unoccupied	
0326-00	Gen Storage	74	Storage	300	1	Storage	
M303-A0	Mechanical/Elect	869	Storage	300	3	Storage	
C301-00	Circulation	28	Unoccupied	0	0	Unoccupied	
	Net Area	10646		Net Total:	118		
				Building Net Total:	546		

Appendix C: Fire Detection Device Spec Sheets

Notification Appliances

Simplex®

True*Alert*® Notification Appliances

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

4901-9820 Electronic Horn, Free-Run
or Smart*Sync*™ Operation, Non-Addressable

Features

Low current, 24 VDC electronic horn provides:

- Harmonically rich sound output suitable for either steady or pulsed operation
- Diode polarized input for connection to reverse polarity, supervised NACs
- Rugged, high impact, flame retardant red thermoplastic housing with white "FIRE" lettering (white cover is available separately)

Switch selectable horn operation modes:

- **Free-Run mode** tracks the output of a conventional fire alarm control panel notification appliance circuit (NAC)
- **SmartSync** two-wire control mode accepts horn control commands from compatible control panels (see list on page 2)**

Free-Run Mode operation provides:

- Horn activated when NAC is in alarm; suitable for Temporal pattern, March Time patterns, or Coded patterns as determined by control panel operation

SmartSync two-wire control of audible and visible notification appliance provides:

- SmartSync control of horn tone as Temporal Pattern, March Time pattern (at 60 BPM), or on continuously; controlled separately from visible appliances on the same circuit
- Visible appliances on the same circuit operate at a synchronized 1 Hz flash rate
- Operation that allows "on-until-silenced" and "on-until-reset" on the same two-wire pair

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

- Easily mounts to single gang, double gang, or 4-inch square electrical box
- In/out wiring terminals, 18 AWG to 12 AWG
- Rear of housing does not extend into box

Optional Accessories:

- Mounting adapters to cover surface mounted electrical boxes and to adapt to Simplex® 2975-9145 boxes
- UL listed wire guard 4905-9961*
- UL/ULC listed sound damper for locations requiring attenuation of 5 to 6 dBA (stairwells, small rooms, highly reverberant areas, etc.)
- White cover with red "FIRE" lettering for on-site color conversion (ordered separately)

Listing Reference:

- UL listed to Standard 464
- ULC listed to Standard S525

4901-9820 TrueAlert Non-Addressable Horn,
Red Cover with White Lettering

Description

TrueAlert non-addressable horn model 4901-9820 is an audible notification appliance with a loud and penetrating, harmonically rich sound that can be controlled either directly from a standard NAC (free-run operation mode) or by the SmartSync two-wire operation mode.

Standard (free-run) operation mode. In the free-run mode, a positive voltage from the controlling NAC will activate the horn according to the desired output of continuous or coded output per the controlling NAC's capabilities.

SmartSync mode. When selected for SmartSync mode and used with compatible Simplex control (refer to list on page 2), this horn can be wired onto the same two-wire NAC circuit as visible appliances but with separately controlled operation. Typical applications are audible notification 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.

SmartSync control two-wire advantage. Allowing these separate controls to be carried on the same two-wire NAC circuit can significantly reduce installation time and expense for both retrofit and new construction.

Flexible mounting. This horn can be semi-flush or surface mounted on a standard single gang, double gang, or 4" square (102 mm) electrical box. Optional accessories are available to increase mounting and application flexibility.

* Refer to page2 for guard listing. 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 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.

** SmartSync two-wire horn/strobe operation is protected under U.S. Patent No. 6,281,789.

SmartSync Two-Wire Control

SmartSync operation mode allows a two-wire circuit to provide the ability to activate both the horn and strobe on the same NAC and then allow the horn to be silenced while the strobe remains flashing. The horn operates as "on-until-silenced" while the strobe operation is "on-until-reset."

SmartSync Control Sources

SmartSync two-wire control is available from:

- 4006, 4008, 4100U, and 4010 Fire Alarm Control Panels (refer to individual product data sheets for more information)
- 4009 IDNet™ NAC Extenders (refer to data sheet S4009-0002)
- SmartSync Control Module (SCM) Model 4905-9938 (refer to data sheet S4905-0003)

Product Selection

Model	Description	Dimensions
4901-9820	TrueAlert non-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)
4905-9838	Optional Sound Damper; package of 20; field installed adhesive backed horn output attenuator; reduces output 5 to 6 dBA **NOTE:** After Sound Damper installation, measure sound level to ensure compliance with applicable code requirements	1-3/4" Diameter (44.5 mm) with 0.31" (8 mm) sound opening

Adapters

Model	Description		Dimensions
4905-9937	Surface mount red 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	Surface mount white 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 Adapter Plate 4905-9931		7-7/8" x 5-1/8" x 2-3/4" D (200 mm x 130 mm x 70 mm)

Synchronization Control Module

Model	Description	Dimensions
4905-9938	SmartSync Control Module, Class A or Class B, installs in 4" square box; refer to data sheet S4905-0003 for details	4" x 4-1/8" x 1-1/4" D (102 mm x 105 mm x 32 mm)

Covers and Guard

Model	Description	Dimensions
4905-9988	Red horn cover with white "FIRE" lettering, available for replacement if required	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, use to convert cover color on-site	
4905-9961*	Wire guard with mounting plate, red, 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)

* UL listed by Space Age Electronics Inc.

4901-9820 TrueAlert Non-Addressable Horn Specifications

Rated Voltage Range		16 VDC to 33 VDC, see Note 1					
Current Ratings		**16 VDC**		**24 VDC**		**33 VDC**	
		21 mA		23 mA		27 ma	
Sound Output Characteristics		2400 to 3700 Hz sweep, modulated at 120 Hz rate					
Sound Output Ratings @ 10 ft (3 m) (see Note 2)		**16 VDC**		**24 VDC**		**33 VDC**	
	Sound Type (Note 2)	**Steady**	**Coded**	**Steady**	**Coded**	**Steady**	**Coded**
	UL 464 Reverberant Chamber	86 dBA	83 dBA	89 dBA	85 dBA	92 dBA	88 dBA
	Anechoic Chamber	93 dBA	89 dBA	96 dBA	92 dBA	96.3 dBA	92.3 dBA

General Specifications

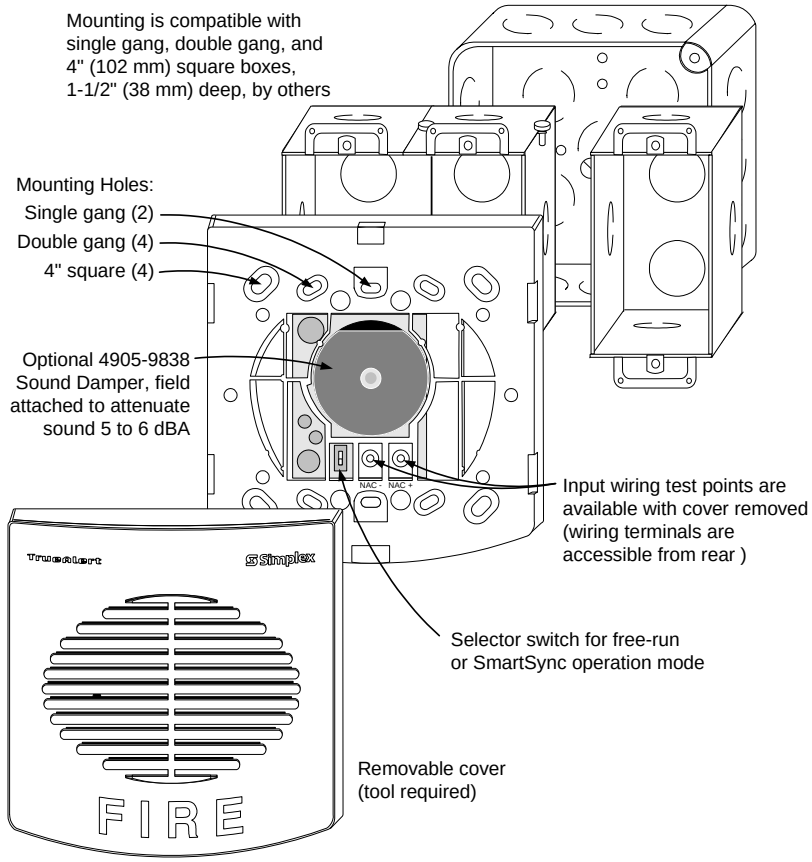
Temperature Range	32° to 122° F (0° to 50° C)
Humidity Range	10% to 93%, non-condensing @ 100° F (38° C)
Connections	Terminal blocks for 18 AWG to 12 AWG (0.82 mm^2 to 3.31 mm^2); two wires per terminal for in/out wiring

NOTES:

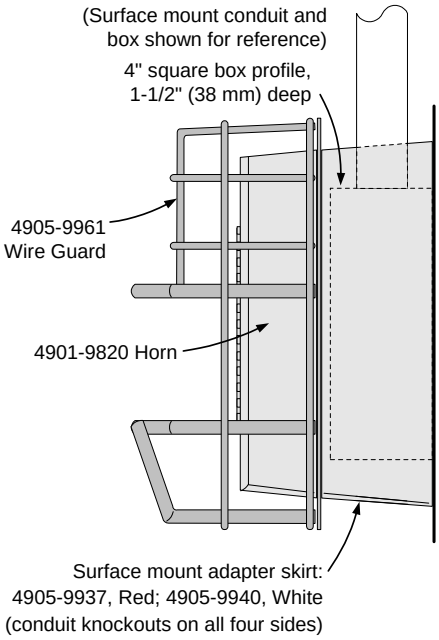
1. The rated voltage range listed is the absolute operating range. Operation outside of this range may cause permanent damage. Please note that 16 VDC is the lowest operating voltage that is allowed at the last appliance on the notification appliance circuit under worst case conditions. NAC voltage drops and standby battery calculations should be made using anticipated operating conditions.
2. Coded values are typical of the output measured with a Temporal pattern or a March Time pattern pulse 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.

Installation Reference

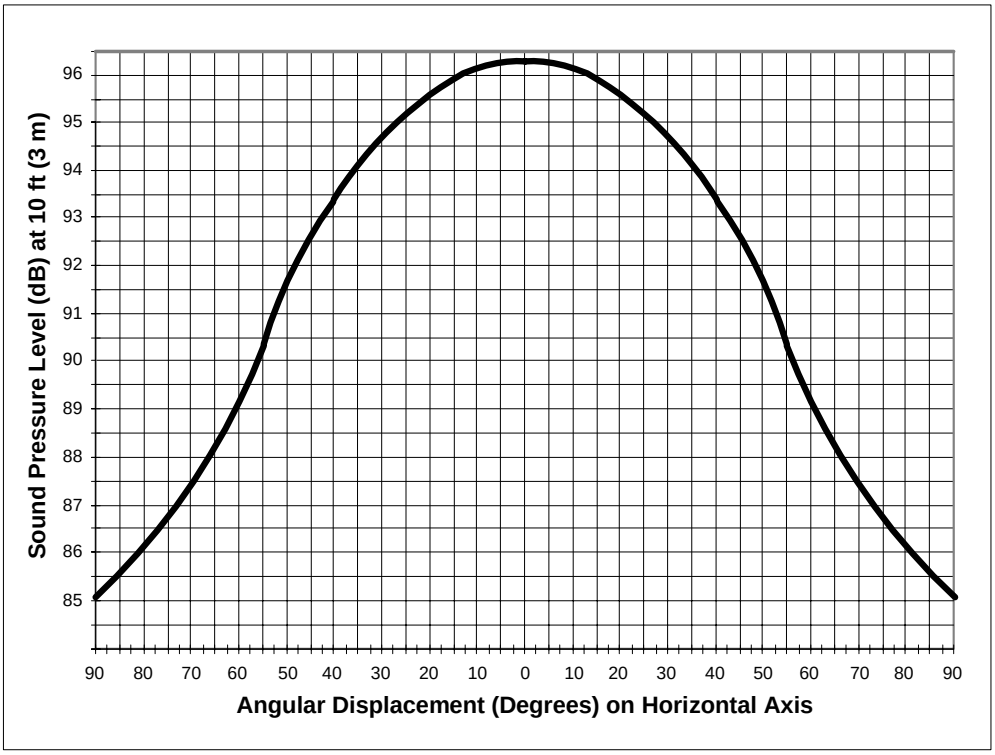
Surface or Semi-Flush Horn Mounting



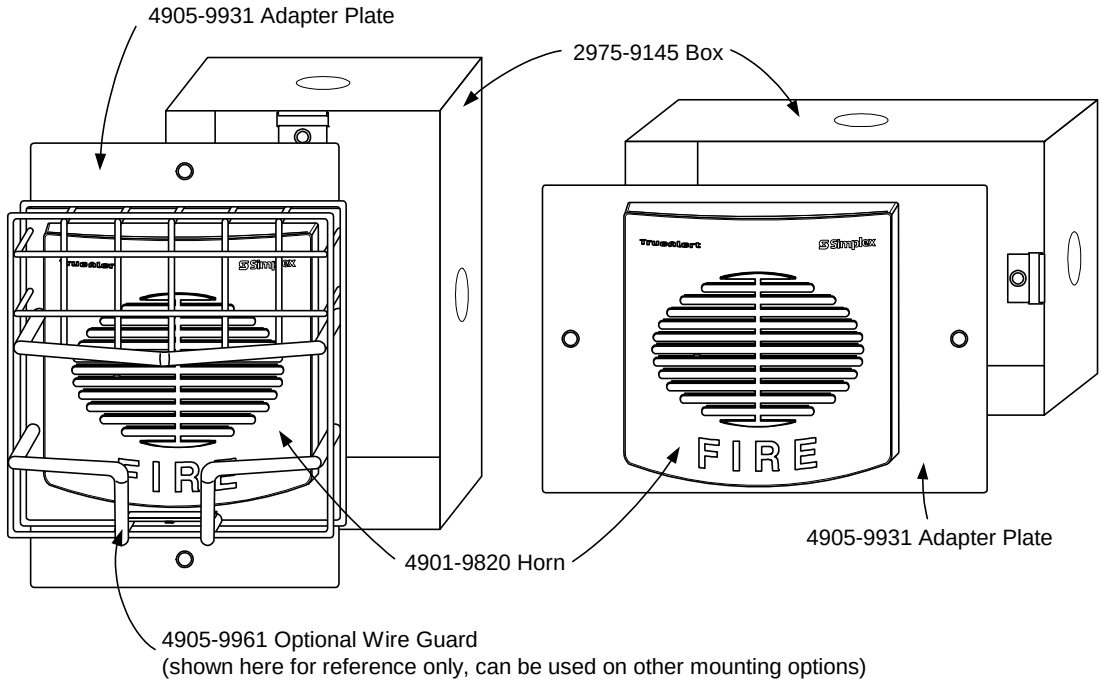
Side View of Horn with Surface Mount Adapter Skirt



Polar Sound Output per ULC Standard S525



4905-9931 Adapter Plate Installation Information



GENTEX CORPORATION

Commander² Series Low Frequency Evacuation Signals

GEC/GES/GEH 24 VDC SERIES

Applications

The Commander² Series is a low profile strobe, horn or horn/strobe combination that offers dependable audible and audible/visual alarms and the absolute lowest current available.

The GE Series is available in fixed candela options of 15/75 and 177.

The Commander² Series horn offers a continuous or synchable temporal three in 2400Hz and mechanical tone, a chime and whoop tone. All tones are easy for the professional to change in the field by using switches.

The GE Series has a minimal operation current and has a minimum flash rate of 1Hz regardless of input voltage.

The Commander² Series is shipped with the standard 4" mounting plate which incorporates the popular Super-Slide® feature that allows the installer to easily test for supervision. The product also features a locking mechanism which secures the product to the bracket without any screws showing.

The Commander² Series also features the patented Checkmate® - Instant Voltage Verification feature which allows the installer to check the voltage drop draw and match it to the blueprint.

The GE Series appliances are ANSI/UL 464, ANSI/UL 1971 and/or ANSI/UL 1638 listed for use with fire protective systems and are warranted for three years from date of purchase.

Standard Features

- Nominal voltage 24VDC
- Fixed candela options of 15/75 and 177
- GEH horn is available in 12VDC or 24VDC
- Super-Slide® Bracket - ease of supervision testing
- Checkmate® - instant voltage verification
- Unit Dimensions: 5” (12.7 cm) high x 4.5” (11.43 cm) wide x 2.5” (6.35 cm) deep
- Synchronize strobe and/or horn with Gentex AVSM Control Module
- Prewire entire system, install mounting bracket, then install signals
- Documented lower installation and operating costs
- Input terminals 12 to 18 AWG
- Switch selection for high or low dBA
- Switch for chime, whoop, mechanical and 2400Hz tone
- Switch for continuous or temporal 3 (not available on whoop tone)
- Tamperproof re-entrant grill
- Surface mount with the GSB (Gentex Surface Mount Box)
- Silence horn while strobes remain flashing
- Faceplate available in red or off-white

Product Listings

SIGNALING UL LISTED

- ANSI/UL 464, ANSI/UL 1971 and/or ANSI/UL 1638 Listed
- CSFM: 7135-0569:122 (GEH-24 & GEC-24)
  7125-0569:123 (GES-24)
  7135-0569: 130 (GEH-12)
- MEA: 285-91-E-XV

Patents

- 7,375,617 May 20, 2008

Product Compliance

- NFPA 72
- Americans with Disabilities Act (ADA)
- IBC/IFC/IRC
- City & State Ordinances/Laws/Regulations
- Quality Management System is certified to: ISO 9001:2008

NEMA MEMBER

ASSEMBLED IN THE USA

GEH 12VDC and 24VDC Low Profile Evacuation Horn

Model Number	Part Number	Nominal Voltage	Reverberant dBA @ 10ft., per ANSI/UL 464	In Anechoic Room dBA @ 10ft.
GEH12-R	904-1239-002	12 VDC	70-82	100
GEH12-W	904-1241-002	12 VDC	70-82	100
GEH24-R	904-1205-002	24 VDC	70-82	100
GEH24-W	904-1207-002	24 VDC	70-82	100

GES 24 VDC Low Profile Evacuation Strobe

Model Number	Part Number	Nominal Voltage	Strobe Candela
GES24-177WR	904-1183-002	24 VDC	177
GES24-177WW	904-1203-002	24 VDC	177
GES24-15/75WR	904-1167-002	24 VDC	15 (ANSI/UL 1971) / 75 (ANSI/UL 1638)
GES24-15/75WW	904-1187-002	24 VDC	15 (ANSI/UL 1971) / 75 (ANSI/UL 1638)

Model Designations:
W = Wall mount
R = Red Faceplate W = White Faceplate

All units are available in plain (no lettering).
Plain units are non-returnable.

ALERT bezel available AGENT bezel available

GEC 24VDC Fixed Candela, Low Profile Evacuation Horn/Strobe

Model Number	Part Number	Nominal Voltage	Strobe Candela	Reverberant dBA @ 10ft., per ANSI/UL 464	In Anechoic Room dBA @ 10ft.
GEC24-177WR	904-1143-002	24 VDC	177	70-82	100
GEC24-177WW	904-1163-002	24 VDC	177	70-82	100
GEC24-15/75WR	904-1127-002	24 VDC	15 (ANSI/UL 1971) / 75 (ANSI/UL1638)	70-82	100
GEC24-15/75WW	904-1147-002	24 VDC	15 (ANSI/UL 1971) / 75 (ANSI/UL 1638)	70-82	100

GE-24 Product Strobe Current Ratings (mA)

	24VDC (16-33 Volts)	
Candela	24VDC	UL Max[1]
15/75cd	63mA	67mA
177cd	96mA	213mA

GEH-12 Product Horn Decibel and Current Ratings

Horn Mode	Minimum dBA @ 10ft. per ANSI/UL 464 (HIGH)	Minimum dBA @ 10ft. per ANSI/UL 464 (LOW)	Regulated 12VDC Max. Operating @ High Setting (mA)
Temp 3 2400Hz	76	69*	29
Temp 3 Mechanical	75	68*	26
Temp 3 Chime	62*	60*	13
Continuous 2400Hz	79	74*	29
Continuous Mechanical	78	72*	26
Continuous Chime	63*	61*	13
Whoop	78	71*	55

GE-24 Product Horn Decibel and Current Ratings

Horn Mode	Minimum dBA @ 10ft. per ANSI/UL 464 (HIGH)	Minimum dBA @ 10ft. per ANSI/UL 464 (LOW)	Regulated 24VDC Max. Operating @ High Setting (mA)
Temp 3 2400Hz	78	71*	28
Temp 3 Mechanical	76	70*	25
Temp 3 Chime	70*	66*	15
Continuous 2400Hz	81	74*	28
Continuous Mechanical	80	72*	25
Continuous Chime	70*	66*	15
Whoop	82	69*	56

NOTES:

- Operating temperature: 32°to 120°F (0° to 49°C). The GE Series is not listed for outdoor use.
  The sound output for the temporal 3 tone is rated lower since the time the horn is off is averaged into the sound output rating. While the horn is producing a tone in the temporal 3 mode its sound pressure is the same as the continuous mode.
- For nominal and peak current across UL regulated voltage range for filtered DC power and unfiltered (FWR [Full Wave Rectified]) power, see installation manual. 12VDC models are DC only.

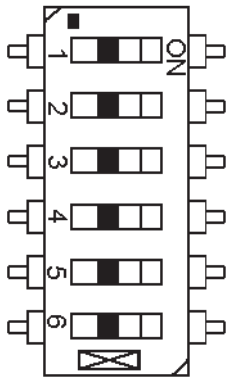
* Operating the horn in this mode at this voltage will result in not meeting the minimum ANSI/UL 464 reverberant sound level required for public mode fire protection service. These settings are acceptable only for private mode fire alarm use. Use the high dBA setting for public mode application (not applicable when using the chime tone. The chime tone is always private mode).

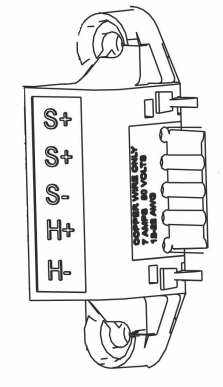
[1] RMS current ratings are per UL average RMS method. UL max current rating is the maximum RMS current within the listed voltage range (16-33VDC for 24VDC units) (8-17VDC for 12VDC units). For strobes the UL max current is usually at the minimum listed voltage (16VDC for 24VDC units) (8VDC for 12VDC units). For audibles the max current is usually at the maximum listed voltage. For unfiltered FWR ratings, see installation manual.

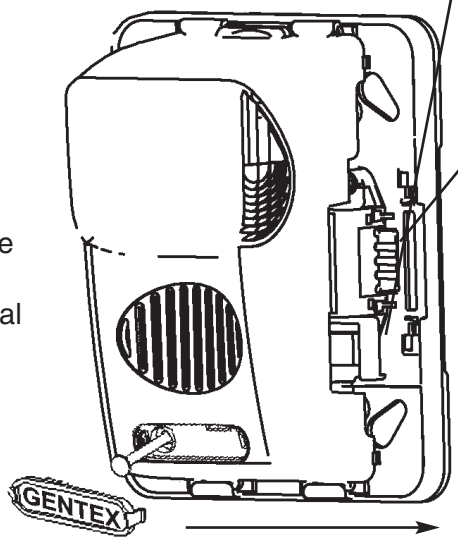
Tone Switch Locations

TONE	SWITCH POSITION		
	3	4	5
Mechanical Temporal 3	ON	ON	ON
Mechanical - Continuous	OFF	ON	ON
2400Hz - Temporal 3	ON	OFF	ON
2400Hz - Continuous	OFF	OFF	ON
Chime - Temporal 3	ON	ON	OFF
Chime - Continuous	OFF	ON	OFF
Whoop	ON	OFF	OFF
Whoop	OFF	OFF	OFF

NOTE:
- Switch Positions 1 and 2 in the OFF position to select isolated horn and strobe power inputs
- Switch Position 6 ON = HIGH dBA
- Switch Position 6 OFF = LOW dBA







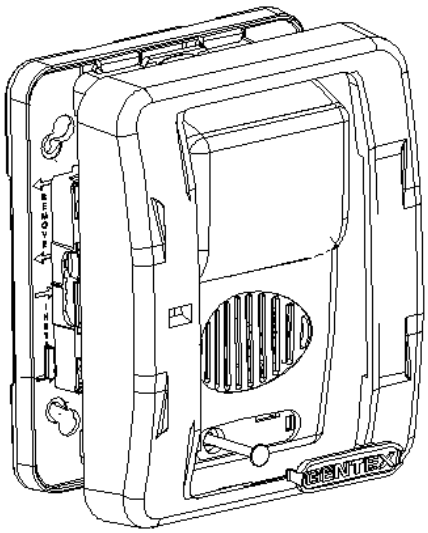
Gentex Super-Slide® Mounting Bracket

Allows the installer to pre-wire the system, test for system supervision, remove the signal head until occupancy, switch out Gentex signals without changing mounting brackets and has locking edge connector for snap-in-place installation.

Gentex Checkmate® Instant Voltage Verification

It is often necessary to confirm the voltage drop along a line of devices. The access holes are provided in the back of the terminal block to allow the voltage to be measured directly without removing the device. Typically this would be done at the end of the line to confirm design criteria. Most measurements will be taken using the S+ and S- locations although access is provided to other locations.

NOTE: Care should be taken to not short the test probes.



To remove bezel, grip both sides of bezel and pull in a downward and outward motion.

Smoke Detector

Simplex®

True*Alarm*® Smoke Detectors

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

TrueAlarm Photoelectric Smoke Detectors
for Two-Wire and Four-Wire Bases

Features

Photoelectric smoke detector with on-board TrueAlarm sensitivity drift compensation**

Functional chamber enclosure:

- Louvered design enhances smoke capture by directing flow to chamber
- Entrance areas are minimally visible when ceiling mounted

Multi-function indicator LED indicates normal and alarm conditions

Magnetically operated functional test:

- Initiates alarm and verifies performance
- Identifies general sensitivity status using detector LED

Models available in two sensitivity settings:

- 4098-9601, Standard Sensitivity, nominal 2.8%/ft obscuration*
- 4098-9605, Special Application Sensitivity, nominal 3.5%/ft obscuration

Available options:

- Bases for 2-wire or 4-wire operation
- Auxiliary alarm relay output
- Remote alarm indicating LED

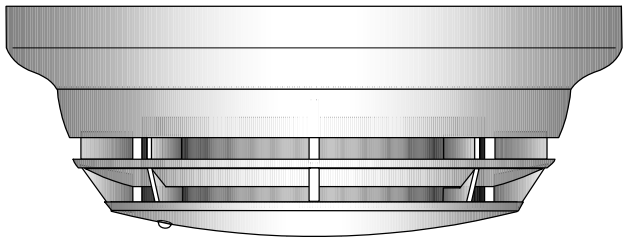
Designed for EMI compatibility

UL listed to Standard 268

Description

Simplex® TrueAlarm photoelectric detectors provide many of the proven TrueAlarm analog sensing features for applications where detectors are connected to conventional 2-wire or 4-wire initiating device circuits (IDCs). Each TrueAlarm detector has an on-board microprocessor that evaluates its photoelectric light scattering chamber activity and makes an intelligent decision based on light obscuration history as to whether an alarm condition is present.

TrueAlarm detectors are packaged in a patented housing that minimizes the visibility of the air intake louvers from the normal viewing locations while maintaining a high performance smoke capture ability**. Bases are available for remote alarm LED indicator connections and auxiliary relay outputs.



4098-9601 TrueAlarm Photoelectric
Detector Mounted in Base

Specifications

Voltage	15 to 32 VDC from Fire Alarm Control Panel IDC
Standby Current	100 µA @ 24 VDC
Alarm Current, 2-Wire Operation	Up to 86 mA maximum, exact current is determined by alarm current limiting of connected IDC
Alarm Current, 4-Wire Operation	24 mA typical @ 24 VDC
Auxiliary Relay Ratings	Refer to page 2 under Product Selection
Air Velocity Range	0-2000 ft/min (0-610 m/min)
UL Listed Temp. Range	32° to 100° F (0° to 38° C)
Operating Temp. Range	15° to 122° F (-9° to + 50° C)
Humidity Range	10% to 95% RH from 32° to 122° F (0° to 50° C) non-condensing
Color	Frost White
Dimensions	4-7/8" Dia. x 1-7/8" H, mounted in base (124 mm x 48 mm); refer to page 3 for detail

* ULC listed model is 4098-9601. 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 7272-0026:219 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.

** TrueAlarm smoke detector operation is protected by one or more of the following U.S. Patents: 5,155,468; 5,173,683; 5,400,014; 5,543,777; 5,710,541; D383,407; D388,352; D392,573.

TrueAlarm Smoke Detector Features

Intelligent Data Evaluation. Conventional smoke detectors will typically drift toward being too sensitive due to the accumulation of dust and dirt. With TrueAlarm analog detection, data from the photoelectric chamber is monitored and analyzed at the detector to provide a continuously shifting reference point.

Drift Compensation. The data evaluation and its shifting reference point provide a software filtering process that compensates for environmental factors (dust, dirt, etc.) and component aging, establishing an accurate reference for evaluating new activity. With this filtering, the resulting drift compensation provides a significant reduction in the probability of false or nuisance alarms caused by shifts in sensitivity – either up or down.

Magnetic Test Information. Status information is available by performing the magnetic test and observing the detector LED pulses. The LED will normally go directly into alarm with the magnetic test. If there is an off-normal condition, the LED pulses first to indicate the condition and then goes into alarm. (See page 3.)

Application Reference

Detector Locations. Locations should be determined only after careful consideration of the physical layout and contents of the area to be protected. Refer to NFPA 72, the *National Fire Alarm Code*. On smooth ceilings, smoke detector spacing of 30 ft (9.1 m) may be used as a guide. For detailed installation information, refer to *4098 Detectors, Sensors, and Bases Application Manual* (574-709).

Sensitivity Selection. The 4098-9601 standard sensitivity detector is recommended for most applications. When a special application for a reduced sensitivity detector is required, the 4098-9605 should be considered. Consult your local Simplex product supplier for assistance in determining the proper selection.

Product Selection

Smoke Detectors

Model	Nominal Sensitivity	Description	Compatibility
4098-9601	2.8%/ft (standard)	TrueAlarm Photoelectric Detector	Compatible with bases: 4098-9788, 4098-9682, and 4098-9683
4098-9605	3.5%/ft (special application sensitivity, not ULC listed)		

Compatible Bases

Model	Description	Details*
4098-9788	**2-Wire Base** with connections for Remote Alarm LED Indicator	IDC and LED connections are screw terminals for in/out wiring, 18 to 14 AWG
4098-9682	**4-Wire Base** with Auxiliary Alarm Relay Contacts and connections for Remote LED Alarm Indicator **NOTE:** Requires external 24 VDC for operation	**Relay Ratings, Single Form "C", For Suppressed Loads:** Power limited, 3 A @ 28 VDC; Non-power limited, 3 A @ 120 VAC
		Wiring Connections (In/Out where required): Relay contacts and IDC wiring, color coded 18 AWG leads; LED wiring, screw terminals for 18 to 14 AWG
4098-9683	**2-Wire Base with Auxiliary Alarm Relay** & connections for Remote LED Indicator **NOTE:** Must be connected as the only device on the IDC to ensure relay operation.	**Relay Ratings, Dual Form "C", For Suppressed Loads:** Power limited, 1 A @ 28 VDC; Non-power limited, 1/2 A @ 120 VAC
		Wiring Connections (In/Out where required): Relay contacts and IDC (-), color coded 18 AWG leads; IDC (+) and LED wiring, screw terminals for 18 to 14 AWG

Detector Accessories

Model	Description		Details*	
4098-9832	Adapter Plate		**Required** for mounting to surface mounted 4" (102 mm) square or 4" octagonal boxes, and to 4" square flush mounted boxes	
			May be used when retrofitting existing bases	
			Compatible with detector bases 4098-9788, -9682, & -9683	
4098-9830	Remote LED Indicator		Mounted on single gang stainless steel plate	
2098-9739	Encapsulated	24 VDC End-of-Line Relay	Dimensions: 2-1/2" x 1-1/2" x 1" (64 mm x 38 mm x 25.4 mm)	**Required** for 4-wire circuits using 4098-9682 base, one per circuit; select mounting type as required; wiring is color coded 18 AWG wire leads
2098-9735	Plate Mounted		Mounted on single gang stainless steel plate	

* Refer to pages 3 and 4 for dimensions and additional mounting details; 18 AWG = 0.82 mm^2; 14 AWG = 2.08 mm^2

Detector Status LED Indications

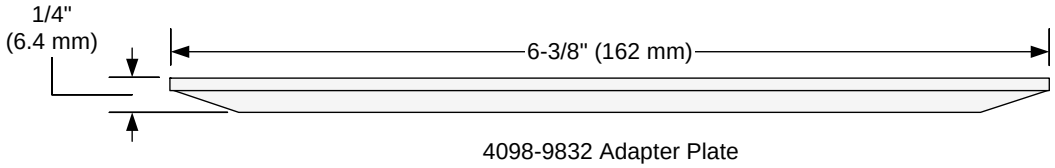
LED Indication	Status
Pulses approximately every 4 seconds	Normal
Steady On	Alarm

LED Response to Magnetic Test *

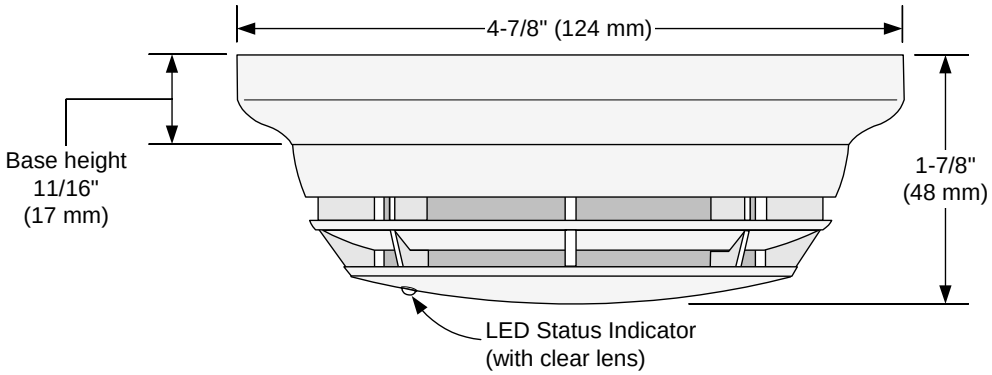
LED Indication	Followed By	Status	Action
LED turns ON	Alarm is initiated	**Normal**, sensitivity is within compensation range	None
LED pulses quickly, 6 times in 3 seconds, then turns ON	Alarm is initiated	**More sensitive**, out of normal compensation range	Cleaning or other **service is required**
LED pulses slowly, 4 times in 8 seconds, then turns ON	Alarm is initiated	**Less sensitive**, out of normal compensation range	
	Does not initiate Alarm	**Detector is malfunctioning**	**Service is required**

* Testing requires placing a magnet at the designated location on the detector cover for 4 seconds. Refer to Application Manual 574-709 for further test and maintenance information.

Dimensions and Reference Information



4098-9832 Adapter Plate



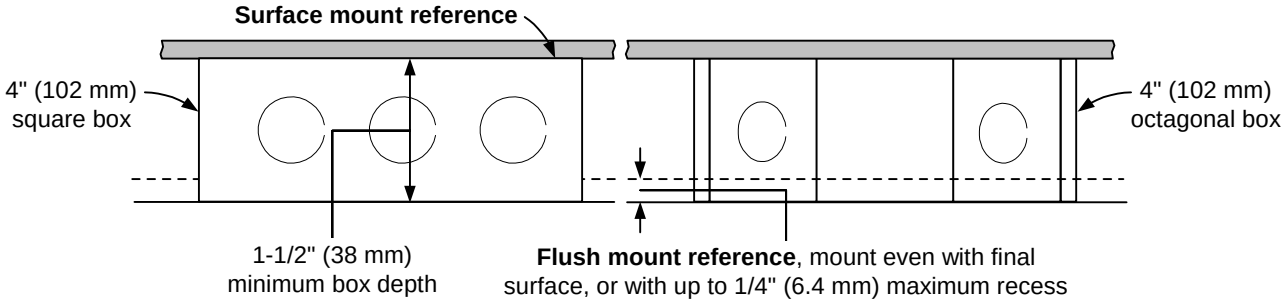
4098-9601 & -9605 Dimensions Mounted on Base

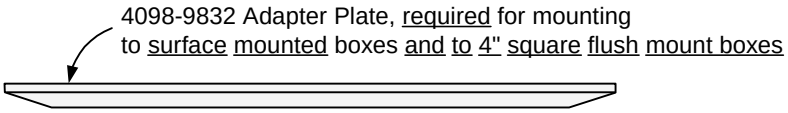
4098-9830 Remote LED Indicator (not to scale)

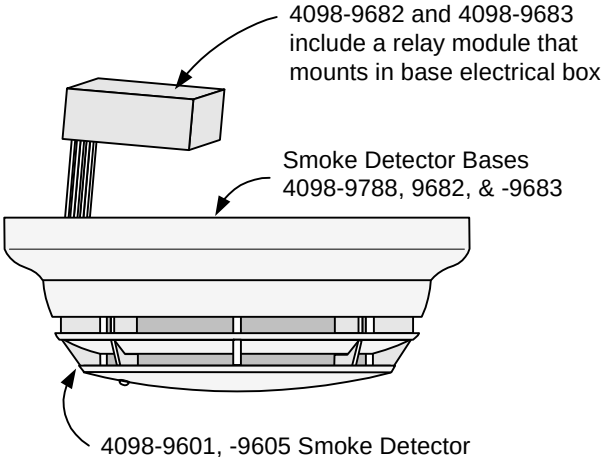
Mounting Information

(Electrical boxes are supplied by others.)

Electrical Box Requirements:
Without relay (base 4098-9788):
4" octagonal or 4" square, 1-1/2" deep
Single gang, 2" deep
With relay (bases 4098-9682 and 4098-9683):
4" octagonal, 1-1/2" deep, with 1-1/2" extension ring
4" square, 1-1/2" deep, with 1-1/2" extension ring







Control Panels

System Accessories, LED Annunciators

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

4602 Series SCU (Status Command Units)
and RCU (Remote Command Units)

Features

Remote LED status annunciation with available remote panel input switch control:

- Compatible with Simplex® 4005, 4010ES, 4100ES, and 4100U series fire alarm control panels
- Also compatible with Simplex legacy panel model series 4002, 4020, 4100, 4120, and Universal Transponders (UT)
- Supervised RUI (remote unit interface) communications require a single, twisted, shielded wire pair to the fire alarm control panel (power is supplied via a second wire pair)
- Red zone status LEDs are provided with preprinted zone numbers or can be individually labeled as desired
- LEDs are pluggable for color changing or replacement; on-board internal pushbutton switch provides LED test
- Surface or flush-mount on standard electrical boxes
- UL listed to Standard 864

Available as single units or can be ordered modular for up to 4 units in a common cabinet:

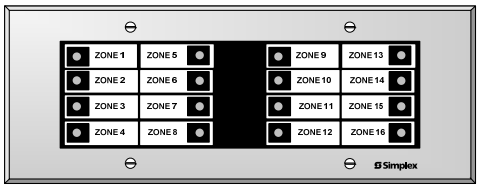
- **4602-9101, Status Command Unit (SCU)** provides 16 red LED zone status indicators
- **4602-9102, Remote Command Unit (RCU)** provides 8 red LED zone status indicators; local power (green) and trouble (yellow) LEDs; local tone-alert; and switches for Trouble Silence, Alarm Silence, System Reset, and Manual Evacuation (EVAC)
- **4602-8001 Series** panels provide selection of a remote cabinet that can mount one RCU and up to three SCUs; options include beige or stainless steel flush mount doors
- **Graphic I/O Board Assemblies** are available separately for use with listed custom graphic annunciator panels; available stand-alone (4602-9150), or plate mounted (4602-7101); selectable as SCU or RCU; terminal blocks are provided for LED, switch, and LED test feature connections

Description

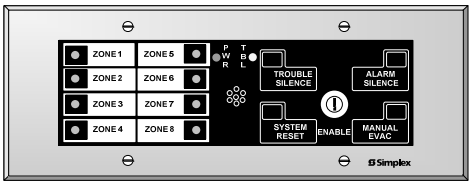
Status Command Units (SCU) provide 16 red zone status LEDs. Multiples may be mounted together for additional zone coverage.

Remote Command Units (RCU) provide 8 red zone status LEDs, and control switches duplicating the switch functions of the host Fire Alarm Control Panel. A keyswitch enables the control switches. A green LED indicates power is present and a yellow LED indicates trouble.

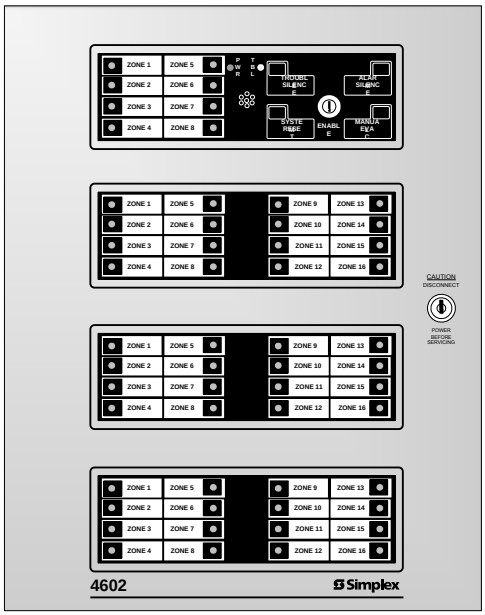
Zone identification (i.e., Zone 1, Zone 2) is provided on "slip-in" labels. Detailed local zone information may be typed on the blank reverse side (i.e., East Wing, First Floor, etc.) of the label. Pushbutton LED test switches are located internally for "lamp test" feature. Terminations are via convenient terminal block connections.



4602-9101 Status Command Unit (SCU)



4602-9102 Remote Command Unit (RCU)



4602-8001 Annunciator Package with RCU on top and three SCUs (shown as standard surface mount trim)

* 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 7120-0026:0156 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.

Product Selection

Individual LED/Switch Annunciators; Six-Gang box mounting (refer to mounting reference on page 3)

Model	Description	Mounting Reference
4602-9101	Status Command Unit (SCU) with beige trim plate	Trim dimensions = 11 $^{13}/_{16}$" W x 4 ½" H (114 mm x 300 mm) Mounts on 6-gang box, 1 ½" minimum depth (38 mm)
4602-9102	Remote Command Unit (RCU) with beige trim plate	
4602-9111	Brushed stainless steel trim plate option for either 4602-9101 or 4602-9102, includes both slotted and tamper resistant screws	
2975-9206	Surface mount box option for use with 4602-9101 or 4602-9102; painted steel, ivory finish; dimensions = 11 $^{31}/_{32}$" W x 4 ⅝" H x 2 ¾" D (304 mm x 117 mm x 70 mm)	

Individual Graphic I/O Module; for use with listed custom graphic annunciator panels

Model	Description
4602-9150	Graphic I/O RCU/SCU Board Assembly; operation is switch selectable as either RCU or SCU; dimensions = 5 ⅛" x 7" (130 mm x 178 mm); see illustration reference below

Plate Mounted Graphic I/O Modules; for use with listed custom graphic annunciator panels

Model	Description
4602-8103	Graphic I/O Mounting Plate for up to four (4), 4602-7101 Graphic I/O RCU/SCU modules; dimensions = 16 ⅛" W x 11 ⅛" H (409 mm x 282 mm)
4602-8902	Select when adding 4602-7101 modules in the field to an existing Graphic I/O annunciator mounting plate
4602-7101	Graphic I/O RCU/SCU module for mounting on 4602-8103 plate (up to four); operation is switch selectable as either RCU or SCU; includes power and control wiring harnesses

Modular LED/Switch Annunciators; Cabinet Mounted (see mounting reference on page 4 for dimensions)

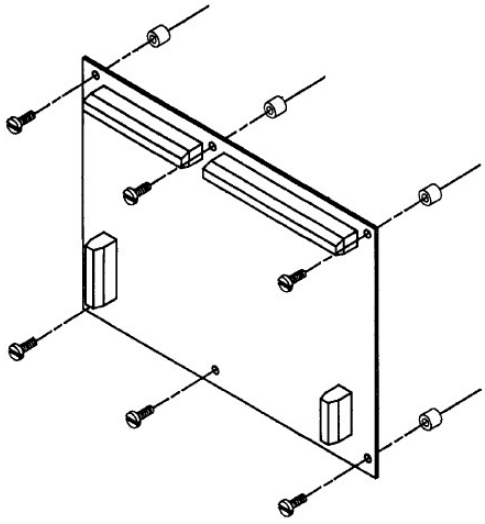
Model	Description	
4602-8001	Basic annunciator panel; includes 2975-9197 beige box and beige surface mount door; has space for up to 4 RCU/SCU modules, ordered separately as listed below	
4602-8901	Select when adding features in the field to an existing 4602 Modular LED/Switch annunciator cabinet	
4602-7001	Remote Command Unit (RCU) module; typically one used per 4602-8001	Up to four modules may be selected for one 4602-8001
4602-6001	Status Command Unit (SCU) module; up to 4 may be selected	
4602-5001	Select when no 4602-7001 or 4602-6001 modules are to be selected; blank filler plates will be provided	
4602-2201	Beige	Flush mount door and trim option; overall dimensions = 16" W x 20" H (406 mm x 508 mm)
4602-2202	Stainless Steel	

SCU/RCU Options

Model	Description
4602-9110	Eight (8) pluggable Yellow LEDs; for field replacement of standard red LEDs
4602-9112	Zone labels numbered 1 through 64

4602-9150 Graphic I/O RCU/SCU Board Only Installation Reference

1. Board size is 5 ⅛" x 7" (130 mm x 178 mm).
2. Orientation may be vertical or horizontal.
3. Mount within the listed custom graphic annunciator enclosure or within a listed steel box close-nippled to the annunciator.
4. Required mounting hardware (not supplied): 6, 6-32 screws, ½" (12.7 mm) minimum length; 6 standoffs ⅜" (9.5 mm) minimum length.
5. Refer to illustration for details.
6. **NOTE:** For multiple custom annunciator Graphic I/O applications, use model 4602-7101 for mounting up to four on plate 4602-8103.



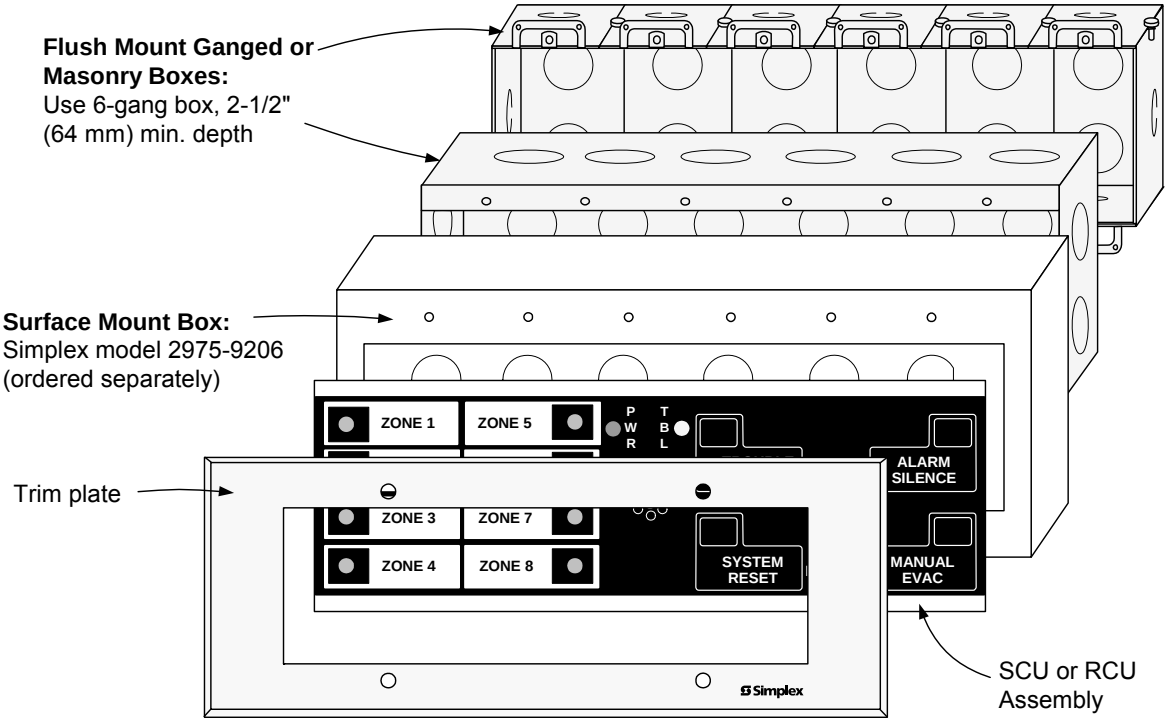
Specifications

Voltage		18.9 to 32 VDC from fire alarm control panel	
Current	4602-9101 SCU	Supervisory = 36 mA; Alarm = 55 mA	
	4602-9102 RCU	Supervisory = 40 mA; Alarm = 80 mA	
	4602-7107 or 4602-9150 Graphic I/O Module	Supervisory = 40 mA; Alarm = 65 mA minimum, up to 2.5 A maximum; LED/lamp driver outputs are rated 150 mA maximum each	
Communications		RUI (Remote Unit Interface) external annunciator communications line SLC (signaling line circuit)	
4100ES/4100U Capacity, Per RUI Output		Up to 31 remote annunciators/MINIPLEX transponders per channel including the 4603-9101 LCD Annunciator, the SCU, and the RCU; refer to data sheet S4100-0031 for additional 4100ES information	
4010ES Capacity		Up to 20 internal or external card addresses including 4603-9101 LCD Annunciators, the SCU, and the RCU; refer to data sheets S4010-0004 for additional 4010ES information (refer to data sheet S4100-0006 for International 4010ES applications)	
4005 RUI Capacity		Up to 16 total SCUs and/or RCUs; refer to data sheet S4005-0001 for additional 4005 information	
Wiring Requirements	Data	Single twisted, shielded pair, 18 AWG (0.82 mm^2)	Wiring connections are via terminal blocks
	Power	18 to 12 AWG (0.82 mm^2 to 3.31 mm^2)	
	Earth	A dedicated earth ground connection to the electrical box is required for proper ESD and EMI protection; wire in accordance with NFPA 70 (*National Electrical Code*) Article 250	
Operating Temperature		32° F to 120° F (0° C to 49° C)	
Operating Humidity		Up to 93% RH, non-condensing @ 90° F (32° C) maximum	

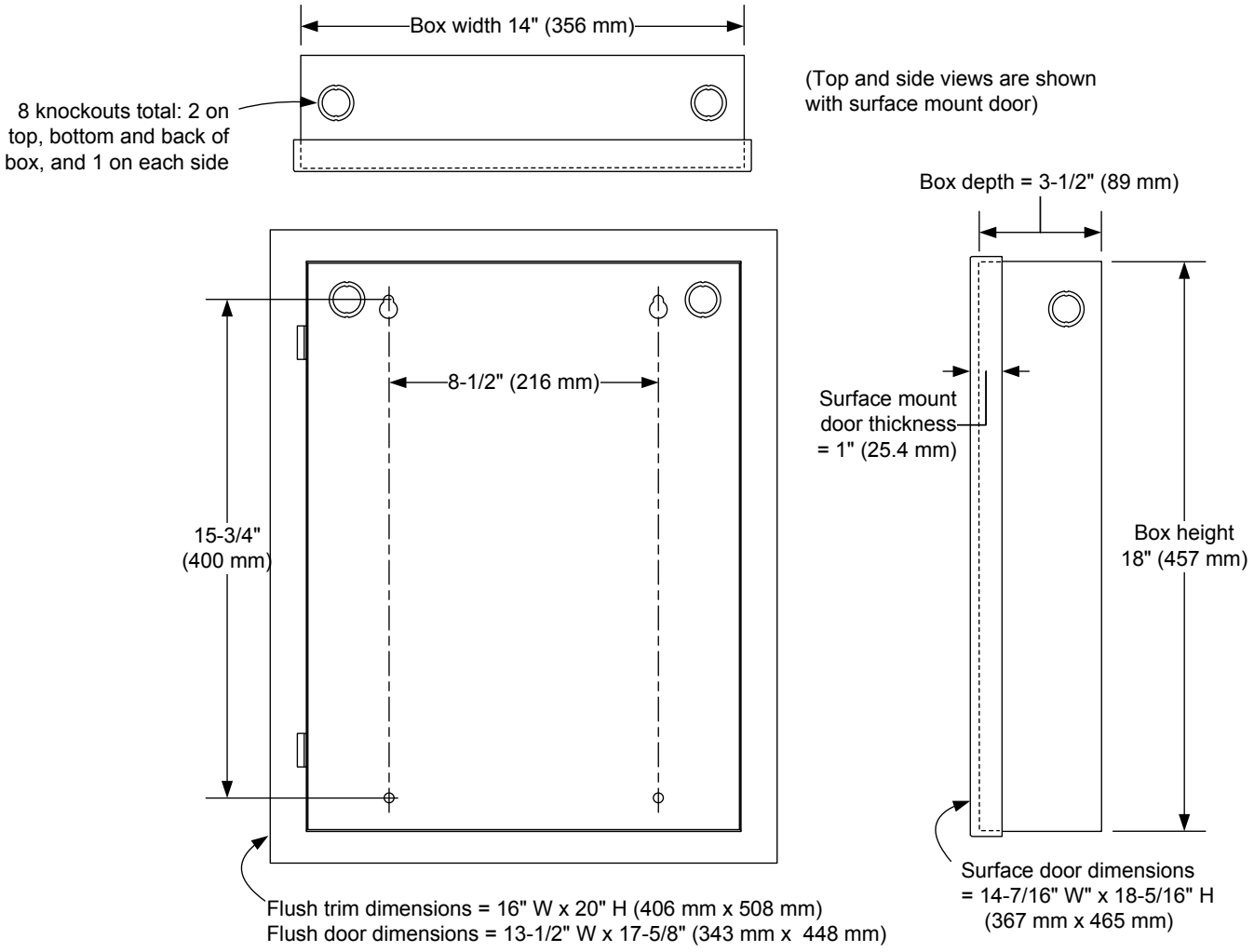
Additional Reference

All	Field Wiring Diagram 841-780
4602-9101 SCU and 4602-9102 RCU	Installation Instructions 574-015
4602-7107 or 4602-9150 Graphic I/O Module	Installation Instructions 574-024

RCU/SCU Mounting Reference



4602-8001 Mounting Reference



LifeAlarm Fire Alarm Control Panels

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

4006 Series Fire Alarm Control Panels
Providing up to Ten IDCs and Four NACs

Features

Control panel operator convenience features:

- Wide viewing angle 2 x 20 (40 character) alphanumeric LCD and dedicated LEDs provide convenient panel status information
- Operation is programmable using a multi-function keypad and the panel LCD or via service computer (PC)
- RS-232 service port provides upload/download PC access for panel configuration and event history logs
- Software updates are via PC download
- Convenient library of standard custom label terms
- Standard on-board DACT provides: Contact ID, 3/1, 4/2, BFSK, and SIA formats
- WALKTEST silent or audible system test
- Voltage and current for both the battery charger and the battery can be displayed at the front panel LCD

Five Standard Initiating Device Circuits (IDCs):

- Five Class B IDCs with optional expansion to ten, all with individual zone disable
- Monitor 2-wire or 4-wire initiating devices including TrueAlarm smoke detectors
- Optional Class A Adapter Module

Two Standard Notification Appliance Circuits (NACs):

- Class A or Class B outputs with solid state overcurrent protection per NAC, each rated for 2 A
- Selectable for Simplex® SmartSync two-wire horn/strobe control or synchronized strobe control

Standard Power Supply:

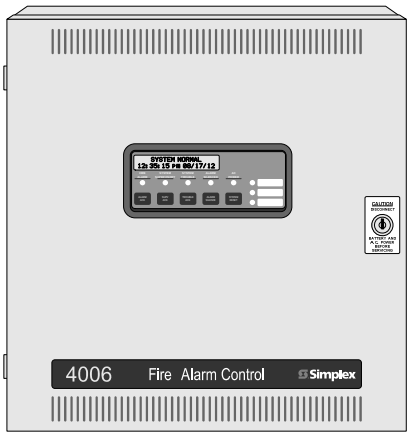
- Provides 3 A maximum @ nominal 24 DC
- Automatic input power selection operates with 120 VAC or 240 VAC, 50 or 60 Hz
- On-board temperature compensated battery charger for up to 12.7 Ah batteries in cabinet (UL and ULC) and up to 25 Ah batteries in separate cabinet (UL only)

Additional standard features:

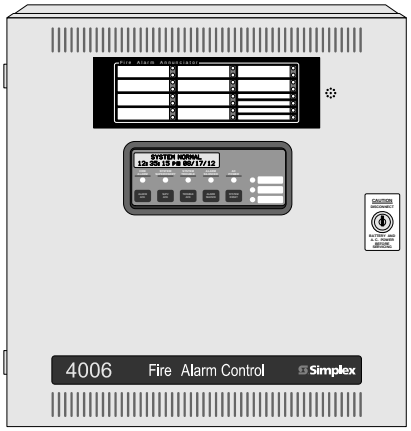
- Programmable Active Status Reminder
- Two auxiliary relays
- IDCs, NACs, and Relay outputs are power limited (AC input, battery circuits, and City Circuit Module outputs are non-power limited)
- Available with beige or red cabinet
- UL listed to Standard 864

Available option modules:

- Door mounted 24 LED annunciator (standard on ULC models)
- 3 A Expansion Power Supply with two on-board 2 A NACs that operate the same as standard NACs



4006-9102 (Beige) Standard Control Panel



4006-9122 (Beige) Control Panel with 24 LED Annunciator

Available option modules *(Continued)*:

- Expansion IDC module with five Class B IDCs
- Class A IDC Adapter Module, City Interface Module, and Auxiliary Relay Module
- Remote LCD and LED/Switch Annunciators

Description

For areas requiring from five to ten initiating zones, the Simplex 4006 Series fire alarm control panels provide flexible initiating circuit monitoring, extensive programmable control capability, and LCD annunciated circuit-specific 20 character custom labels.

* See page 2 for additional ULC and MEA information. 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 7165-0026:318 for allowable values and/or conditions concerning material presented in this document. It is subject to re-examination, revision, and possible cancellation. 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.

Standard Feature Details

Five Class B IDCs are each capable of supporting up to 30 Simplex current-limited smoke detectors or electronic heat detectors (see list on page 4) as well as manual stations and other compatible contact closure initiating devices. IDCs are capable of Class A operation with an optional adapter module and can be programmed as Style C (short or open initiates a trouble) for use with current limited devices only.

Two, 2 A On-Board NACs provide conventional reverse polarity operation, selectable as Class A or Class B, with electronic control and overcurrent protection. Operation is selectable for synchronized strobe or SmartSync horn/strobe two-wire operation. Horn control can be selected at the panel for: Temporal pattern coding, Steady On, Slow March Time of 20 beats per minute (BPM), or Fast March Time of 120 BPM. **Note:** When selected for SmartSync horn/strobe control, March Time produces 60 BPM.

The 24 VDC Auxiliary output provides up to 500 mA for system use. (Auxiliary output current is counted for total power supply capacity.)

Standard Auxiliary Relay Outputs. Two relay outputs are available, selectable as normally open or normally closed, rated 2 A @ 30 VDC per below:

Aux Relay 1 is normally assigned to General Alarm operation but is programmable (see page 7)

Aux Relay 2 (Trouble) is energized when Normal and is de-energized with a Trouble condition.

On-Board Dual Line DACT. Operation can be selected for Contact ID, SIA, 3/1, 4/2, and BFSK formats. Reporting includes Alarm, Supervisory, Trouble, and AC Failure. Operation includes automatic 24 hour test and programmable power fail report delay.

Standard Feature Details *(Continued)*

Power Supply and Battery Charger. DC power output is 3 A @ 24 VDC for panel use. The temperature compensated battery charger (sealed lead-acid batteries only) is rated for up to 25 Ah batteries per UL 864 and up to 12.7 Ah per ULC-S527. (Up to 12.7 Ah batteries fit in the cabinet, larger batteries require an external cabinet.) Panel electronics can measure and display voltage and current for the power supply, batteries and the battery charger (standard and expansion power supply). Depleted battery trouble is monitored and annunciated and depleted battery cutout can be selected. Active battery status monitor supervises charger operation.

Optional Feature Details

Expansion Power Supply. Provides 3 A total @ 24 VDC, two additional 2 A NACs, and an additional auxiliary power output of 500 mA. Output operation is the same as on the standard power supply.

Expansion IDC Module. Provides 5 additional Class B IDCs with operation the same as the standard IDCs.

Expansion Relay Module. Provides 10 programmable relays, jumper selectable as N.O. or N.C. Contacts are rated 2 A @ 30 VDC. Typical application is to track status of each IDC. See page 7 for relay program options.

Class A Adapter Module. Converts 5 IDCs from Class B to Class A operation. Two modules can be mounted for use with the Expansion IDC Module.

City Circuit Modules. These modules are available with or without on-board disconnect switches, depending on local requirements (either type can be disconnected through the front panel under password control). Connections are for Remote Station (reverse polarity) or Municipal Master (local energy). Reporting includes Alarm, Supervisory, and Trouble.

Product Selection

Control Panel

Model	Color	Description	Listings		Standard Feature Summary
4006-9102	Beige	Standard fire alarm control panel	MEA	UL, FM, & CSFM	5 Class B IDCs, 2 Class B/Class A NACs, 3 A power supply with battery charger; on-board DACT; 120/240 VAC, 50/60 Hz (autoselect)
4006-9101	Red				
4006-9122	Beige	Fire alarm control panel with 24 LED Annunciator on front door	ULC		
4006-9121	Red				

Option Modules

Model	Description	
4006-9801	Expansion Power Supply; 3 A, with 2 NACs, 120/240 VAC, 50/60 Hz	Select up to one of each as required
4006-9802	Expansion IDC Module; 5 Class B IDCs	
4006-9803	Expansion Relay Module; 10 relays selectable as either N.O. or N. C.	
4006-9804	Class A Adapter Module; converts 5 IDCs from Class B to Class A	Select up to two maximum
4006-9805	City Circuit Module with disconnect switch	Select one if required
4006-9806	City Circuit Module without disconnect switch	

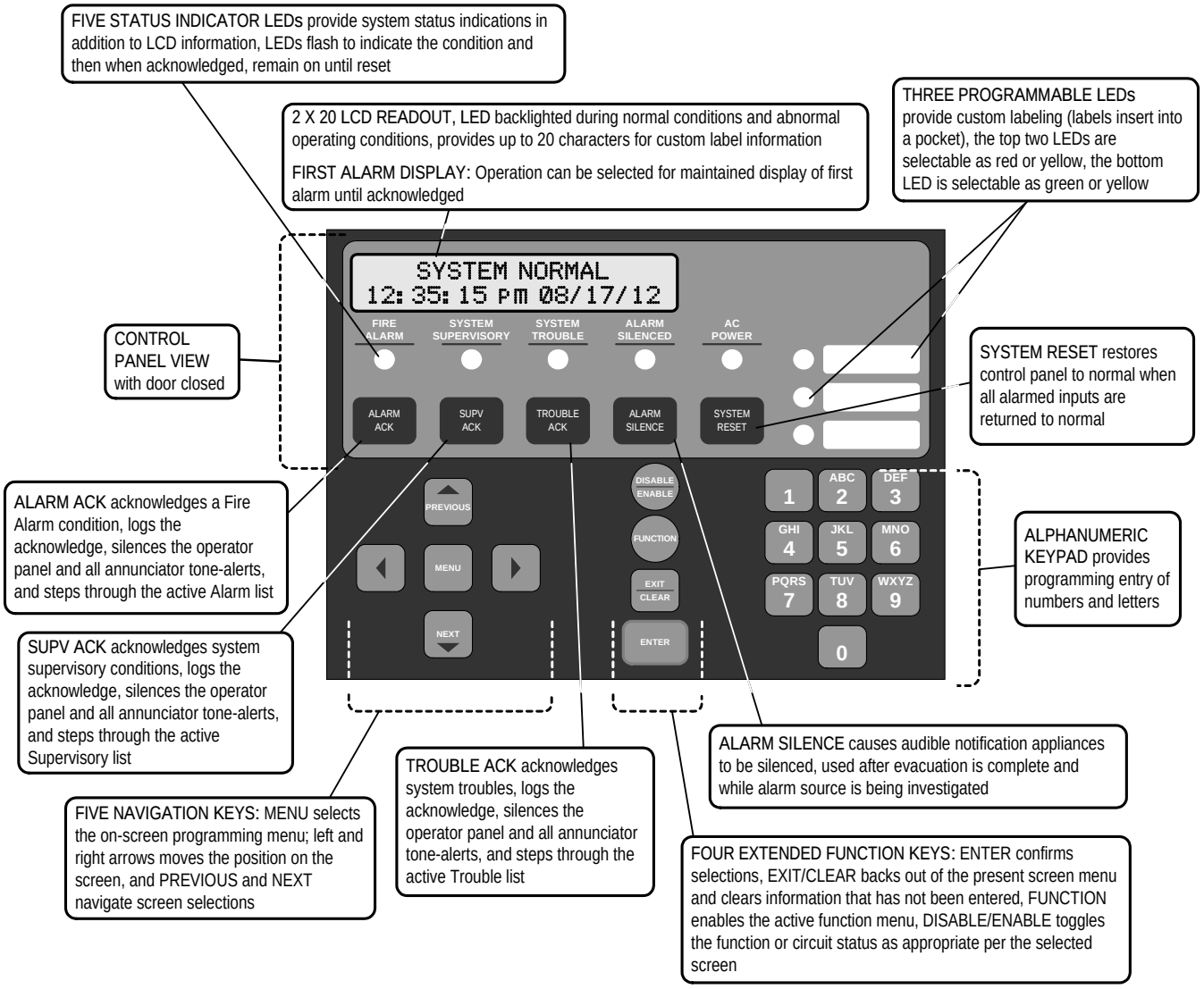
Accessories

Model	Description
2975-9811	Beige semi-flush trim kit; 1-7/16” (37 mm) wide; includes four corners and trim pieces for top, bottom, and sides
2975-9812	Red semi-flush trim kit; 1-7/16” (37 mm) wide; includes four corners and trim pieces for top, bottom, and sides
4009-9801	Beige External Battery Cabinet for up to 25 Ah batteries; mounts close-nippled to control panel cabinet; dimensions = 16-1/4” W x 13-1/2” H x 5-3/4” D (413 mm x 343 mm x 146 mm) [depth increased for 25 Ah effective 7/2005]

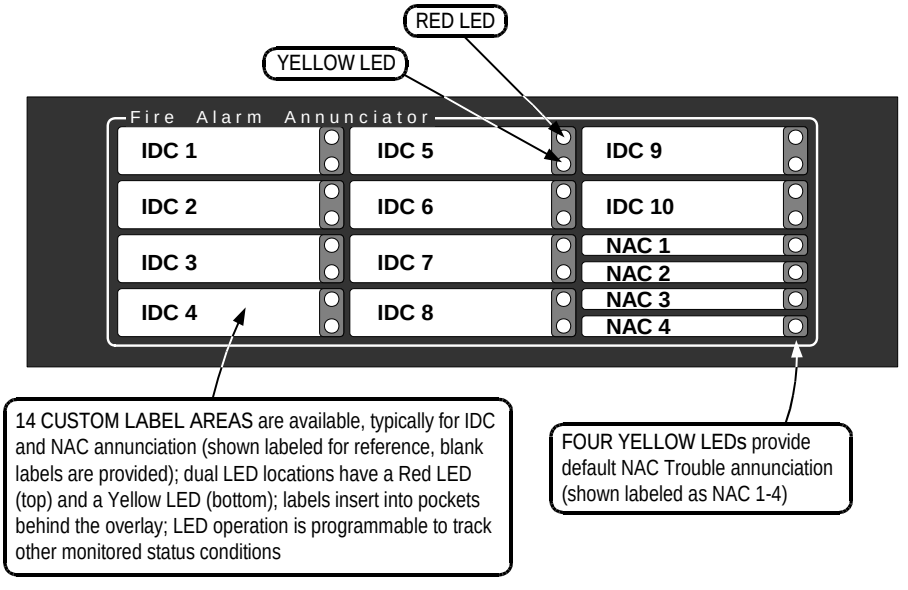
Batteries, 12 Volt (select one battery model per system standby requirements; order quantity of two)

Model	Size	Model	Size	Location	Model	Size	Location
2081-9272	6.2 Ah	2081-9288	12.7 Ah	For cabinet mount	2081-9275	18 Ah	Requires 4009-9801 External Battery Cabinet (UL listed only)
2081-9274	10 Ah				2081-9827	25 Ah	

Keyboard Reference



Door LED Annunciator Details



Specifications (Refer to Installation Instructions 579-704 for additional information)

Power Ratings			
AC Input Ratings	Input Voltage	120 VAC, 60 Hz; 220/230/240 VAC, 50/60 Hz, auto-select	
	Input Current, Standard	2 A maximum @ 120 VAC input; 1.5 A maximum @ 240 VAC input	
	Input Current with Expansion Power Supply	4 A maximum @ 120 VAC input; 3 A maximum @ 240 VAC input	
Power Supply Output Rating		3 A maximum @ 24 VDC in alarm (see NAC details on page 6)	
Battery Charger		Temperature compensated charger is rated for up to 25 Ah per UL 864; up to 12.7 Ah per ULC-S527	
Standby Current		130 mA; with 5 IDCs fully loaded, tone-alert silenced, trouble LED on	
Standard Circuit Ratings (NOTE: Total DC current = 3 A maximum)			
Notification Appliance Circuits (NACs) **NOTE:** See details on page 6		2 A maximum @ 24 VDC, per circuit; available as Class A or Class B; Class B end-of-line resistor = 10 kΩ, 1/2 W; Model 4081-9008 (P/N 733-894)	
Initiating Device Circuits (IDCs)	Supervisory Current	3 mA maximum	
	Alarm Current	60 mA maximum	
	Capacity	Each IDC supports up to 30 detectors (smoke or electronic heat) and manual stations as required; wiring distance is limited to 50 Ω maximum	
	End-of-Line Resistor	3.3 kΩ, 1/2 W; Model 4081-9002 (P/N 733-893) for Class B IDCs	
Annunciator Communications	Quantity Supported	Up to four annunciator modules per panel (see page 5 for details)	
	Wiring Type	Twisted pair, or twisted, shielded pair; 18 AWG (0.82 mm^2)	
	Bus-Style Wiring	Up to 4000 ft (1219 m); 0.58 µF (580 nF) maximum capacitance; 35 Ω max.	
	"T-Tap" Wiring	Up to 10,000 ft (3048 m) total wiring; up to 2500 ft (762 m) to farthest device	
	Line Matching Resistor	Bus-style, connect one at panel and one at end of line	100 Ω, 1/2 W; 4081-9011; (part number 733-974)
		T-Tap, connect one at panel and one at farthest device	
	Suppression	Use 2081-9044 Overvoltage Protectors where wiring leaves and enters a building (refer to data sheet S2081-0016)	
Auxiliary Power Output		500 mA maximum @ 24 VDC	
Standard Auxiliary Relay Outputs	Relay 1	Programmable operation	Contacts rated 2 A @ 30 VDC, 0.35 power factor; jumper selectable as N.O. or N.C.
	Relay 2	Trouble operation	
Wiring Connections for Above Circuits and AC Input		Terminals rated for 18 AWG to 12 AWG (0.82 mm^2 to 3.31 mm^2)	
Option Module Ratings			
Class A IDC Adapter Module		Five circuits per module, rated same as circuits	
Ten Relay Auxiliary Module 4006-9803	Contact Ratings	2 A @ 30 VDC, 0.35 power factor; jumper selectable as N.O. or N.C.	
	Wiring	Terminals rated for 18 AWG to 12 AWG (0.82 mm^2 to 3.31 mm^2)	
Environmental Ratings			
Operating Temperature Range		32° to 120°F (0° to 49° C)	
Operating Humidity Range		Up to 93% RH, non-condensing @ 100.4° F (38° C) maximum	

Reference Information, Compatible Simplex Peripherals

Compatible Simplex Detectors

Model	Type	Description		Data Sheet
4098-9601	Photoelectric smoke detectors for 2-wire and 4-wire bases	Standard detector (2.8% nominal)		S4098-0015
4098-9605		Reduced sensitivity detector (3.5% nominal)		
4098-9602		Combination smoke and heat detector		S4098-0017
4098 Series	Duct detector housings	2-wire and 4-wire models		S4098-0029
4098 Series	Ionization Smoke Detectors	2-wire and 4-wire models		S4098-0018
4098-9612	Electronic heat detectors for 2-wire and 4-wire bases	135° F (57°C)	Fixed temperature heat detector	S4098-0014
4098-9614		200° F (93°C)		
4098-9613		135° F (57°C)	Fixed temperature heat detector with rate-of-rise detection	
4098-9615		200° F (93°C)		

Compatible System Expansion Panels

Model	Type	Description	Data Sheet
4003 Series	Voice Control Panel	Provides a remote voice control panel with on-board NACs, internal microphone, and remote microphone input	S4003-0002
4009 Series	Remote NAC Extender	Provides remote NACs; includes power supply and battery charger; 4 extenders max/NAC; **4006 uses NAC output to provide control**	S4009-0002

Note: Contact your local Simplex Product Supplier for additional compatible peripherals.

Supervisory and Alarm Currents

Model	Module	Supervisory	Alarm
4006-9101 4006-9102	Standard fire alarm control panel	130 mA	160 mA + 60 mA per IDC in Alarm
4006-9121 4006-9122	Control panel with 24 LED Annunciator	148 mA	210 mA + 60 mA per IDC in Alarm
4006-9801	Expansion Power Supply	50 mA	60 mA
4006-9802	Expansion IDC Module	50 mA	50 mA + 60 mA per IDC in Alarm
4006-9803	Expansion Relay Module	0 mA + 10 mA per energized relay	0 mA + 10 mA per energized relay
4006-9804	Five Circuit IDC Class A Adapter	0 mA normal; 10 mA per IDC in trouble	0 mA normal; 10 mA per IDC in trouble
4006-9805	City Circuit Module with disconnect switch	30 mA	60 mA
4006-9806	City Circuit Module without disconnect switch	30 mA	60 mA
4606-9101	Remote LCD Annunciator (see data sheet S4606-0001)	65 mA	140 mA
4610-9111	Remote LED/Switch Annunciator (see data sheet S4610-0001)	40 mA	70 mA (all LEDs and tone-alert on)

**** Current Calculation Information:**

1. To determine total supervisory current, add currents of modules in panel to base system value **and** all auxiliary loads.
2. To determine total alarm current, add currents of modules in panel to base system alarm current **and** add all panel NAC loads **and** all auxiliary loads.

Remote Annunciator Options

The 4006 supports up to four annunciator options including:

- Door Mounted 24 LED Annunciator
- 4610-9111 Remote LED/Switch Annunciators
- 4606-9101 Remote LCD Annunciators

Annunciators communicate at a rate of 9600 baud with 24 VDC power supplied by separate wiring.

4610-9111 LED Annunciator Features:

- 16 LEDs with programmable functions and dedicated LEDs for Alarm Silenced, Lost Communications, Trouble, and Power-on
- Keyswitch access controlled switches for Acknowledge, Alarm Silence, Reset, and Lamp Test
- Local tone-alert

4606-9101 LCD Annunciator Features:

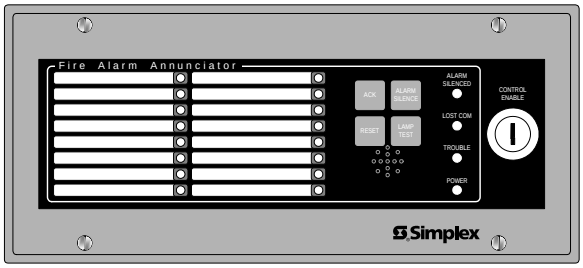
- LCD readout with two lines of 40 characters each and LED backlighting
- Wide viewing angle, super-twist design
- Keyswitch access controlled

Control switches and status LEDs for:

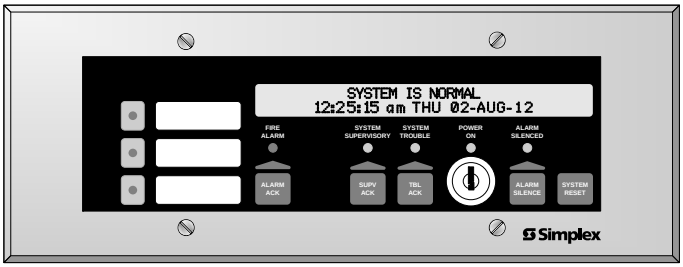
- Alarm, supervisory, or trouble acknowledge
- Alarm silence and System Reset

Three programmable LED indicators:

- Two LEDs are selectable as red or yellow
- One LED is selectable as green or yellow
- With provisions for custom labeling



4610-9111 LED/Switch Annunciator



4606-9101 LCD Annunciator

IDC Operation Modes

The following IDC operation modes are selectable from either the front panel or the PC programmer

Function Type	Description	Device State	IDC Status
FIRE	Fire monitor zone	Normal = Current Limited = Short = Open =	NORMAL FIRE FIRE TROUBLE
WATER	Waterflow monitor zone	Normal = Current Limited = Short = Open =	NORMAL FIRE FIRE TROUBLE
HEAT	Heat detector zone		
DUCT	Duct detector zone		
PULL	Manual (pull) station zone		
SMOKE	Smoke detector zone		
SO	Sprinkler Supervisory	Normal = Current Limited = Short = Open =	NORMAL SUPERVISORY SUPERVISORY TROUBLE
WSO	Combination waterflow and water supervisory zone	Normal = Current Limited = Short = Open =	NORMAL SUPERVISORY ALARM TROUBLE
SUPV	Supervisory monitor	Normal = Current Limited = Short = Open =	NORMAL SUPERVISORY SUPERVISORY TROUBLE
UTIL	Supervised utility monitor	Normal = Current Limited = Short = Open =	OFF ON ON TROUBLE
TROUBLE	Trouble monitor	Normal = Current Limited = Short = Open =	NORMAL TROUBLE TROUBLE TROUBLE
VSMOKE	Verified fire alarm; the abnormal (current limited) state causes the alarm verification cycle to start; a short is an immediate alarm	Normal = Current Limited = Short = Open =	NORMAL VERIFY FIRE TROUBLE
STYLEC	Style C fire monitor	Normal = Current Limited = Short = Open =	NORMAL FIRE TROUBLE TROUBLE
LATSUPV	Latching supervisory monitor (supervisory latches until system is reset)	Normal = Current Limited = Short = Open =	NORMAL SUPERVISORY SUPERVISORY TROUBLE

Detailed NAC Ratings

NAC Ratings, Maximum per NAC	Appliances
Special Application: 2 A; strobe synchronization is UL listed across all 4 system NACs for these 4906 Series appliances	Simplex 4901 Series (horns) and 4906 Series Multi-Candela non-addressable strobes, horn/strobes, and speaker/strobes (contact your Simplex product representative for compatible appliances)
Regulated 24 VDC: 1.5 A **NOTE:** Maximum strobe load on main power supply or expansion power supply is **1.35 A** per power supply (2.7 A total); remainder of power supply rating is available for other loading	Power for other UL listed appliances; use associated external synchronization modules where required

NAC Operation Modes

Function Type	Description
SSIG	Alarm signal, on until silenced
RSIG	Alarm signal, on until reset
TROUBLE	Trouble signal
SUPV	Supervisory signal
QALERT	SmartSync 2-wire horn/strobe control; horn on until silenced, strobe on until reset
WHEELOCK	Provides Wheelock strobe synch protocol when using only Wheelock strobes on panel, not to be mixed with Simplex strobes
UTILITY	Utility signal, generic non-alarm

Relay Operation Modes

The following relay operations are selectable from either the front panel or the PC programmer.

Common Fire Alarm Operations

Function Type	Relay Activates Upon	Relay Deactivates Upon
SRELAY	General Alarm	Silence
RRELAY	General Alarm	Reset
SUPV	Supervisory condition	Clear
TRBL	Trouble condition	Clear

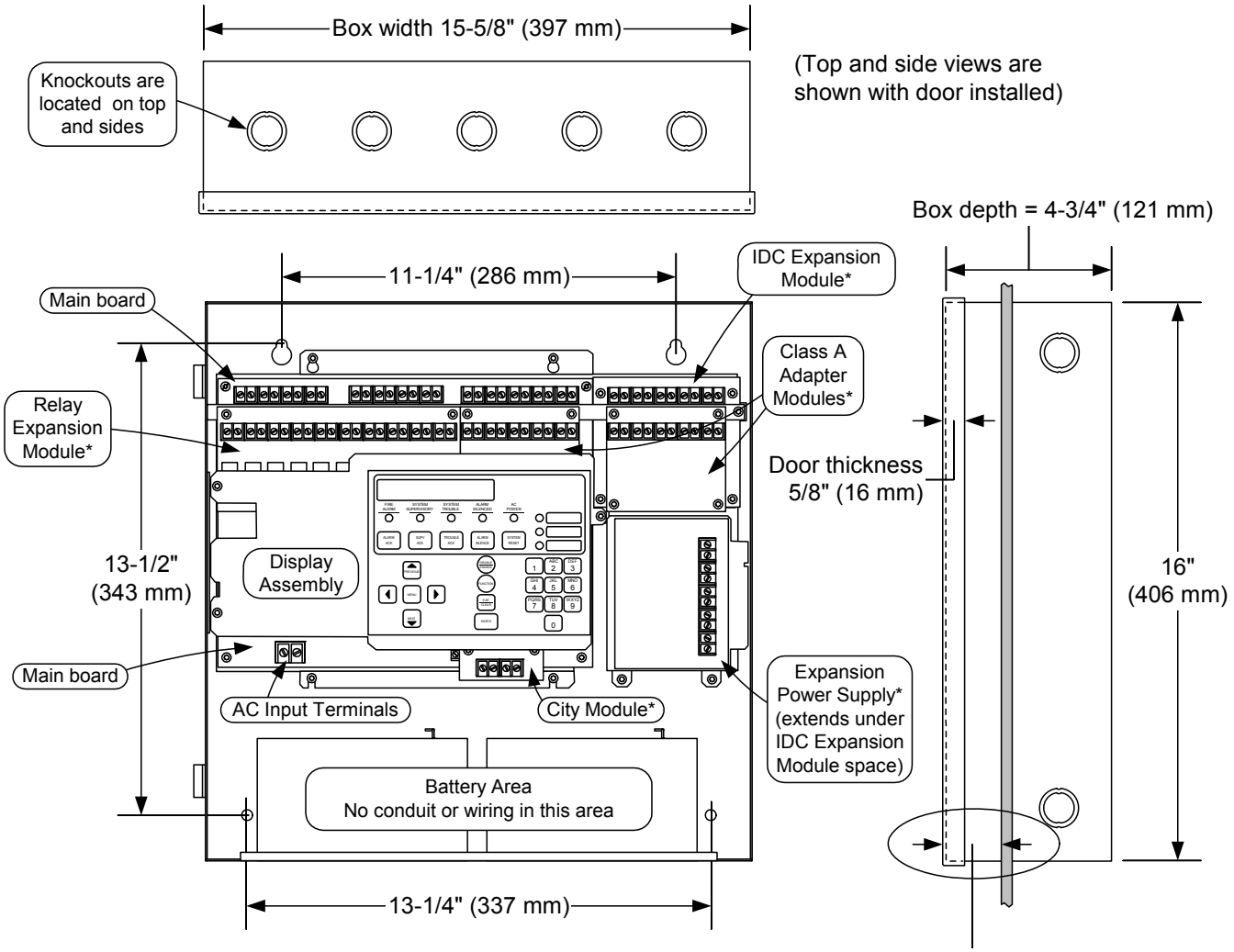
Special Functions

Function Type	Description
UTILITY	Utility IDC in the same alarm group activates
PRIMARY	General alarm; relay is tied to Primary Elevator Recall contacts
ALTERN	General alarm; relay is tied to Alternate Elevator Recall contacts
DRESET	Relay provides 24 VDC power to 4-wire detectors; relay turns off for 5 seconds on System Reset
DHOLDER	Relay provides 24 VDC to larger door holder relay with separate power source; relay activates on general alarm to remove power to door holder relay and close doors

Additional Programming Feature Details

<table>
<tr><th>Function</th><th colspan="9">Details</th></tr>
<tr><td>Custom labels</td><td colspan="9">Up to 20 characters per point; a built-in message library provides for commonly used words for easy front panel programming</td></tr>
<tr><td rowspan="2">Message Library</td><td colspan="9">For front panel label creation convenience, the following words can be selected as part of a custom label (_designates a built-in space; typing the first letter of a word/number will select the closest word in alphabetical/numerical sequence)</td></tr>
<tr><td>North
South
East
West
Front</td><td>Center
rear
5th
Flr_1
Flr_2</td><td>Flr_3
Flr_4
Flr_5
RM_</td><td>Basement
Floor
Garage
Hallway
HVAC_Room
Kitchen</td><td>Lobby
Office
Patient
upper
lower</td><td>main
first
2nd
3rd
4th</td><td>Boiler_RM
Classroom
Closet_
Corridor
Elect_RM</td><td>Elevator
Entrance
Restroom
Room
Stairway</td><td>Storeroom
Wing
Zone</td></tr>
<tr><td>History logs</td><td colspan="9">Three separate logs: Alarm (100 entries), Supervisory (100 entries), and Trouble (300 entries); logs can be queried separately, or as a combined log; logs can be downloaded for printing or archiving using the RS-232 service port</td></tr>
<tr><td>Autoprogram</td><td colspan="9">Automatically scans system for installed option modules and configures panel programming accordingly; modes are available to detect new modules only, recreate default programming and then add all modules found</td></tr>
<tr><td>Alarm Groups</td><td colspan="9">Up to 99 alarm groups are available, any point may be in up to 3 alarm groups; this allows NAC and relay operation to be associated with IDC inputs according to local response requirements</td></tr>
<tr><td>WALKTEST</td><td colspan="9">Allows one person to perform system testing; alarm or trouble tests are followed by automatic reset; the alarm zone is sounded out by associated audible notification or the response is silently logged into the Alarm log</td></tr>
<tr><td>Manual Control</td><td colspan="9">Allows selection of individual relays or NACs for system testing</td></tr>
<tr><td>Passcode Protection (4-digit number)</td><td colspan="9">Level 1 = Acknowledge, Silence, System Reset, View logs, View point information, and Lamp Test
Level 2 = All Level 1 + Set Time/Date, Point Control, Enable/Disable points
Level 3 = All Level 2 + Clear logs, Clear verification tallies, Custom label editing, and WALKTEST
Level 4 = All Level 3 + Programming, Upload/Download; this is the Service access level</td></tr>
</table>

Installation and Module Placement Reference



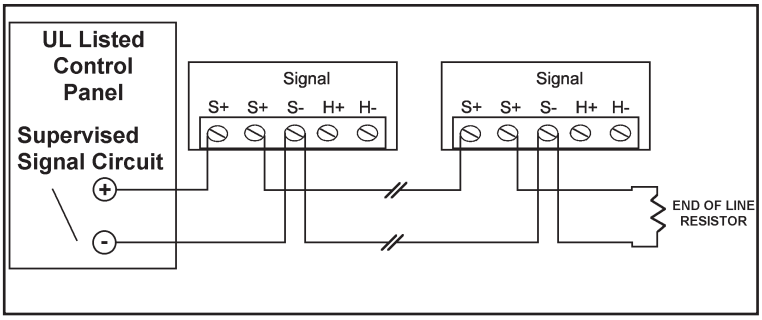
* Indicates optional modules

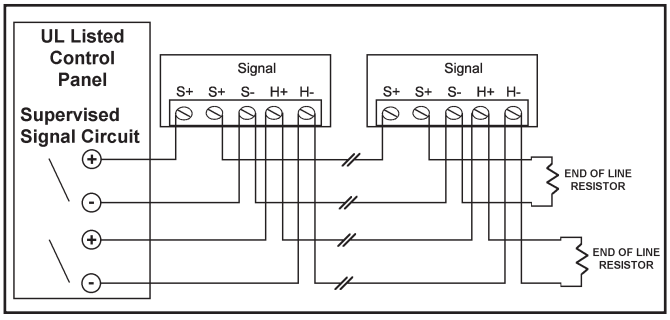
NOTE: For semi-flush mounting, cabinet must extend 1-1/2" (38 mm) minimum from wall surface

Manual Pull Station

GEC/GES/GEH 24 VDC SERIES

Conventional GES/GEC Series Wiring Diagrams





NOTES:

- All strobes are designed to flash as specified with continuous applied voltage. Strobes should not be used on coded or pulsing signaling circuits. However, use of the Gentex AVSM control module or Gentex synchronization protocol is permitted to synchronize the strobe, horn and/or mute the horn. See Technical Bulletin 014 for additional information.
- **FOR SYNCHRONIZATION WIRING INFORMATION, REFERENCE AVSM CONTROL MODULE DATA SHEET (551-0031) AND/OR AVSM CONTROL MODULE MANUAL (550-0284) FOR SYNCHRONIZATION MODULE WIRING DIAGRAMS. AVSM CONTROL MODULE DATA SHEET AND MANUAL CAN BE OBTAINED AT http://www.gentex.com OR CALL GENTEX CORPORATION AT 1-800-436-8391.**
- **When synchronizing the GEH 12VDC Series, the Gentex AVSM control module or Gentex synchronization protocol MUST be used.**

Architect & Engineering Specifications

The audible and/or visible signal shall be Gentex GE Series or approved equal and shall be listed by Underwriters Laboratories Inc. per ANSI/UL 1971, ANSI/UL 1638 and/or ANSI/UL 464. The notification appliance shall also be listed with the California State Fire Marshal (CSFM) and the Bureau of Standards and Appeals (NYC).

The notification appliance (combination audible/visible and audible units only) shall produce a peak sound output of 100dBA or greater at 12VDC or 24VDC as measured in an anechoic chamber. The signaling appliance shall also have the capability to silence the audible signal while leaving the visible signal energized with the use of a single pair of power wires. Additionally, the user shall be able to select either continuous or temporal tone output with the temporal signal having the ability to be synchronized.

The audible/visible and visible signaling appliance shall also maintain a minimum flash rate of 1Hz or up to 2Hz regardless of power input voltage. The appliance shall also be capable of meeting the candela requirements of the ADA (75Cd) for the combination listed (UL 1971/UL 1638) listed models. The appliance shall have an operating current of 67mA or less at 24 VDC for the 15/75Cd for the strobe circuit.

The appliance shall be polarized to allow for electrical supervision of the system wiring. The unit shall be provided with a mounting bracket with terminals with barriers for input/output wiring and be able to mount to a single gang or double gang box or double workbox without the use of an adapter plate. The unit shall have an input voltage range of 16-33 volts with either direct current of full wave rectified power.

The appliance shall be capable of test supervision without disconnecting wires, verify voltage without removing unit and be capable of mounting to a surface back box.

24 units per carton
27 pounds per carton

GENTEX CORPORATION
Fire Protection Products Group • www.gentex.com
10985 Chicago Drive • Zeeland, Michigan 49464
616.392.7195 • 1.800.436.8391 • 616.392.4219 Fax

551-0049-02

Simplex

Multi-Application Peripherals

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

Non-Coded, Non-Addressable Manual Stations; 2099 Series Single and Double Action Operation

Features

Manual fire alarm stations for general purpose applications:

- Operation complies with ADA requirements
- Pull lever protrudes when alarmed
- Break-rod is supplied (use is optional)
- Screw terminals for wiring connections
- Tamper resistant reset key lock (keyed same as Simplex® fire alarm cabinets)

Operation types include:

- Single action
- Double Action, Breakglass or Push Type
- Institutional Model, key operated only
- Optional NO GRIP Single Action Retrofit Kits are available with a more easily operated pull lever for applications where anticipated users may find the standard station lever difficult to activate
- Optional Local Alarm cover
- Optional pre-signal and annunciator contacts

Multiple mounting options:

- Surface or semi-flush with standard boxes or matching Simplex boxes
- Flush mount adapter kit

UL listed to Standard 38

Operation

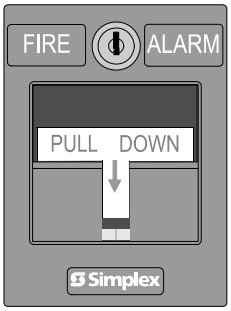
Activation of the Simplex single action manual stations requires a firm downward pull to activate the alarm switch. Completing the action breaks an internal plastic break-rod (visible below the pull lever, use is optional). The use of a break-rod can be a deterrent to vandalism without interfering with 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.

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.

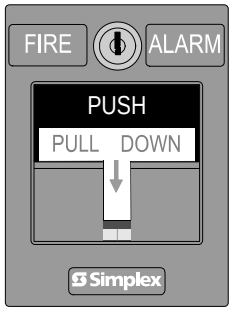
Double Action Stations (Push Type) require that a spring loaded interference plate (marked PUSH) be pushed back to access the pull lever of the single action station.

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.)

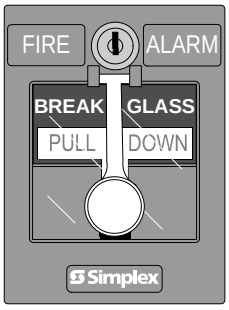
Station testing is performed by physical activation of the pull lever. Electrical testing can be also performed by unlocking the station housing to activate the alarm switch.



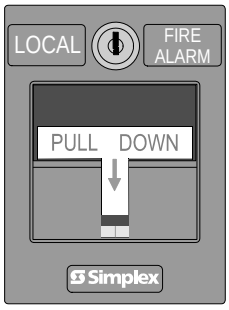
Single Action Station



Double Action Station (Push Type)

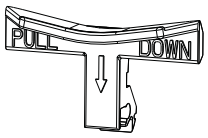


Double Action Station (Breakglass)



Local Fire Alarm Cover Option

Single Action Station with Institutional Cover



4099-9805 NO GRIP Retrofit kit

Operation *(Continued)*

Institutional Stations activate by key operation only allowing access for manual alarms to be initiated by authorized personnel. Operation requires key insertion and opening of the station cover.

Single Action Station NO GRIP Retrofit Kit 4099-9805. 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 4099-9805 Retrofit kit provides a more easily operated pull lever compared to standard stations.

* Refer to page 2 for models with MEA acceptance. 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 7150-0026:175 (Pull Boxes) and 7150-0026:0224 (NO GRIP Retrofit Kit) for allowable values and/or conditions concerning material presented in this document. It is subject to re-examination, revision, and possible cancellation. 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.

Operation *(Continued)*

Pre-Signal Option activates when the lever is pulled. General alarm initiation requires a key to activate a keyswitch located behind the pull lever.

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.

Testing requires physical activation of the pull lever (except for institutional stations).

Application Reference

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

Application Reference *(Continued)*

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.

Product Selection

Single Action Models (General Alarm)

Model	MEA	Pre-Signal	Annunciator Contacts, N.O.	Annunciator Contacts, N.C.	Local Alarm Cover	Institutional Cover	Mounting Notes
2099-9754	✓						1
2099-9101	✓		✓				2
2099-9102	✓			✓			
2099-9107		✓	✓				
2099-9755	✓				✓		1
2099-9762	✓					✓	1

Double Action Models (General Alarm)

Model	MEA	Break-Glass	Push	Pre-Signal	Annunciator Contacts N.O.	Annunciator Contacts N.C.	Mounting Notes
2099-9103	✓	✓					1
2099-9104	✓	✓			✓		2
2099-9105	✓	✓				✓	
2099-9108		✓		✓	✓		
2099-9756	✓		✓				1
2099-9757	✓		✓		✓		2
2099-9758	✓		✓			✓	
2099-9759			✓	✓	✓		

Accessories

Model	Description
4099-9805	Retrofit Kit for field conversion of a single action station to a NO GRIP station; (reference Instructions 579-1007)
2099-9803	Replacement breakglass (standard, English)
2099-9804	Replacement break-rod
2099-9819	Flush adapter kit, black (refer to page 4)
2099-9820	Flush adapter kit, beige (refer to page 4)
2099-9822	Replacement retaining clip for breakglass
2099-9828	Institutional cover kit
2975-9178	Red, surface mount box, sheet metal, 5-3/16” H x 4” W x 2-3/16” D (127 mm x 102 mm x 56 mm)
2975-9022	Red, cast aluminum surface mount box, 5” H x 3-7/8” W x 2-3/16” D (127 mm x 98 mm x 56 mm)

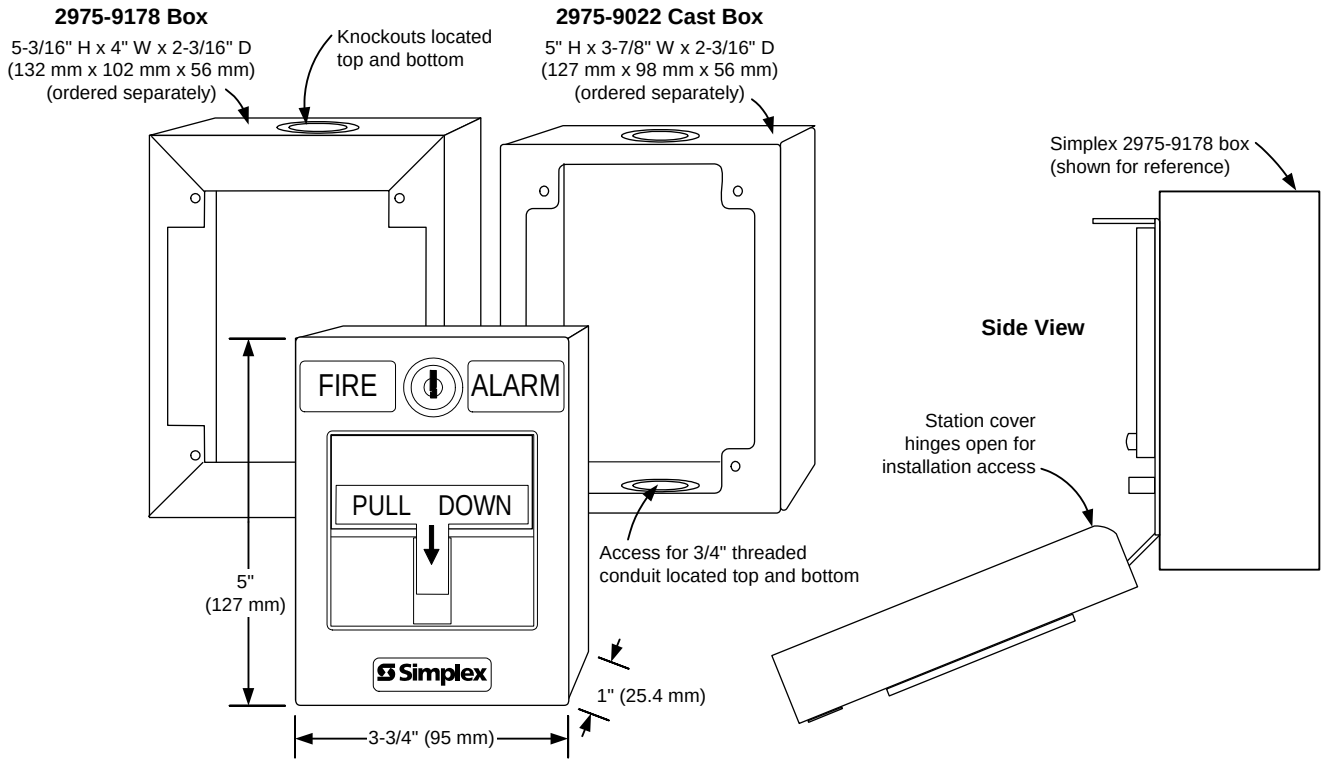
Notes:

1. These models can be semi-flush mounted using a standard single gang 2-1/2” (64 mm) deep switch box. DO NOT RECESS BOX, mount box flush or with 1/16” (2 mm) maximum protrusion. These models can also be surface mounted on a Wiremold box model number V5744S, 4-5/8” H x 2-7/8” W x 2-1/4” D (117 mm x 73 mm x 57 mm).
2. For surface mount, these models require 2975-9178 or 2099-9022 boxes. For semi-flush mount, these models require a 4” (102 mm) square box with a single gang cover plate (see diagram on page 3).

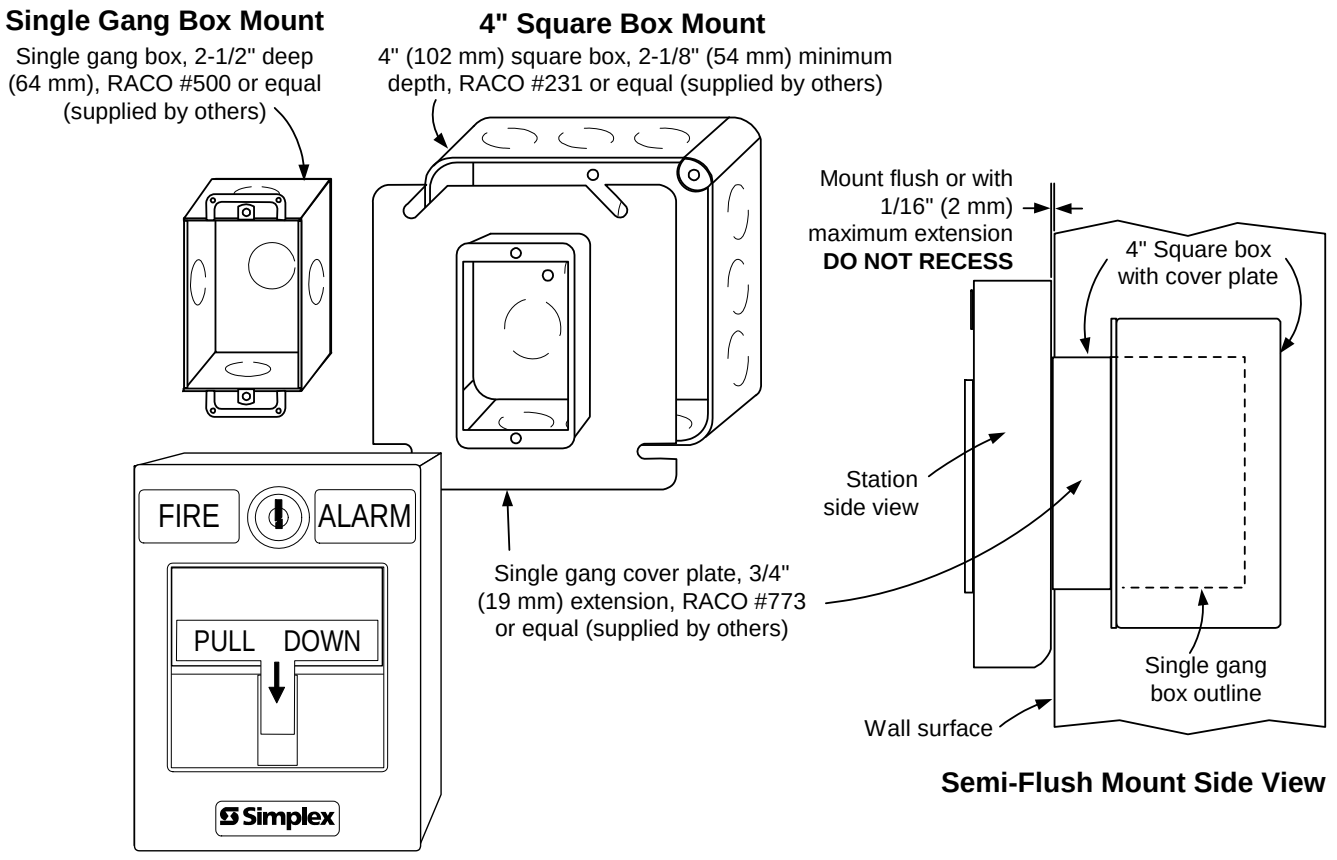
Additional Manual Station Reference

Non-Addressable Manual Stations	Data Sheet	Addressable Manual Stations	Data Sheet
Releasing Stations	S2099-0010	Standard Addressable	S4099-0001
Stations for hazardous locations (Ring-Pull)	S2099-0008	Addressable for Releasing	S4099-0002
Metal housing and explosion-proof/weather-proof stations (T-Handle)	S2099-0009	Wire Guard (addr./non-addr.)	S2099-0004

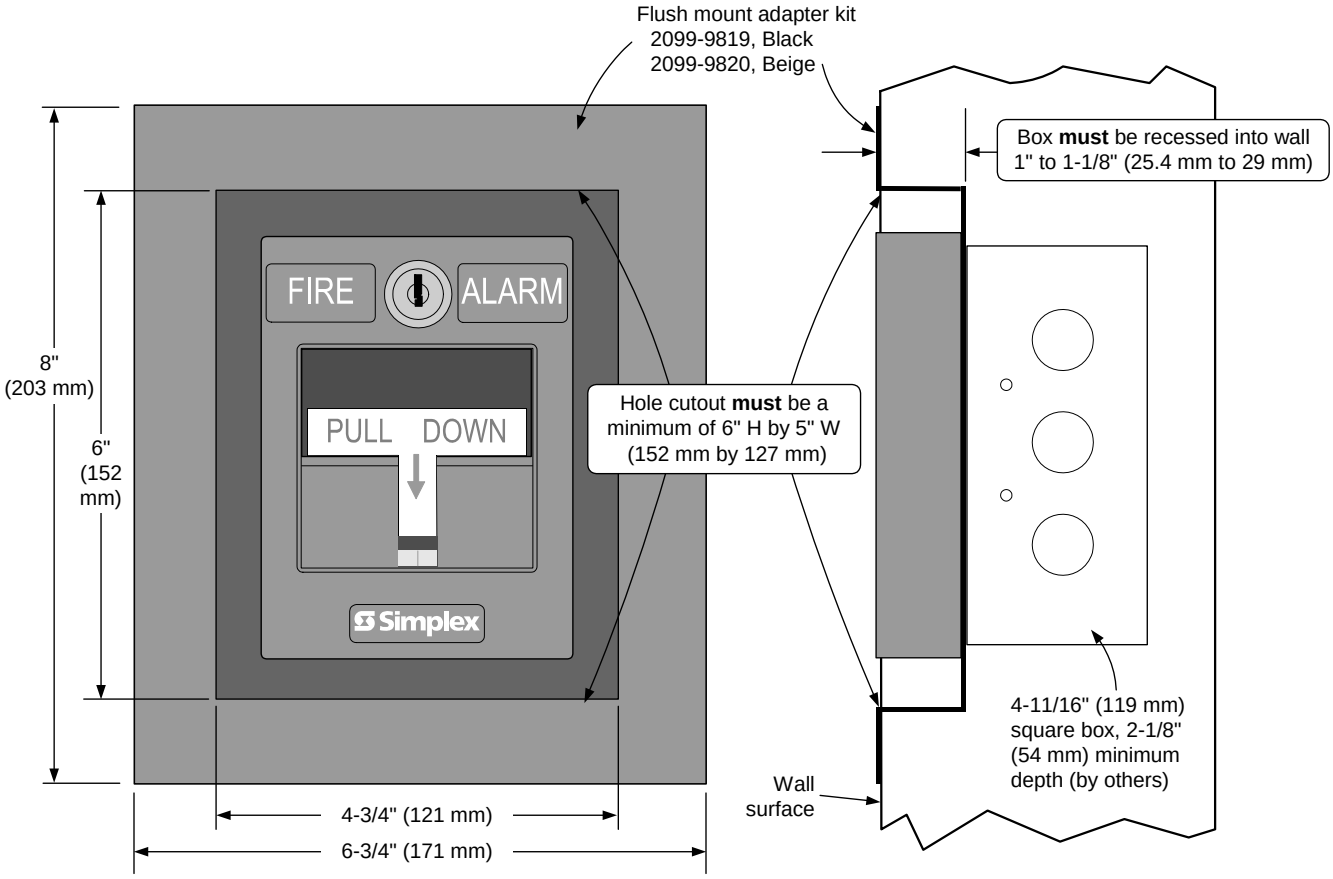
Surface Mounting Reference



Semi-Flush Mounting Reference



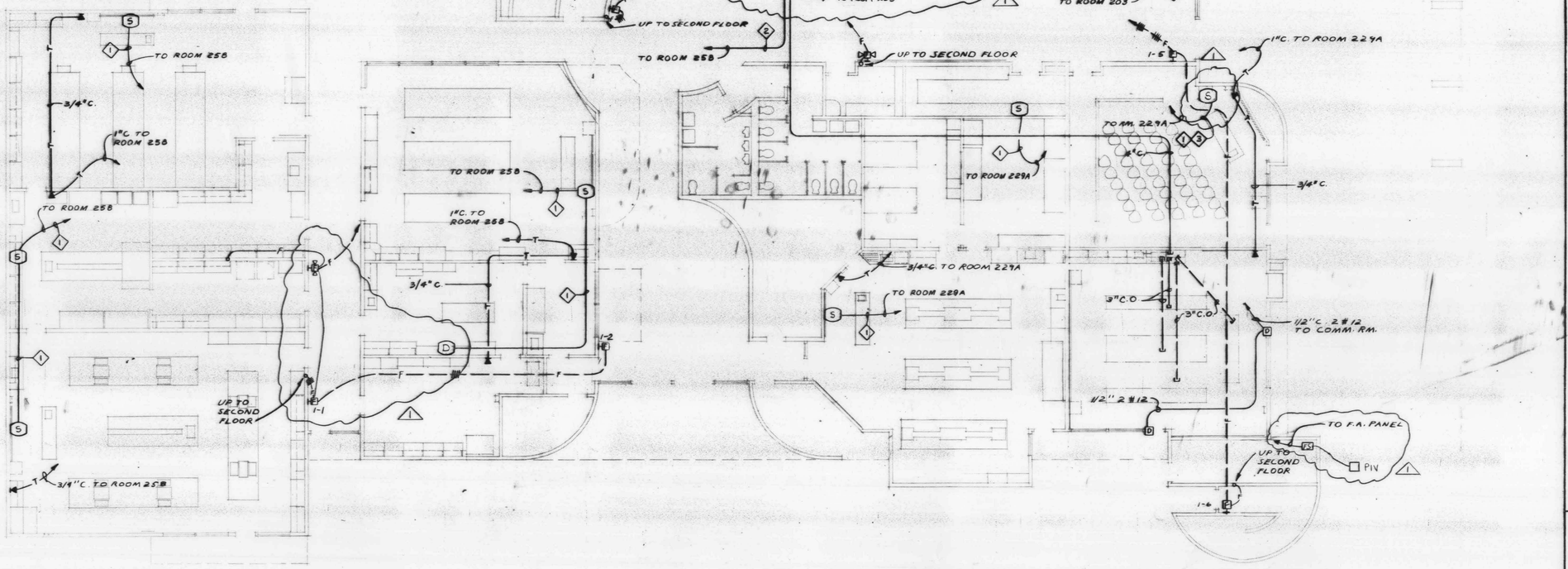
Flush Mount Reference



Specifications

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 high impact polycarbonate
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)

Appendix D: Original Fire Alarm Plans

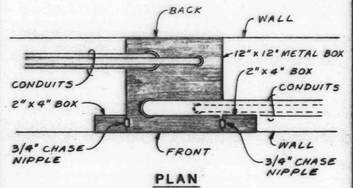


FIRST FLOOR SIGNAL PLAN

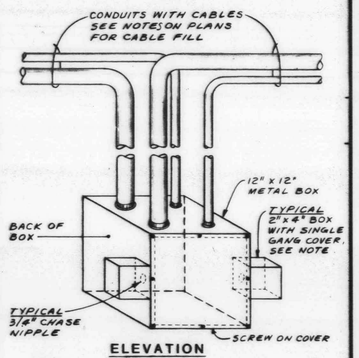
1/8"=1'-0"

SHEET NOTES:

1. 1-2" CONDUIT WITH: 1-HOME RUN IEEE 802.3 FROM EACH ROOM.
   1-LOOPED DIW-50.
   2-LOOPED RG-6 COAX CABLES.
   1-3/4" CONDUIT WITH: 1-HOME RUN KIW-4 FROM EACH ROOM.
2. 4-4" CONDUIT ONLY HOME RUN TO COMMUNICATIONS ROOM 101 ON FIRST FLOOR.
3. 2-3" CONDUITS ONLY.
4. LINE WALLS OF COMMUNICATIONS ROOM WITH 3/4" PLYWOOD BACKBOARD - FLOOR TO CEILING.



PLAN

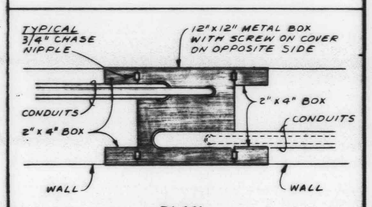


ELEVATION

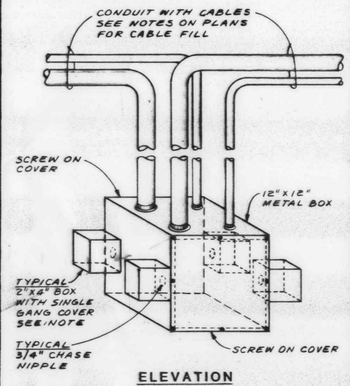
NOTE:
2" X 4" BOXES SHALL BE SO MOUNTED SUCH THAT SINGLE GANG COVERS CAN BE INSTALLED.

A / E-10 **ONE ROOM SERVICE BOX**

N.T.S. (SYMBOL (S) ON PLANS)



PLAN

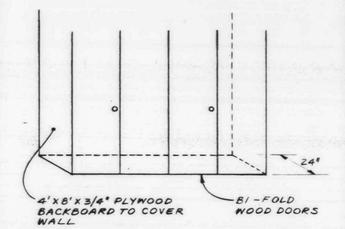


ELEVATION

NOTE
2" X 4" BOXES SHALL BE SO MOUNTED SUCH THAT SINGLE GANG COVERS CAN BE INSTALLED.

B / E-10 **TWO ROOM SERVICE BOX**

N.T.S. (SYMBOL (D) ON PLANS)



C / E-10 **BACKBOARD**

N.T.S.

011 E10 Of 17 1st Floor Signal Plan 1985-12-09

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Project Office 1129 Marsh Street San Luis Obispo, California 93401 805 543 6482

AGRICULTURE SCIENCE BUILDING
CALIFORNIA POLYTECHNIC STATE UNIVERSITY
SAN LUIS OBISPO, CALIFORNIA

JACK D. TODD, INC
ELECTRICAL ENGINEER
SAN JOSE CALIFORNIA, JOB NO. 8525
EE 5526 PROJECT 84078

FIRST FLOOR SIGNAL PLAN

APPROVED

DRAWN LTD	CHECKED JDT
DATE 12- 9-85	

RECORD DRWG
10-18-88

JOB NO. 8525

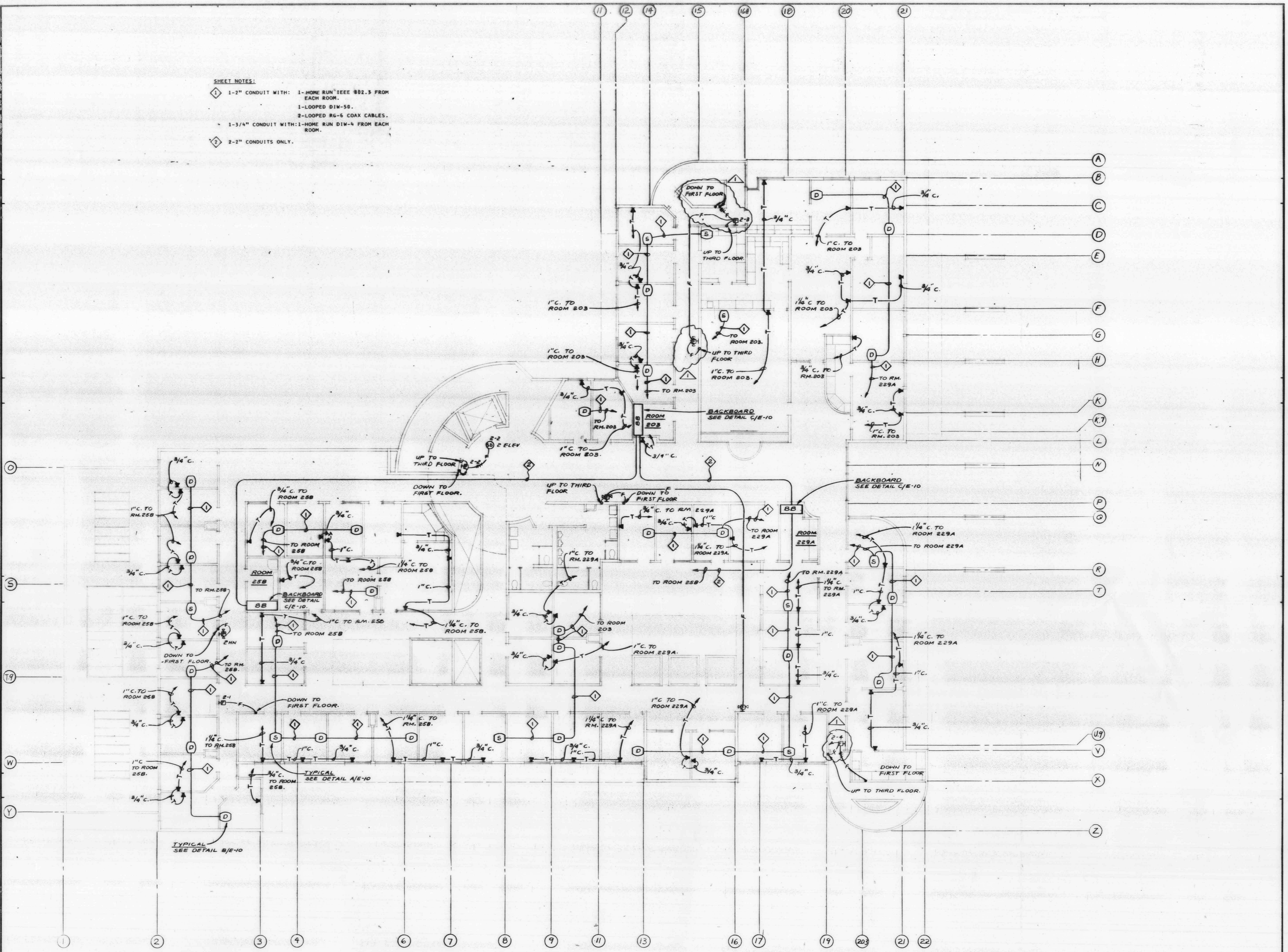
E-10

OF 17 SHEETS

SHEET NOTES:

<1> 1-2" CONDUIT WITH: 1-HOME RUN IEEE 802.3 FROM EACH ROOM.
1-LOOPED DIW-50.
2-LOOPED RG-6 COAX CABLES.
1-3/4" CONDUIT WITH: 1-HOME RUN DIW-4 FROM EACH ROOM.

<2> 2-2" CONDUITS ONLY.



SECOND FLOOR SIGNAL PLAN

1/8" = 1'-0"

SCARAB GRAPHICS NO. 93244

011 E11 Of 17 2nd Floor Signal Plan 1985-12-09

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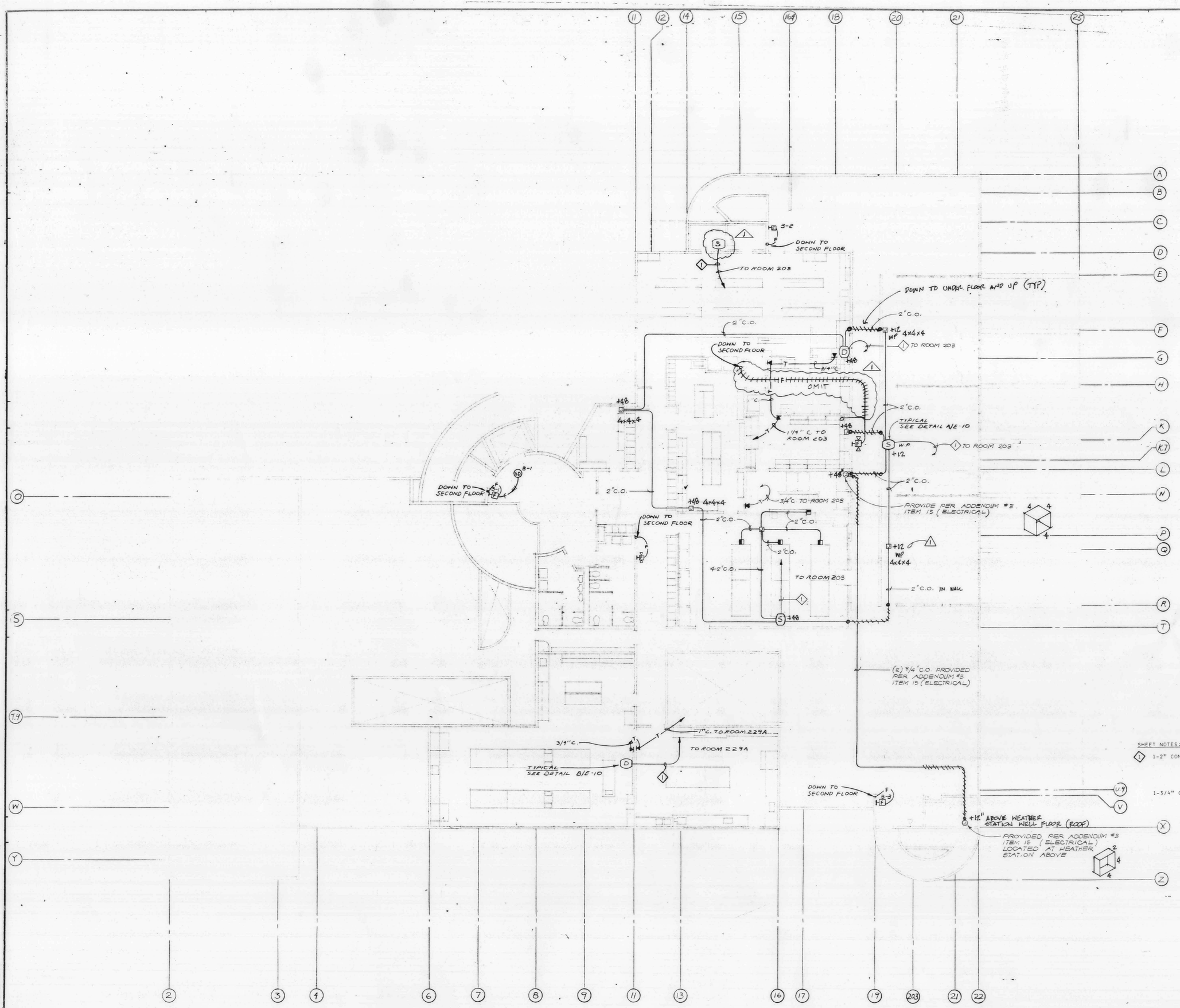
SAN LUIS OBISPO, CALIFORNIA

JACK D. TODD INC
ELECTRICAL ENGINEER
SAN JOSE CALIFORNIA 298 4926
PROJECT 84076

SECOND FLOOR SIGNAL PLAN

APPROVED

DRAWN BH	CHECKED JDT
DATE 12-9-85	
RECORD DRWG 10-18-88	
JOB NO. 8425	
E-11	
OF 17	SHEETS



SHEET NOTES:

1. 1-2" CONDUIT WITH: 1-HOME RUN IEEE 802.3 FROM EACH ROOM.
   1-LOOPED K1W-50
   2-LOOPED RG-6 COAX CABLES.
   1-3/4" CONDUIT WITH: 1-HOME RUN D1W-4 FROM EACH ROOM.

THIRD FLOOR SIGNAL PLAN

1/8"= 1'-0"

△1 DATE: 2/20/87
BY: F.M.

011 E12 Of 17 3rd Floor Signal Plan 1985-12-09

SCARAB GRAPHICS NO. 83244

VENTURE ARCHITECTS
Ross Levin & Macintyre Architects and Maul-Stewart Associates, Inc. A Joint Venture
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AGRICULTURE SCIENCE BUILDING

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SAN LUIS OBISPO, CALIFORNIA

JACK D TODD, INC.
ELECTRICAL ENGINEER
SAN JOSE CALIFORNIA EN 4626
EE 5618 PROJECT 84078

THIRD FLOOR SIGNAL PLAN

APPROVED

DRAWN BH CHECKED JDT
DATE 2-9-85
△1 2-20-87
RECORD DRWG
△2 10-18-88

JOB NO. 8425

E-12

OF SHEETS

EQUIPMENT - POWER SCHEDULE

NOTE 1

ITEM NO.	APPR. QTY.	DESCRIPTION	HP	KVA	AMPS	VOLTS	φ	W	REMARKS
37	1	GLASSWARE WASHER / DRYER	—	—	20	120	1	2	
41	1	AUTOCLAVE							
44	1	GROWTH CHAMBER	—	—	70	208/120	3	4	
53	1	FLOWHOOD	—	—	7.1		1	3	
54	1	FLOWHOOD	—	—	13.9		1	3	
55	1	FLOWHOOD	—	—	7.7		1	3	
71	1	REFRIGERATOR	—	—	11.2	120	1	2	
89	2	FUME HOOD	1HP			208/120	1	2	FOUR 120V REC. 2 LAMPS FIXT. TWO 208V REC. FAN SW
93	1	REFRIGERATOR	—	—	—	120	1	2	
94	1	FREEZER	—	—	—	120	1	2	
103	1	ICE MACHINE			8.6	120	1	2	
104	6	GROWTH CHAMBER		.75KW		120	1	2	
106	1	DISTILLER		1KW		120	1	2	
107	1	GROWTH CHAMBER		3.5KW		208/120	3	4	
108	2	GROWTH CHAMBER		6KW		208/120	3	4	30A. ₵
109	1	DEMINERALIZER							
127		OVEN			30	208	3	4	
157	1	REFRIGERATOR							
158	3	LIGHT TABLE							
159	1	REFRIGERATOR							
AH-1	1	AIR HANDLING UNIT	10			208	3	3	
AH-2	1		15						
AH-3	1		10						
RF-1	1	RETURN FAN	5			208	3	3	
RF-2	1		7 1/2						
RF-3	1		5						
HEF-1	1	HOOD EXHAUST FAN	1/2			208	3	3	
HEF-2	1		3/4						
HEF-3	1		3/4						
HEF-4	1		1/2						
HEF-5	1		1/2						
HEF-6	1		1/2						
HEF-7	1		1/2						
HEF-8	1		1/2						
HSF-1	1	HOOD SUPPLY FAN	1/2						
HSF-2	1		1/2						
HSF-3	1		1/2						
HSF-4	1		1/2						
HSF-5	1		1/2						
HSF-6	1		1/2						
EF-1	1	ROOF EXHAUST FAN	3/4			208	3	3	
EF-2	1		25M			120	1	2	
EF-3	1		1 1/2			208	3	3	
EF-4	1		3/4			208	3	3	
EF-5	1		1/2			208	3	3	
SP-1	1	SOLAR PUMP	1/4			120	1	2	
HX-1	1	PACKAGED HEAT EXCHANGER	TWO 3			208	3	3	ONE PUMP IS STANDBY
HHWP-1	1	HEATING HOT WATER PUMP	3/4			208	3	3	
HHWP-2	1		3/4						
HHWP-3	1		3/4						
HHWP-4	1		3/4						
HHWP-5 (1)	1		1/3						
AC-1	1	AIR CONDITIONER			30.5	208	3	3	COMP=21.7 AMPS, INDOOR FAN=3/4HP OUTDOOR FAN=1 1/2HP.
ACP-1	1	AIR COMPRESSOR	7 1/2			208	3	3	
VP-1	1	VACUUM PUMP	1 1/2			208	3	3	

NOTES: 1. ITEM NUMBERS CORRESPOND TO EQUIPMENT SCHEDULE NUMBER ON THE ARCHITECTURAL DRAWINGS.

PANEL SCHEDULE: "3C"

MAIN BUS: 225 AMP 208Y/120 VOLT 3 φ 4 W
TYPE NQ08 TRIM SURFACE

CIR. No	BKR. AMP	BKR. POLE	No OF OUTLETS LTG.	REC.	MISC.	TYPE OF LOAD AND LOCATION	VOLT — AMPS "A"	"B"	"C"
1				4		REC. 307, 308	800		
3	20	3		4		307, 310, 315		800	
5				3		307, 309			600
2				3		306, 307	600		
4	20	3		4				800	
6				4					800
7				4		307	800		
9	20	3		4				800	
11				4					800
8				4		306	800		
10	20	3		4				800	
12				4					800
13				1		FUME HOOD 306	100		
15	20	3		2				400	
17				2					400
14	20	2		1			1000		
16								1000	
18	20	2		1					1000
19	20	2		1		REC. 307	1000		
21								1000	
23	20	2		1					1000
20	–	–				(PART OF ₵ 18)	1000		
22	20	2		1		FUME HOOD 307		1000	
24									1000
25	–	–				(PART OF ₵ 23)	1000		
27	20	2		1		FUME HOOD 307		1000	
29									1000
26	20	2		1			1000		
28								1000	
30	20	2		1					1000
31				4			800		
33	20	3	2					200	
35				4					800
32	–	–				(PART OF ₵ 30)	1000		
34	20	1				SPARE		1000	
36									1000
37						TABLE RM 307	1000		
39						SPARE		1000	
41									1000
38						SPACE			
40									
42									
TOTAL VOLT-AMPS PER PHASE							10900	10800	11200

TOTAL LOAD 33 KVA. MAX. φ = 93 AMPS
MAIN BREAKER: FRAME — TRIP LUGS ONLY

PANEL SCHEDULE: "3B"

MAIN BUS: 225 AMP 208Y/120 VOLT 3 φ 4 W
TYPE NQOB TRIM FLUSH

CIR. No	BKR. AMP	BKR. POLE	No OF OUTLETS LTG.	REC.	MISC.	TYPE OF LOAD AND LOCATION	VOLT — AMPS "A"	"B"	"C"
1				3		REC. 303, 304	600		
3	20	3		3				600	
5				3					600
2				5		304, 304B	1000		
4	20	3		1				1000	
6				1					1000
7				1			1000		
9	20	3		1				1000	
11				5					1000
8				1		304	1000		
10	20	3		1				1000	
12				1					1000
13				4			800		
15	20	3		4				800	
17				4					800
14				4		305A, 305B	800		
16	20	3		4				800	
18				4					800
19				4		305B, 305C	800		
21	20	3		4				800	
23				4					800
20	20	2		1			1000		
22								1000	
24	20	2		1					1000
25						COLD RM. COMP. UNIT	650		
27	15	3						650	
29									650
26	–	–				(PART OF ₵ 24)	1000		
28	20	1				COLD RM. BLOWER		450	
30						EXH. FAN			600
31						DRY ROOM COMP. UNIT	1000		
33								1000	
35									1000
32						GREENHOUSE SHADES 305C			
34						SPACE			
36									
37									
39									
41									
38									
40									
42									
TOTAL VOLT-AMPS PER PHASE							9650	9000	9250

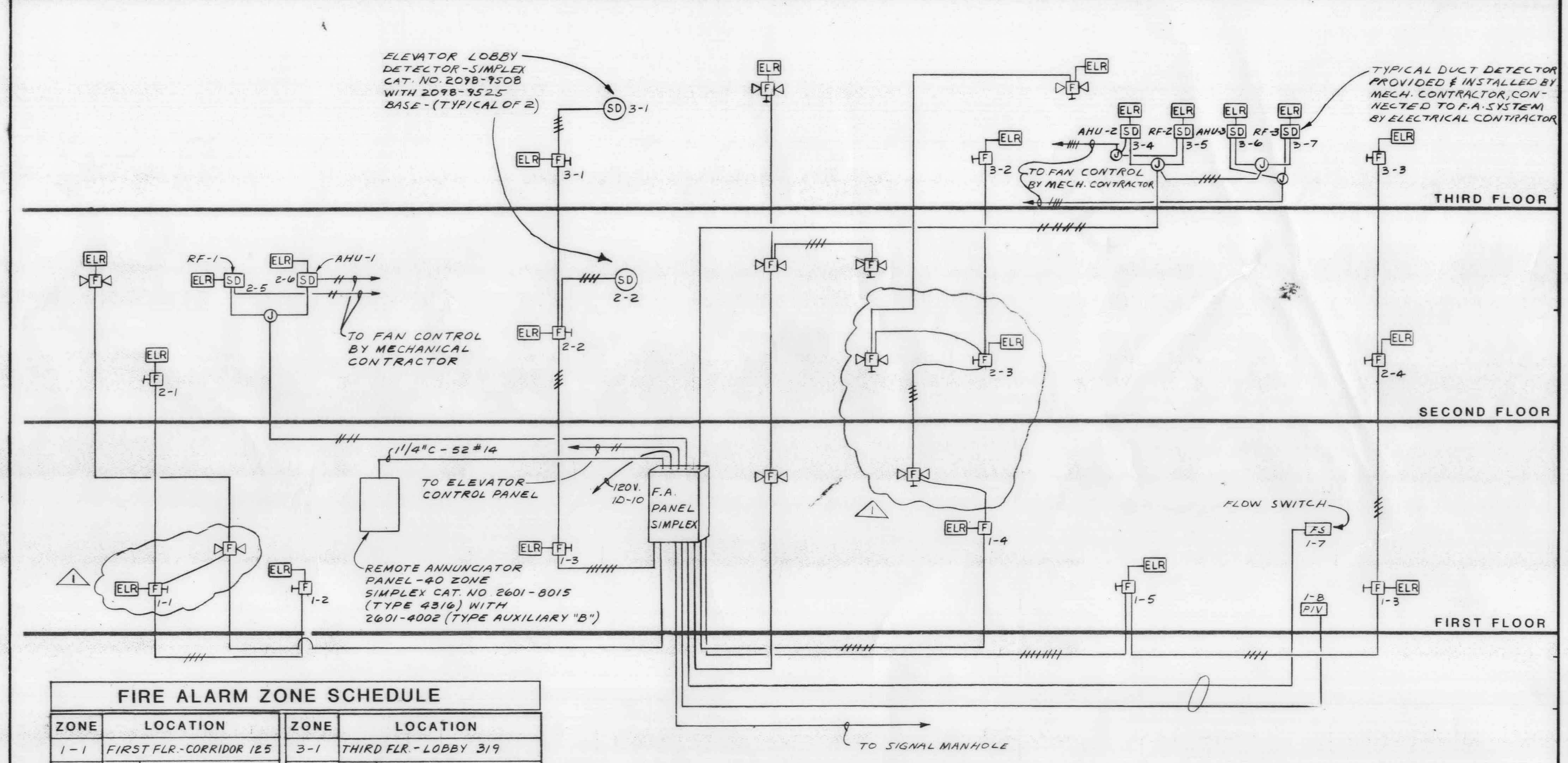
TOTAL LOAD 28 KVA. MAX. φ = 80 AMPS
MAIN BREAKER: FRAME — TRIP LUGS ONLY

PANEL SCHEDULE: "3A"

MAIN BUS: 225 AMP 208Y/120 VOLT 3 φ 4 W
TYPE NQOB TRIM FLUSH

CIR. No	BKR. AMP	BKR. POLE	No OF OUTLETS LTG.	REC.	MISC.	TYPE OF LOAD AND LOCATION	VOLT — AMPS "A"	"B"	"C"
1				1		REC. 302A	1000		
3	20	3		1		302B		1000	
5				5		302, 321			1000
2				5		302	1000		
4	20	3		4				800	
6				4					800
7				4			800		
9	20	3		5				1000	
11				4					1000
8				4		304A, 302, 304B	800		
10	20	3		4				800	
12				5					1000
13				5		302, 316, 317	1000		
15	20	3		5		301, 302, 303		1000	
17				1		DRINKING FOUNT.			800
14	30	2			1	OVEN	2800		
16								2800	
18	30	2			1	OVEN			2800
19	20	2		1		REC. 302	1000		
21								1000	
23	20	2		1					1000
20	–	–				(PART OF ₵ 18)	2800		
22	20	2		1		REC. 302		1000	
24									1000
25	–	–				(PART OF ₵ 23)	1000		
27	20	2		1		FUME HOOD 302		1000	
29									1000
26	20	2		1			1000		
28								1000	
30	20	1				SPARE			1000
31			1			FUME HOOD 302	100		
33	20	3		2				400	
35				2					400
32	30	1				BRY AIR DRYER	1000		
34	30							1000	
36	30								1000
37	20					GREENHOUSE SHADES 305A	1000		
39						GREENHOUSE SHADES 305B		1000	
41						SPARE			1000
38						SPACE			
40									
42									
TOTAL VOLT-AMPS PER PHASE							15300	13800	13600

TOTAL LOAD 43 KVA. MAX. φ = 128 AMPS
MAIN BREAKER: FRAME — TRIP LUGS ONLY



FIRE ALARM ZONE SCHEDULE

ZONE	LOCATION	ZONE	LOCATION
1-1	FIRST FLR.-CORRIDOR 125	3-1	THIRD FLR.-LOBBY 319
1-2	LOBBY 128	3-2	COURT 321
1-3	LOBBY 131	3-3	VEST. 327
1-4	CORRIDOR 139	3-4	MECH. ROOM
1-5	HALL 133	3-5	
1-6	STAIR#2 142	3-6	
1-7	FLOW SWITCH	3-7	
1-8	POST INDICATOR VALVE		
2-1	SECOND FLR.-CORRIDOR 266		
2-2	LOBBY 278		
2-3	CORRIDOR 218		
2-4	CORRIDOR 273		
2-5	MECH. ROOM		
2-6			

FIRE ALARM RISER DIAGRAM AND ZONE SCHEDULE

VENTURE ARCHITECTS
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CALIFORNIA POLYTECHNIC STATE UNIVERSITY
SAN LUIS OBISPO, CALIFORNIA

JACK D. TODD INC.
ELECTRICAL ENGINEER
SAN JOSE, CALIFORNIA 295-4525
PROJECT 84079

PANEL SCHEDULES AND FIRE ALARM RISER DIAGRAM

APPROVED

DRAWN LD CHECKED JDT
DATE 12-9-85
RECORD DRWG 10-18-88
JOB NO. 8425
E-17
OF 17 SHEETS

SCARAB GRAPHICS NO. 93244

011 E17 Of 17 Panel Schedules And Fire Alarm Riser Diagram 1985-12-09

Appendix E: Detact Analysis of Smoke Detector

A viable location for a fire in the Agriculture Science building is in its electrical and mechanical rooms where machinery is always producing heat and not occupied the majority of the time. A good fire scenario would be in the electrical room because not only is it likely place for equipment to smolder or a fire to start, it also only has one smoke detector in the room unlike mechanical rooms that have multiple sampling tubes serving the entrance of the exhaust ducts of the air system in the room. The electrical room logically would most likely take longer to detect the hazard forming.

To simulate this fire scenario, I will be using the detact analysis of a t-squared fire used in annex B of NFPA 72. Furthermore, I will be implementing a function in matlab programmed by me to simulate this scenario. This function can be seen in appendix B. The RTI of the detector is not specified in the plans or by the manufacturer so I will assume an RTI value of 2 (m-s) / because this scenario will have the tendency to smolder and in case the detector doesn't activate during this period, the compartment holding the electrical equipment will reach flash over conditions and will ignite, growing at a now faster rate. So, the fire will be modeled using a fire growth rate of 0.047 kW/s . Also, I will assume the fuel load can be closely modeled as polyurethane and PVC, making the detectors activation temperature 7.2ºC higher than the ambient temperature according to table B.4.7.5.3 in NFPA 72. Assuming the ambient temperature is 20ºC, then the activation temperature will be 27.2ºC. The ceiling height is 3.048 m and the spacing for smoke detectors is 9.144 m.

Here is the results from the simulation:

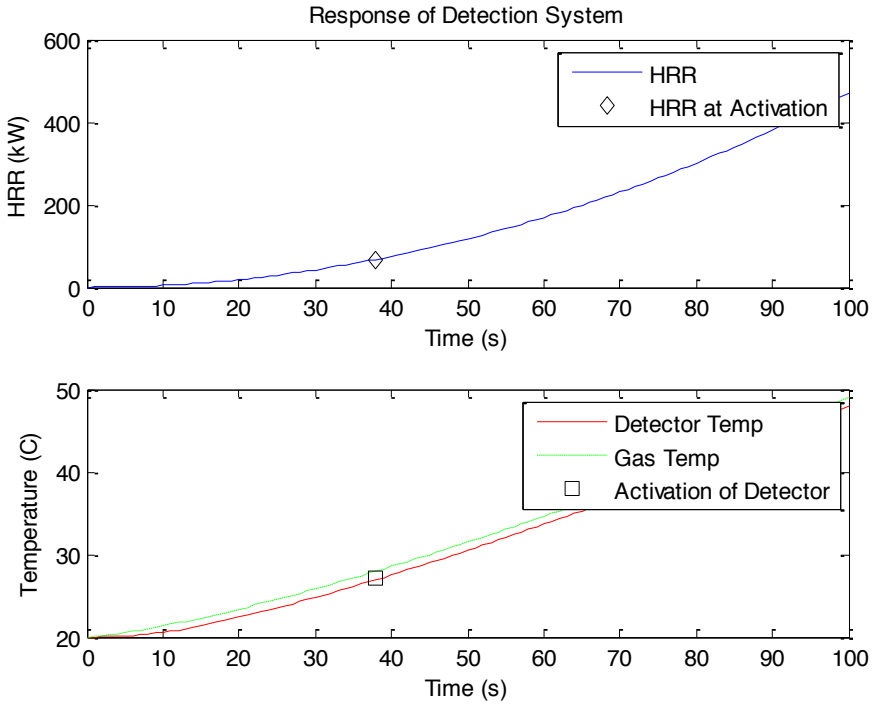


Figure 63 - Smoke Detector Activation Simulation

Where,

activation time = 38 s
Heat Release Rate (HRR) at activation = 67.87 kW

Another scenario would be in a mechanical room where the fire scenario remains the same. The only thing that changes is the device characteristics because the mechanical rooms are fitted with air ducts protected by sampling tubes at their entrance. The RTI is assumed to be 25 (m-s) / to minimize nuisance alarms and the spacing is now 3.048 m.

The results that follow are:

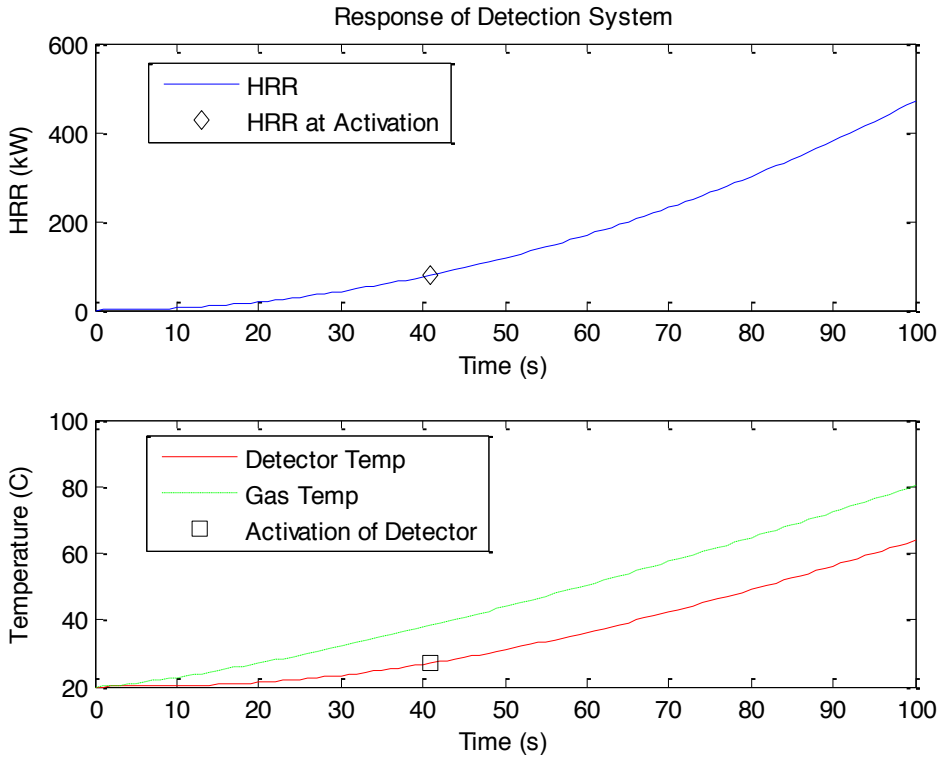


Figure 64 – Sampling Tube Activation Scenario

Where,

Activation time = 41 s
HHR at activation = 79.01 kW

These scenarios are all within reason because the devices activate within a minute of the fire starting and the heat release rate is well below critical levels.

The third fire scenario would include the activation of a fire sprinkler in the building. The fire sprinklers have a listed spacing of 3.3528 m (11 ft), activation temperature of 135ºC and have a RTI value of 100

(m-s) / . In this scenario, the most likely source of fire would be a smoldering match used to light a Bunsen burner in one of the labs.

Results:

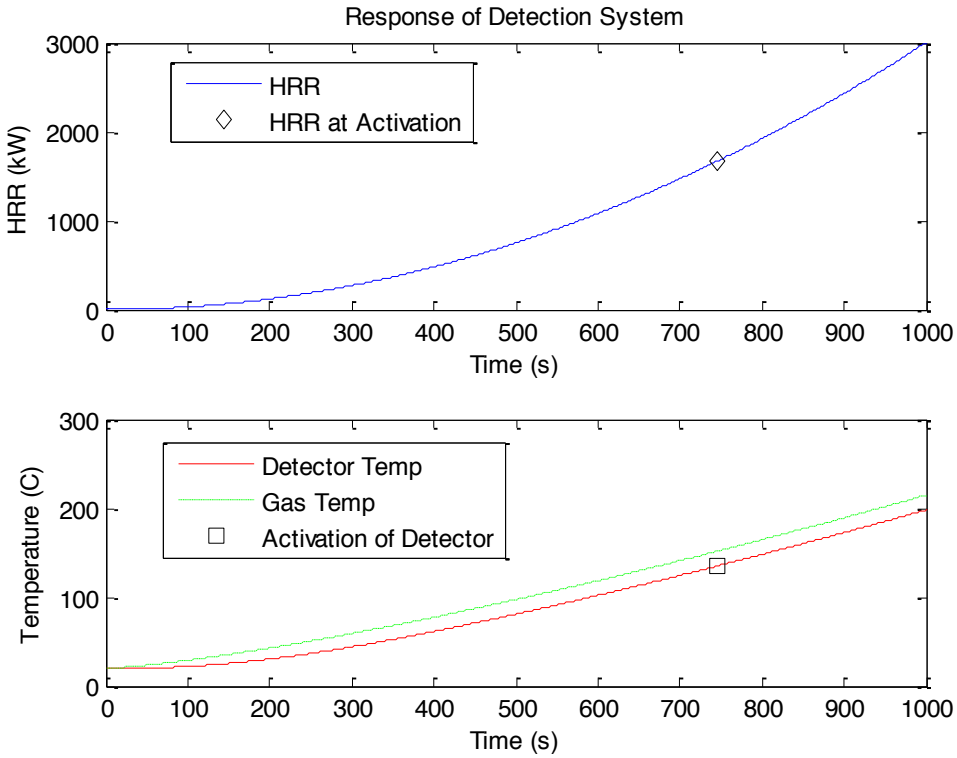


Figure 65 – Fire Sprinkler Detact Model

where,

Activation time = 745 s

HHR at activation = 1.67 MW

Appendix F:Detact Model Function in Matlab

```
function [r,t_act,Q_act,Q_supp] = detector(time,h,S,T_a,RTI,n,k)
% time=duration(s),h=height(m),S=spacing,T_a=activation temp
% RTI=Response time index,n=2(t-squared),k=fire growth rate(kW/s^2)

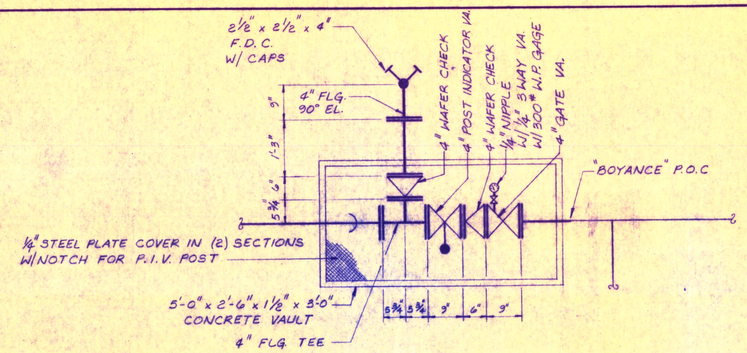
% This program simulates the detact analysis approach by NFPA 72 annex B (use SI
units)

x=1;                                    % Boolean logic for 'if' statement
t = 0:1:time;                              % time interval in seconds
delta_t = t(2)-t(1);                       % time between sampling points
r = (sqrt(2)/2)*S;              % furthest point fire can be from detector
T_0 = 20;                             % Ambient temperature assumed at 20 C
rh = r/h;             % ratio between radial distance and ceiling height
Q = k*t.^n;                                % HRR at time t
T_pl = 16.9*((Q.^(2/3))/h^(5/3));     % Temperature at h and above fire
T_cj = T_0 + (0.3*T_pl)./rh^(2/3);     % Temperature of gas at detector
u_pl = (Q.^(1/3))/h^(1/3);           % Velocity of plume at h above fire
u_cj = (0.2*u_pl)./rh^(5/6);       % Velocity of ceiling jet at detector
T_d = T_0;                      % initial temperature to get into for loop

for i=1:length(t)  % For loop calculates detector temperature at time t
    T_d(i+1) = T_d(i) + ((sqrt(u_cj(i))/RTI)*(T_cj(i)-T_d(i))*delta_t);
    if T_d(i+1) >= T_a && x == 1
        t_act = t(i);                      % Time when detector activates
        Q_act = Q(i);                 % HRR at time of detector activation
        x = 0;           % Prevents logic from entering 'if'
                         % statement again after finding activation time
    end
end

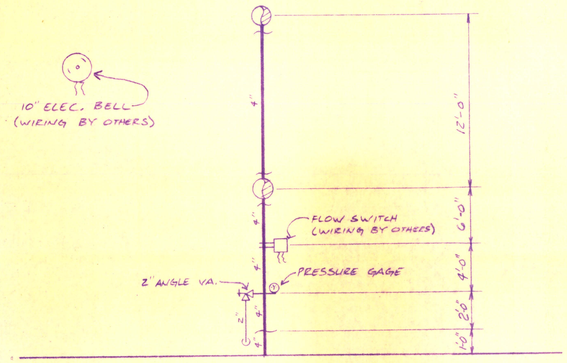
subplot(2,1,1), plot(t,Q,'-',t_act,Q_act,'kd')
title('Response of Detection System')
xlabel('Time (s)')
ylabel('HRR (kW)')
legend('HRR','HRR at Activation')
subplot(2,1,2), plot(t,T_d(1:length(t)),'r-',t,T_cj,'g-.',t_act,T_a,'ks')
xlabel('Time (s)')
ylabel('Temperature (C)')
legend('Detector Temp','Gas Temp','Activation of Detector')
if time >= 1300
    Q_supp = Q(t_act + 20*60);      % HRR at time suppression is applied
    figure                             % Plot new figure
    plot(t,Q,'-',t(t_act + 20*60),Q_supp,'kd')
    title('HRR until Suppression Applied')
    xlabel('Time (s)')
    ylabel('HRR (kW)')
    legend('HRR','HRR at the Time Suppression is Applied')
else
    Q_supp = 0;                        % Fire Brigade haven't arrived yet
```

Appendix G: Original Fire Suppression Plans



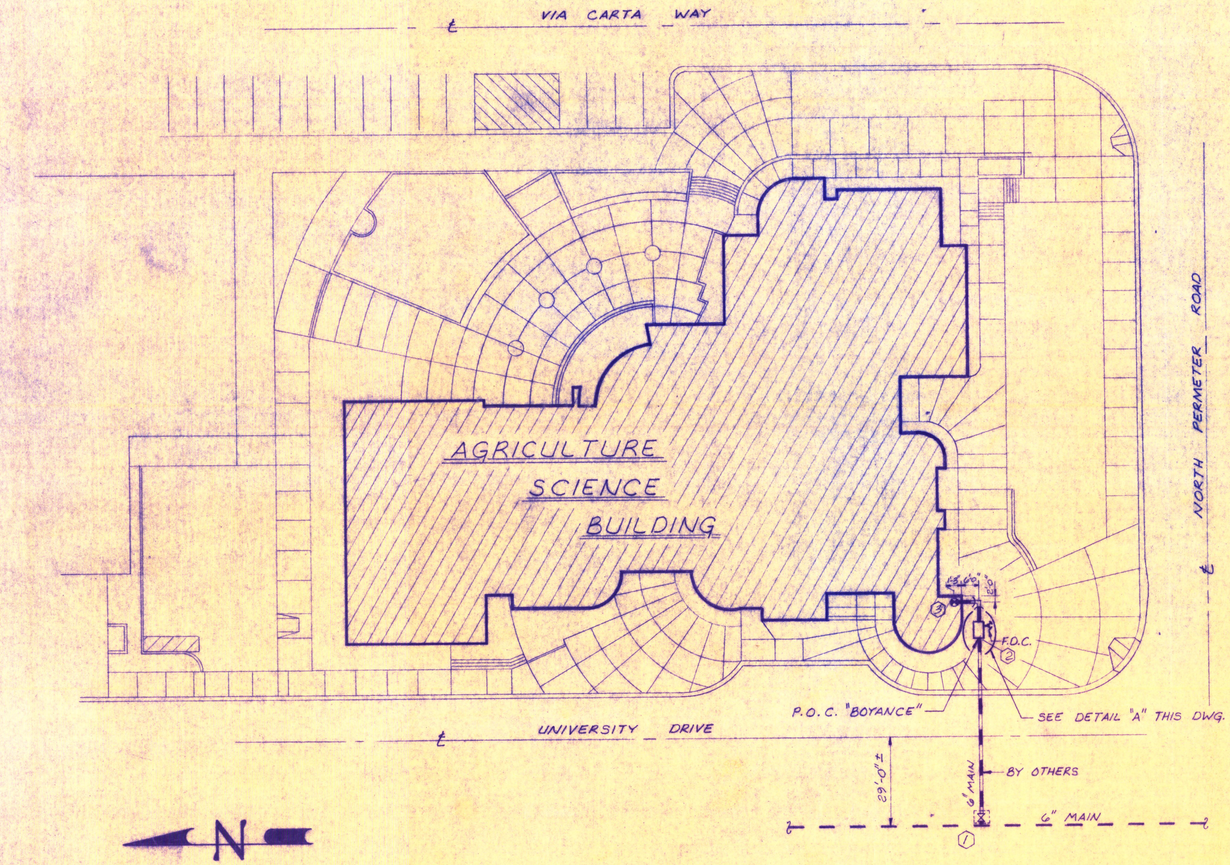
DETAIL "A"

SCALE: ¾" = 1'-0"



RISER DETAIL

NO SCALE



SITE PLAN NORTH

SITE PLAN

SCALE: 1" = 20'-0"

NO EXCEPTION TAKEN ☐ MAKE CORRECTIONS NOTED
☐ REJECTED ☐ REVISE AND RESUBMIT
☐ SUBMIT SPECIFIED ITEM

Checking is only for general conformance with the design concept of the project and general compliance with the information given in the contract documents. Any action shown is subject to the requirements of the plans and specifications. Contractor is responsible for: dimensions which shall be confirmed and correlated at the job site; fabrication processes and techniques of construction; coordination of his work with that of other trades; and the satisfactory performance of his work.

ROSS LEVIN MACINTYRE ARCHITECTS

DATE FEB 26 1987 By ANB

☒ SUBMITTAL ACCEPTABLE
☐ SUBMITTAL REJECTED
☐ REVISE AND RESUBMIT
☐ ITEMS SHOWN ON THIS SUBMITTAL MAY BE FURNISHED IN COMPLIANCE WITH CORRECTIONS AND/OR COMMENTS NOTED HEREON.

The review of this submittal and/or comments or corrections shown hereon do not relieve contractor from compliance with the requirements of the drawings and specifications of the project to which the submittals pertain. This review is only for check of general conformance with the design concept of the project and general compliance with the information given in the contract documents. The contractor is responsible for: confirming and correlating all quantities and dimensions; selecting fabrication processes and techniques of construction; coordinating his work with that of all other trades; and performing his work in a satisfactory manner.

GURRIES & OSAMOTO, INC. MECHANICAL ENGINEERS

Dated: FEB 13 1987

By:

GENERAL NOTES:

1. Material and installation to conform with N.F.P.A. Pamphlet 13 and authority having jurisdiction.
2. Earthquake bracing designed and installed on the job.
3. Proper rodding and thrust blocking installed in underground.
4. This structure will be classed: Light Hazard ___
   Ordinary Hazard Group 1, 2, 3. Extra Hazard Group 1, 2
5. Water Supply Information: Static Pressure ___ P.S.I. Residual ___ G.P.M. flowing at ___ P.S.I.
6. There are no unsprinklered buildings within 20'-0" of this structure.

APPROVED FIRE AND PENAL CODE FEB 13 1987 BY

BUILDING OFFICIAL

HANGER NUMBERS AND DESCRIPTIONS

#1	U-Hook	#13	Eye-Rod, Expansion Shield For Concrete, And Hanger Ring
#2	Wrap-Around U-Hook		
#3	U-Hook w/ Uneven Legs	#13W	Eye-Rod, Drive Or Lag Screw, And Hanger Ring
#4	Threaded U-Bolt	#14	J-Rod, Eye-Rod, Nut And Washer, And Hanger Ring
#5	Ceiling Plate, Machine Thread Rod, And Hanger Ring	#20	Powder-Driven Stud For Concrete, Rod Coupling, Machine-Thread Rod, And Hanger Ring
#7	Concrete Insert, Machine-Thread Rod, And Hanger Ring	#21S	Pipe-Strap
#9	Double-Nut, Washers, Machine-Thread Rod, And Hanger Ring	#24	C-Clamp, Machine Thread Rod, And Hanger Ring
		#24A	Top-Beam Clamp, Machine- Thread Rod, And Hanger Ring
#9SBB	Side-Beam Bracket, Double-Nut, Washers, Machine-Thread Rod And Hanger Ring	#88C	Angle-Iron Knee-Brace Attached To Concrete
#10	Lag-End Rod And Hanger Ring (Rod Button Optional)	#88W	Angle-Iron Knee-Brace Attached To Wood
		#100	Riser-Brace w/ U-Bolt
#11	Toggle-Wing, Machine-Thread Rod, And Hanger Ring (Rod Button Optional)	#101	Pipe Stand
		#110	Trapeze Bar
#12	Expansion Shield For Concrete, Machine-Thread Rod, Hanger Ring	#120	Denotes Non-Standard Hanger As Detailed On Plans

SYMBOLS AND ABBREVIATIONS

- NODE # FOR HYDR. CALC.
- PIPE # FOR HYDR. CALC.
- 12'-4" ℄ OF PIPE ABOVE FINISH FLOOR
- EARTHQUAKE BRACING: 2 & 4 WAY
- HANGER
- UNION
- SCREWED CAP
- GROOVED COUPLING
- GROOVED CAP
- GROOVED ELBOW
- GROOVED TEE
- SCREWED PLUG
- SYSTEM RISER
- FIRE HOSE RACK ASSEMBLY
- FLANGED CONNECTION

B-C	BOTTOM OF BEAM TO ℄ OF PIPE
J-C	BOTTOM OF JOIST (OR PURLIN) TO ℄ OF PIPE
S-C	BOTTOM OF SHEATHING TO ℄ OF PIPE
NTS	NOT TO SCALE
NIC	NOT IN CONTRACT
UNO	UNLESS NOTED OTHERWISE
N&C"	NIPPLE AND CAP

- BULL-HEADED TEE W/ 1" RISER TO UPRIGHT HEAD AND 1" DROP TO PENDENT HEAD
- BULL-HEADED TEE W/ UPRIGHT HEAD AND 1" DROP TO PENDENT HEAD

SPRINKLERS

QTY.	SYMB.	TYPE	TEMP.	FINISH	ORIF.	CANOPY	FINISH
	○	UPRIGHT					
	⊗	UPRIGHT WITH RISER					
	◎	PENDENT					
	◉	PENDENT WITH DROP					
	●	UPRIGHT HIGH TEMP.					
	◁	SIDEWALL					
		TOTAL SPRINKLERS THIS SHEET:					

CONTRACT RESPONSIBILITIES

ITEM	OTHERS
STREET WATER CONNECTION	
UNDERGROUND WATER MAINS	
EXCAVATION	
BACKFILL	
WIRING	
PAINTING	

NO.	DATE	BY	REVISIONS — SEE FLAGGED AREA ON PLAN

THIS PLAN PREPARED BY THE BAKERSFIELD OFFICE FOR

AGRICULTURE SCIENCE BUILDING
CAL POLY STATE UNIVERSITY
SAN LOUIS OBISPO, CALIF.

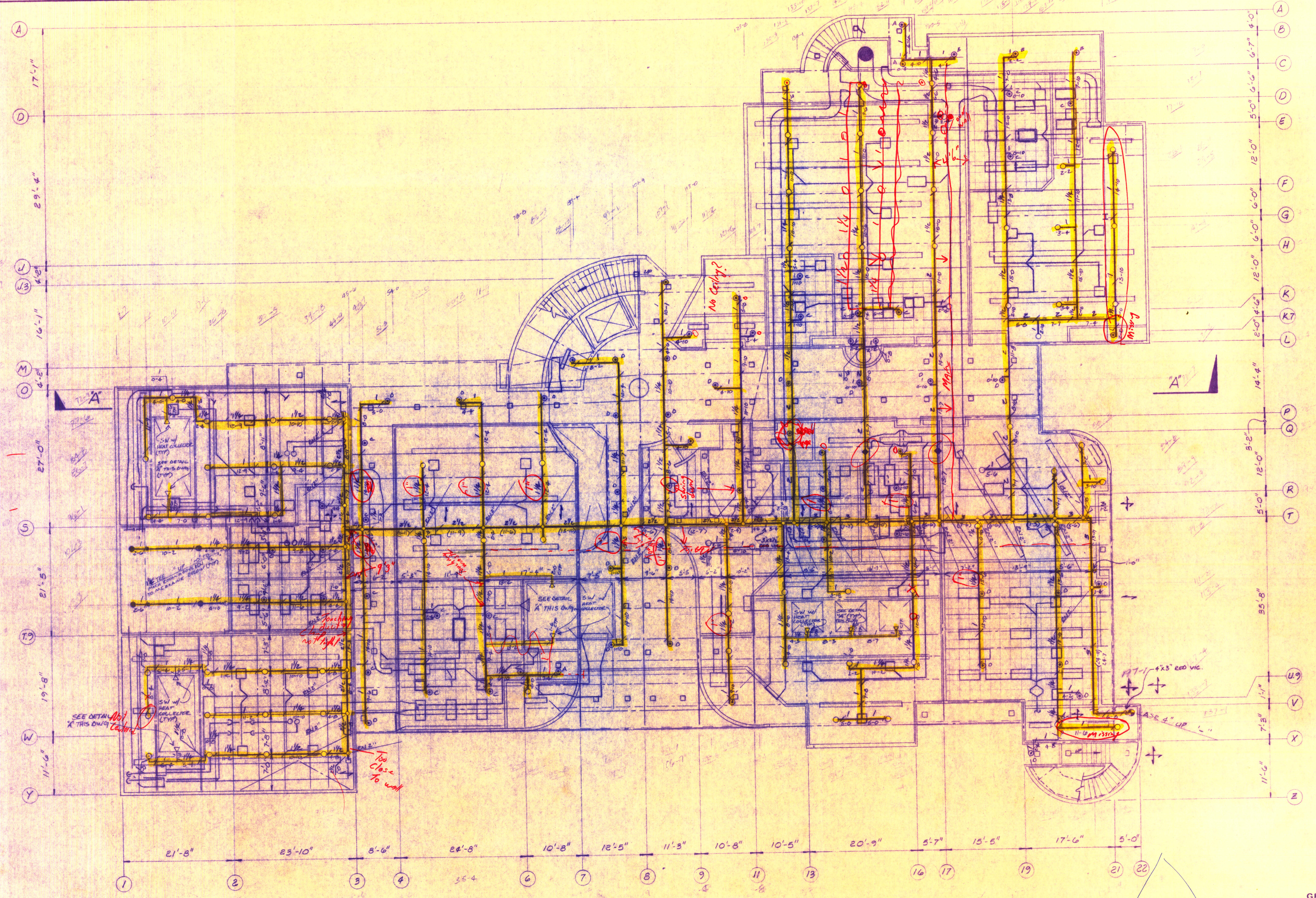
SCALE AS NOTED DATE 10-2-86

DRAWN BY ES CONTRACT NO. 720 SHT. 1 OF 5

BOYANCE AUTOMATIC SPRINKLER CO. INC.

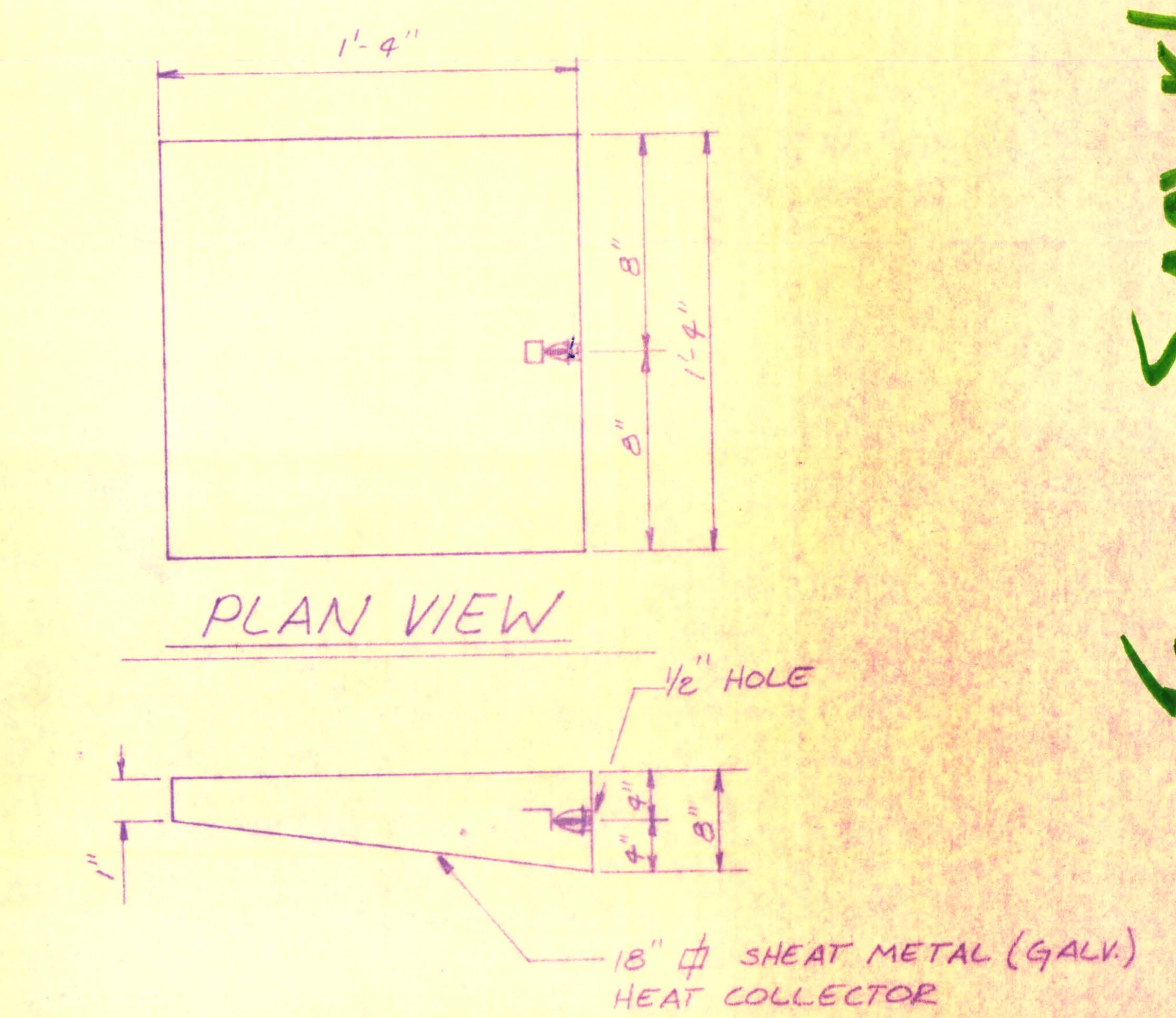
1902 E. CALIFORNIA AVENUE
BAKERSFIELD, CALIFORNIA 93307
TELEPHONE 805 872-2388
LICENSE # 428039

Fire Sprinklers



1ST FLOOR

SCALE: 1/8" = 1'-0"

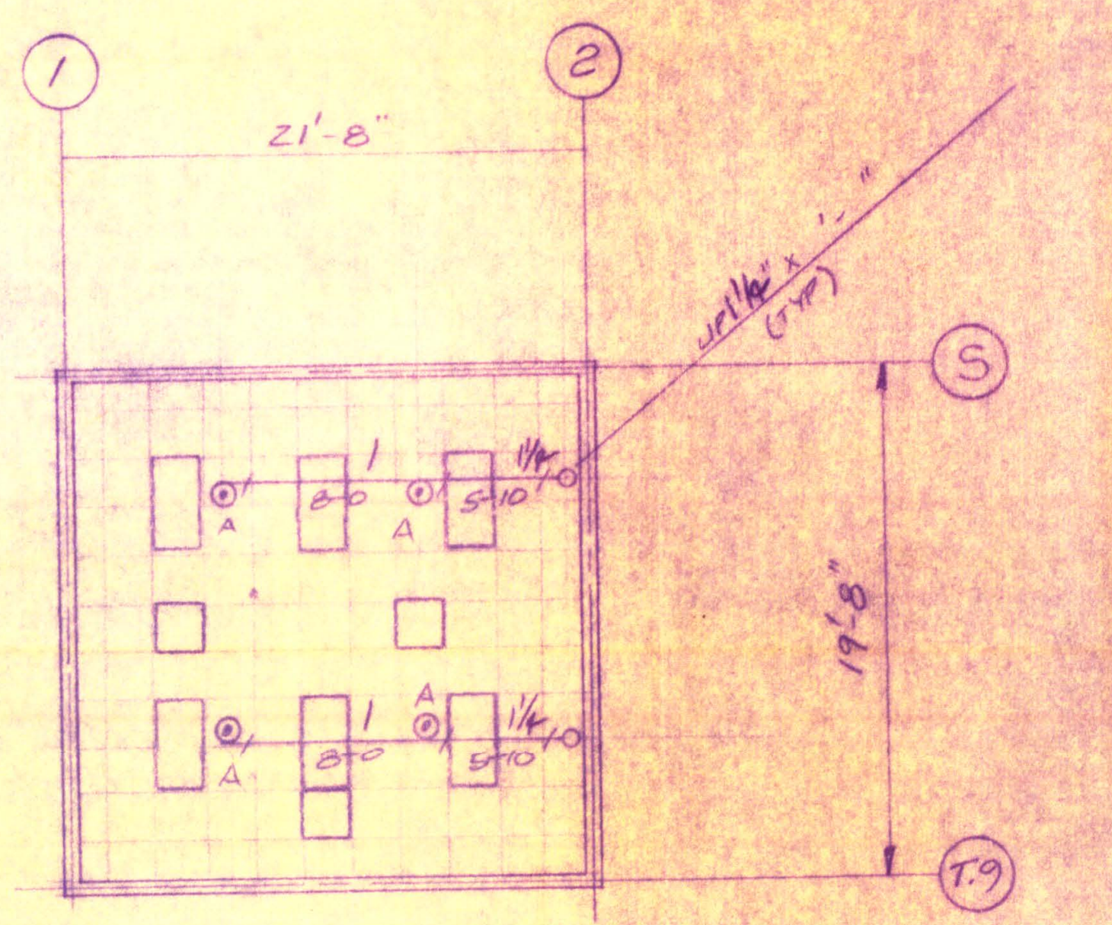


PLAN VIEW

DETAIL "A"

HEAT COLLECTOR

SCALE: NONE



MEZZAINE

SCALE: 1/8" = 1'-0"

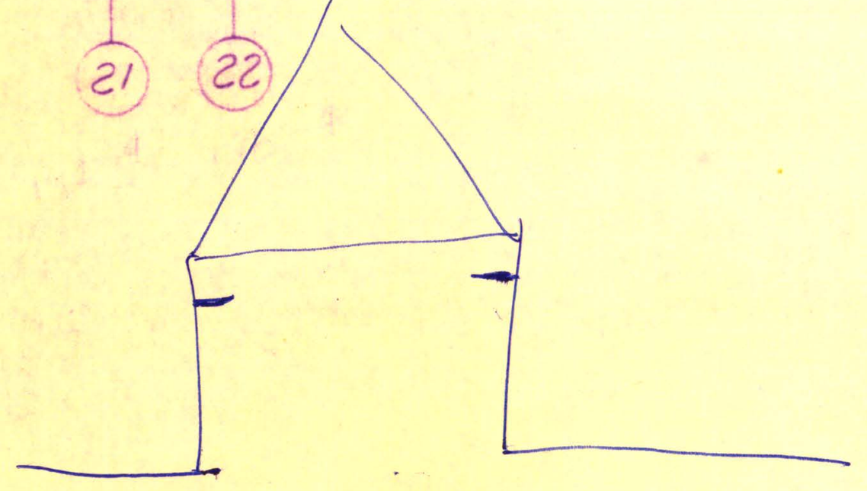
NOTES:

DROP SCHEDULE

A = 8-0
B = 8-6
C = 9-0
D = 10-10
E = 11-4

① ALL MAINS TO BE HUNG W/ #24 HANGERS

② ALL BRANCHLINES TO BE HUNG W/ #10 HANGERS



Fire Sprinkler

GENERAL NOTES:

1. Material and installation to conform with N.F.P.A. Pamphlet 13 and authority having jurisdiction.
2. Earthquake bracing designed and installed on the job.
3. Proper rodding and thrust blocking installed in underground.
4. This structure will be classed: Light Hazard X
   Ordinary Hazard Group 1. 2. 3. Extra Hazard Group 1. 2.
5. Water Supply Information: Static Pressure______P.S.I. Residual______G.P.M. flowing at______P.S.I.
6. There are no unsprinklered buildings within 20'-0" of this structure.

1ST FLOOR

APPROVED FIRE AND PANIC ONLY
FEB 4 1987
STATE FIRE MARSHAL SOUTHERN REGION

LINE NO.	NO. OF LINES	LINE NO.	NO. OF LINES	LINE NO.	NO. OF LINES

HANGER NUMBERS AND DESCRIPTIONS

No.	Description	No.	Description
#1	U-Hook	#13	Eye-Rod, Expansion Shield For Concrete, And Hanger Ring
#2	Wrap-Around U-Hook	#13W	Eye-Rod, Drive Or Lag Screw, And Hanger Ring
#3	U-Hook w/ Uneven Legs	#14	J-Rod, Eye-Rod, Nut And Washer, And Hanger Ring
#4	Threaded U-Bolt	#20	Powder-Driven Stud For Concrete, Rod-Coupling, Machine-Thread Rod, And Hanger Ring
#5	Ceiling Plate, Machine Thread Rod, And Hanger Ring	#21S	Pipe-Strap
#7	Concrete Insert, Machine-Thread Rod, And Hanger Ring	#24	C-Clamp, Machine Thread Rod, And Hanger Ring
#9	Double-Nut, Washers, Machine-Thread Rod, And Hanger Ring	#24A	Top-Beam Clamp, Machine-Thread Rod, And Hanger Ring
#9SBB	Side-Beam Bracket, Double-Nut, Washers, Machine-Thread Rod And Hanger Ring	#88C	Angle-Iron Knee-Brace Attached To Concrete
#10	Lag-End Rod And Hanger Ring (Rod Button Optional)	#88W	Angle-Iron Knee-Brace Attached To Wood
#11	Toggle-Wing, Machine-Thread Rod, And Hanger Ring (Rod Button Optional)	#100	Riser-Brace w/ U-Bolt
#12	Expansion Shield For Concrete, Machine-Thread Rod, Hanger Ring	#101	Pipe Stand
		#110	Trapeze Bar
		#120	Denotes Non-Standard Hanger As Detailed On Plans

SYMBOLS AND ABBREVIATIONS

Symbol	Meaning	Abbr.	Meaning
⬡	NODE # FOR HYDR. CALC.	B-C	BOTTOM OF BEAM TO ℄ OF PIPE
□	PIPE # FOR HYDR. CALC.	J-C	BOTTOM OF JOIST (OR PURLIN) TO ℄ OF PIPE
(12'-4")	℄ OF PIPE ABOVE FINISH FLOOR	S-C	BOTTOM OF SHEATHING TO ℄ OF PIPE
	EARTHQUAKE BRACING: 2 & 4 WAY	NTS	NOT TO SCALE
	HANGER	NIC	NOT IN CONTRACT
	UNION	UNO	UNLESS NOTED OTHERWISE
	SCREWED CAP	N&C	NIPPLE AND CAP
	GROOVED COUPLING	◑	BULL-HEADED TEE W/ 1" RISER TO UPRIGHT HEAD AND 1" DROP TO PENDENT HEAD
	GROOVED CAP	●	BULL-HEADED TEE W/ UPRIGHT HEAD AND 1" DROP TO PENDENT HEAD
	GROOVED ELBOW		
	GROOVED TEE		
	SCREWED PLUG		
	SYSTEM RISER		
	FIRE HOSE RACK ASSEMBLY		
	FLANGED CONNECTION		

SPRINKLERS

QTY.	SYMB.	TYPE	TEMP.	FINISH	ORIF.	CANOPY	FINISH
73	○	UPRIGHT	212°	BRASS	1/2	—	—
	⊗	UPRIGHT WITH RISER					
	◎	PENDENT					
76	◉	PENDENT WITH DROP	165°	CHROME	1/2	—	—
4	●	UPRIGHT HIGH TEMP.	212°	BRASS	1/2	—	—
	◁	SIDEWALL					

TOTAL SPRINKLERS THIS SHEET: 153

CONTRACT RESPONSIBILITIES

ITEM	BOYANCE	OTHERS
STREET WATER CONNECTION		✓
UNDERGROUND WATER MAINS	✓	
EXCAVATION	✓	
BACKFILL		✓
WIRING		✓
PAINTING		✓

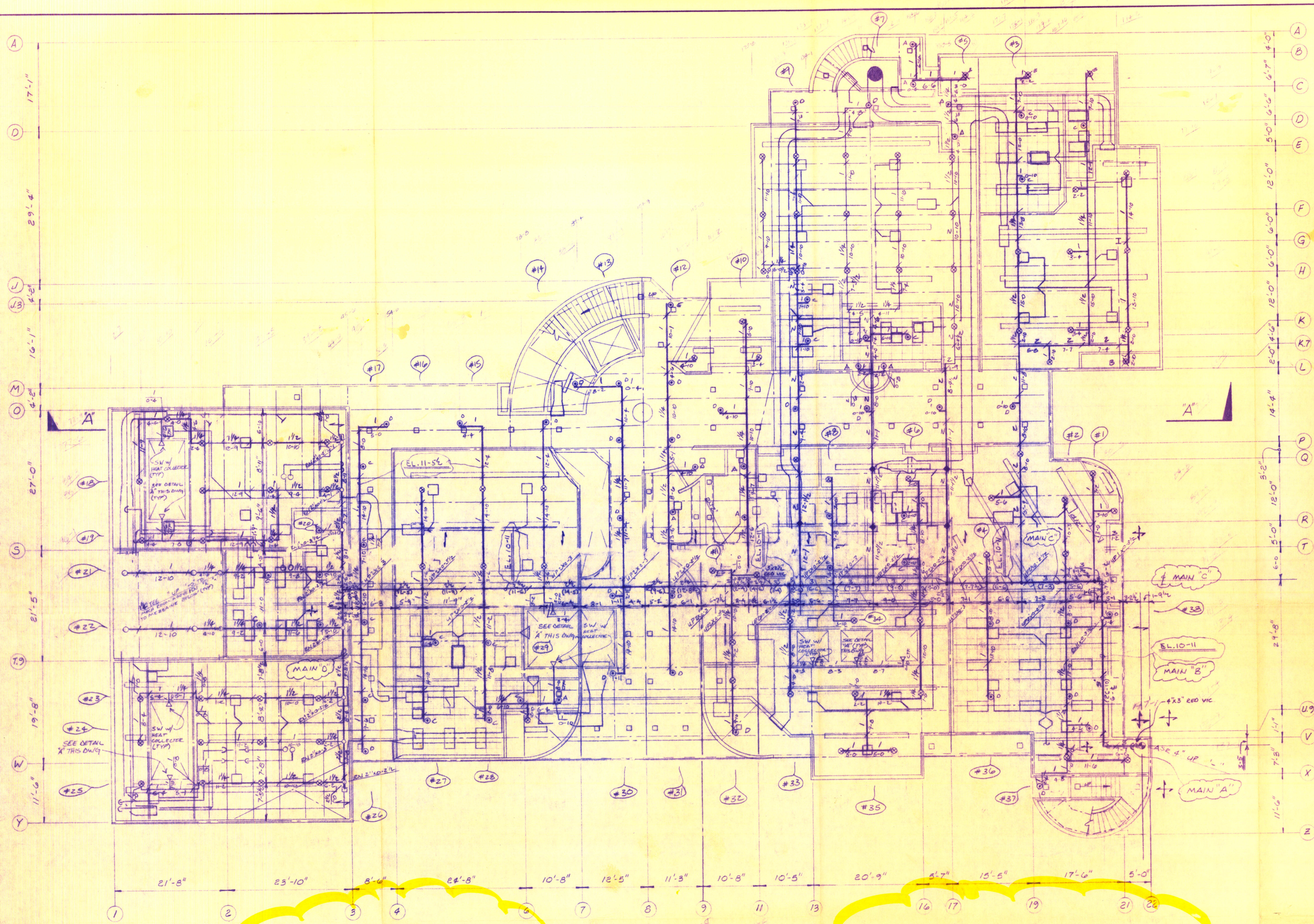
NO.	DATE	BY	REVISIONS – SEE FLAGGED AREA ON PLAN

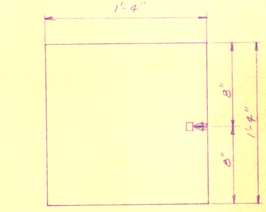
THIS PLAN PREPARED BY THE BAKERSFIELD OFFICE FOR

AGRICULTURE SCIENCE BUILDING
CAL POLY STATE UNIVERSITY
SAN LOUIS OBISPO, CALIF.

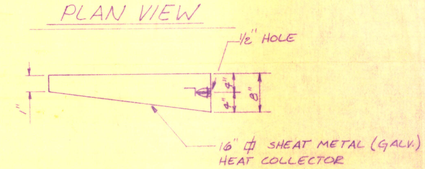
SCALE: AS NOTED | DATE: 10-1-86 | DRAWN BY: BS | CONTRACT NO: 720 | SHT. 2 OF 5

BOYANCE AUTOMATIC SPRINKLER CO. INC.
1902 E. CALIFORNIA AVENUE
BAKERSFIELD, CALIFORNIA 93307
TELEPHONE 805 872-2386
LICENSE # 428039





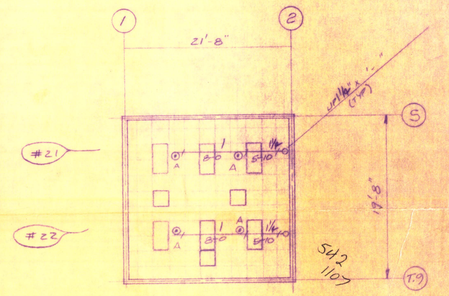
PLAN VIEW



DETAIL "A"

HEAT COLLECTOR

SCALE : NONE



MEZZAINE

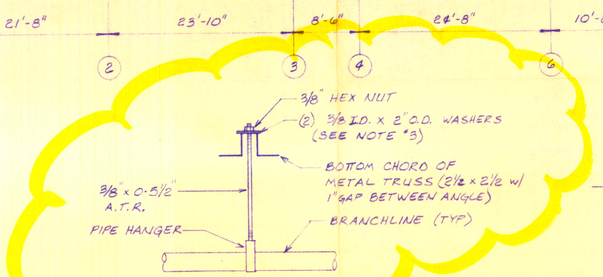
SCALE: ⅛" = 1'-0"

NOTES:

DROP SCHEDULE	
A = 3-11½	
B = 3-5½	
C = 2-9½	
D = 1-1½	
E = 0-7½	

CEILING HEIGHT
8'-0"
8'-6"
9'-0"
10'-10"
11'-4"

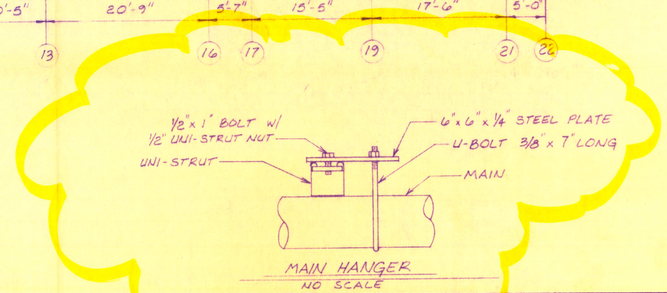
① ALL UPRIGHT HEADS W/RISER WILL BE 1'-1½"
② ALL BRANCHLINES WILL BE HUNG W/ #9 HANGER 0'-5½" (USE OVER SIZED ⅜ WASHER TO SPAN 2½" ANGLE ON TRUSS)
③ DOUBLE UP WASHERS.



LINE HANGER
NO SCALE

1ST FLOOR

SCALE : ⅛" = 1'-0"



MAIN HANGER
NO SCALE

GENERAL NOTES:

1. Material and installation to conform with N.F.P.A. Pamphlet 13 and authority having jurisdiction.
2. Earthquake bracing designed and installed on the job.
3. Proper rodding and thrust blocking installed in underground.
4. This structure will be classed: Light Hazard X
   Ordinary Hazard Group 1. 2. 3. Extra Hazard Group 1. 2.
5. Water Supply Information: Static Pressure ____ P.S.I. Residual: ____ G.P.M. flowing at ____ P.S.I.
6. There are no unsprinklered buildings within 20'-0" of this structure.

1ST FLOOR

Plan Review Engineer Only
MAY 18 1987
BAKERSFIELD FIRE MARSHAL SOUTHERN REGION
As Built June 9/16/87
APPROVED FIRE AND FIRE SAFETY
PER ____ DATE

LINE NO.	NO. OF LINES	LINE NO.	NO. OF LINES	LINE NO.	NO. OF LINES

HANGER NUMBERS AND DESCRIPTIONS

#1	U-Hook	#13	Eye-Rod, Expansion Shield For Concrete, And Hanger Ring
#2	Wrap-Around U-Hook	#13W	Eye-Rod, Drive Or Lag Screw, And Hanger Ring
#3	U-Hook w/ Uneven Legs	#14	J-Rod, Eye Rod, Nut And Washer, And Hanger Ring
#4	Threaded U-Bolt	#20	Powder-Driven Stud For Concrete, Rod Coupling, Machine-Thread Rod, And Hanger Ring
#5	Ceiling Plate, Machine Thread Rod, And Hanger Ring	#21S	Pipe-Strap
#7	Concrete Insert, Machine-Thread Rod, And Hanger Ring	#24	C-Clamp, Machine Thread Rod, And Hanger Ring
#9	Double-Nut, Washers, Machine-Thread Rod, And Hanger Ring	#24A	Top-Beam Clamp, Machine-Thread Rod, And Hanger Ring
#9SBB	Side-Beam Bracket, Double-Nut, Washers, Machine-Thread Rod And Hanger Ring	#88C	Angle-Iron Knee-Brace Attached To Concrete
#10	Lag-End Rod And Hanger Ring (Roof Button Optional)	#88W	Angle-Iron Knee-Brace Attached To Wood
#11	Toggle-Wing, Machine-Thread Rod, And Hanger Ring (Rod Button Optional)	#100	Riser-Brace w/ U-Bolt
#12	Expansion Shield For Concrete, Machine-Thread Rod, Hanger Ring	#101	Pipe Stand
		#110	Trapeze Bar
		#120	Denotes Non-Standard Hanger As Detailed On Plans

SYMBOLS AND ABBREVIATIONS

- NODE # FOR HYDR. CALC.
- PIPE # FOR HYDR. CALC.
- 12'-4" ℄ OF PIPE ABOVE FINISH FLOOR
- EARTHQUAKE BRACING: 2 & 4 WAY
- HANGER
- UNION
- SCREWED CAP
- GROOVED COUPLING
- GROOVED CAP
- GROOVED ELBOW
- GROOVED TEE
- SCREWED PLUG
- SYSTEM RISER
- FIRE HOSE RACK ASSEMBLY
- FLANGED CONNECTION

- B-C BOTTOM OF BEAM TO ℄ OF PIPE
- J-C BOTTOM OF JOIST (OR PURLIN) TO ℄ OF PIPE
- S-C BOTTOM OF SHEATHING TO ℄ OF PIPE
- NTS NOT TO SCALE
- NIC NOT IN CONTRACT
- UNO UNLESS NOTED OTHERWISE
- N&C NIPPLE AND CAP
- BULL HEADED TEE W/ 1" RISER TO UPRIGHT HEAD AND 1" DROP TO PENDENT HEAD
- BULL HEADED TEE W/ UPRIGHT HEAD AND 1" DROP TO PENDENT HEAD

SPRINKLERS

QTY.	SYMB.	TYPE	TEMP.	FINISH	ORIF.	CANOPY	FINISH
6	○	UPRIGHT	212°	BRASS	½	—	—
82	⊗	UPRIGHT WITH RISER	212°	BRASS	½	—	—
	⊜	PENDENT					
70	◉	PENDENT WITH DROP	165°	CHROME	½	—	—
	●	UPRIGHT HIGH TEMP.	212°	BRASS	½	—	—
9	◁	SIDEWALL	212°	BRASS	½	—	—
4	⊠	PENDENT-HORIZ (DRY)	165°	BRASS	½	—	—

TOTAL SPRINKLERS THIS SHEET: 165

CONTRACT RESPONSIBILITIES

ITEM	BOYANCE	OTHERS
STREET WATER CONNECTION		✓
UNDERGROUND WATER MAINS	✓	
EXCAVATION	✓	
BACKFILL		✓
WIRING		✓
PAINTING		✓

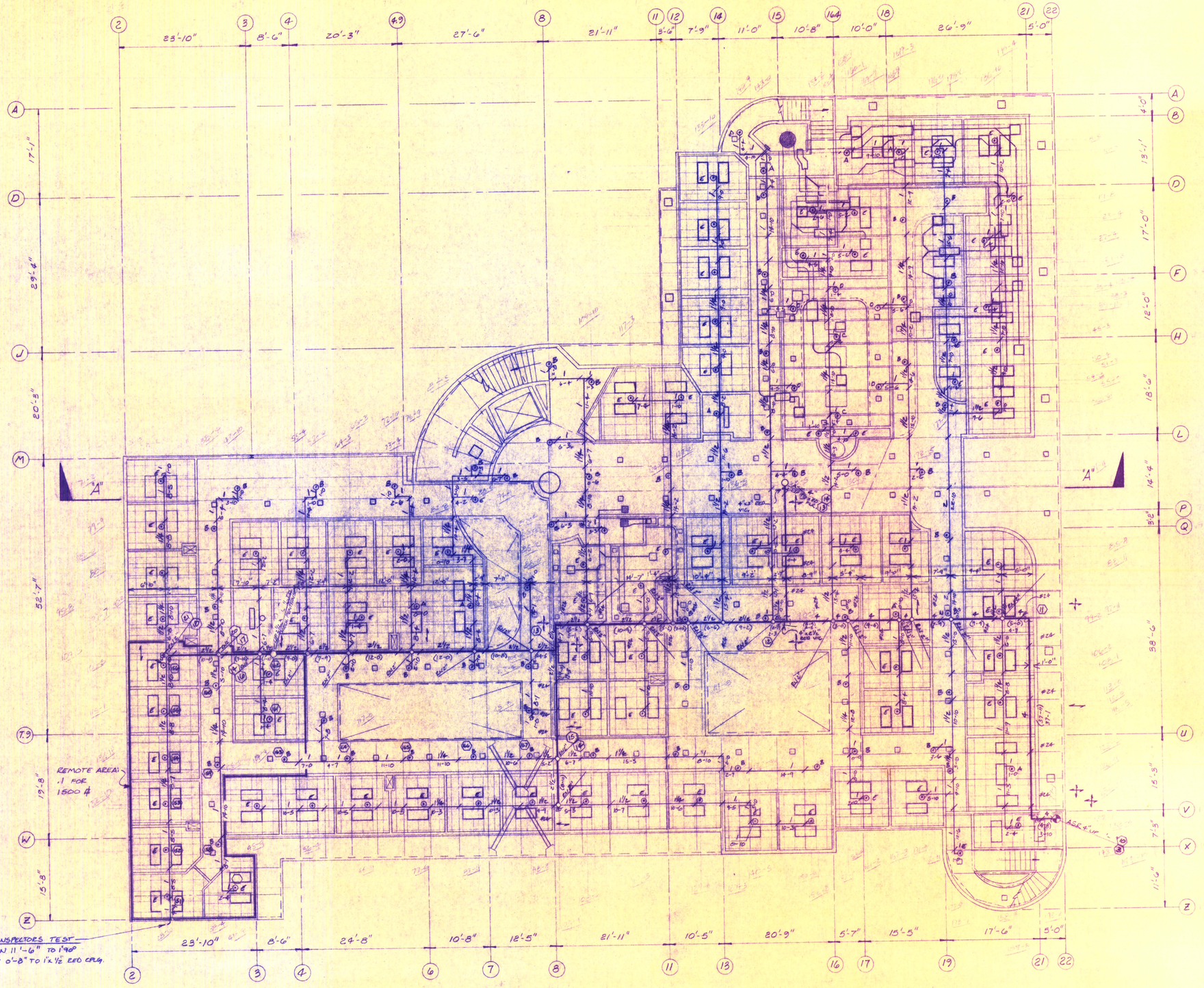
NO.	DATE	BY	REVISIONS - SEE FLAGGED AREA ON PLAN

THIS PLAN PREPARED BY THE BAKERSFIELD OFFICE FOR

AGRICULTURE SCIENCE BUILDING
CAL POLY STATE UNIVERSITY
SAN LOUIS OBISPO, CALIF.

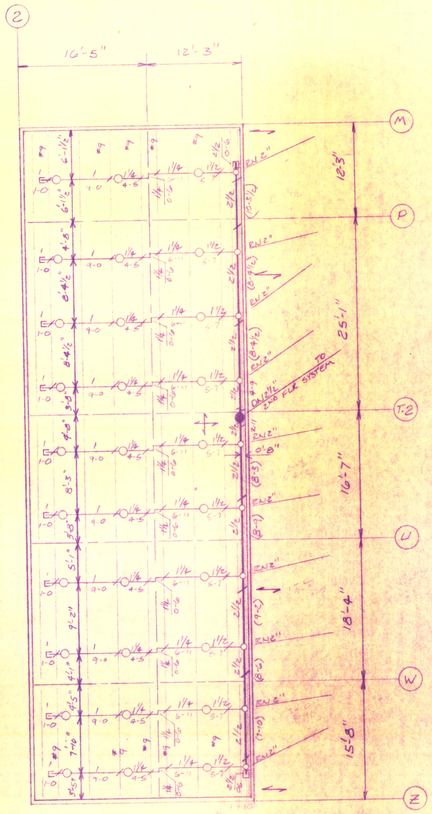
SCALE AS NOTED | DATE 9-16-87 | DRAWN BY [illegible] | CONTRACT NO. 87-29 | SHT 2 OF 5

BOYANCE AUTOMATIC SPRINKLER CO. INC.
1902 E. CALIFORNIA AVENUE
BAKERSFIELD, CALIFORNIA 93307
TELEPHONE 805 872-2386
LICENSE # 428039



2ND FLOOR

SCALE : 1/8" = 1'-0"



MECHANICAL PENTHOUSE

SCALE : 1/8" = 1'-0"
ABOVE 2ND FLOOR

NOTES:

DROP SCHEDULE

A =	9-0
B =	9-5
C =	10-0
D =	7-8½
E =	8-0

1. ALL MAIN TO BE HUNG W/ #24 HANGERS 1-11
2. ALL BRANCHLINES TO BE HUNG W/ #10 HANGERS 1-11
3. MAINS HUNG FROM "Z" PURLINS WILL USE #9 HANGERS 1-11
4. BRANCHLINES HUNG FROM "Z" PURLINS WILL USE #9 HANGERS 1-11

GENERAL NOTES:

1. Material and installation to conform with N.F.P.A. Pamphlet 13 and authority having jurisdiction.
2. Earthquake bracing designed and installed on the job.
3. Proper rodding and thrust blocking installed in underground.
4. This structure will be classed: Light Hazard X
   Ordinary Hazard Group 1. 2. 3. Extra Hazard Group 1. 2.
5. Water Supply Information: Static Pressure_____P.S.I. Residual_____G.P.M. flowing at_____P.S.I.
6. There are no unsprinklered buildings within 20'-0 of this structure.

2ND FLOOR

APPROVED FIRE AND PANIC CONT. FEB 4 1987 STATE FIRE MARSHAL BUILDING CODES

LINE NO.	NO. OF LINES	LINE NO.	NO. OF LINES	LINE NO.	NO. OF LINES

HANGER NUMBERS AND DESCRIPTIONS

#1	U-Hook	#13	Eye-Rod, Expansion Shield For Concrete, And Hanger Ring
#2	Wrap-Around U-Hook	#13W	Eye-Rod, Drive Or Lag Screw, And Hanger Ring
#3	U-Hook w/ Uneven Legs	#14	J-Rod, Eye-Rod, Nut And Washer, And Hanger Ring
#4	Threaded U-Bolt	#20	Powder-Driven Stud For Concrete, Rod Coupling, Machine-Thread Rod, And Hanger Ring
#5	Ceiling Plate, Machine Thread Rod, And Hanger Ring	#21S	Pipe Strap
#7	Concrete Insert, Machine-Thread Rod, And Hanger Ring	#24	C-Clamp, Machine Thread Rod, And Hanger Ring
#9	Double-Nut, Washers, Machine-Thread Rod, And Hanger Ring	#24A	Top-Beam Clamp, Machine Thread Rod, And Hanger Ring
#9SBB	Side-Beam Bracket, Double-Nut, Washers, Machine-Thread Rod And Hanger Ring	#88C	Angle-Iron Knee-Brace Attached To Concrete
#10	Lag-End Rod And Hanger Ring (Rod Button Optional)	#88W	Angle-Iron Knee-Brace Attached To Wood
#11	Toggle-Wing, Machine-Thread Rod, And Hanger Ring (Rod Button Optional)	#100	Riser-Brace w/ U-Bolt
#12	Expansion Shield For Concrete, Machine-Thread Rod, Hanger Ring	#101	Pipe Stand
		#110	Trapeze Bar
		#120	Denotes Non-Standard Hanger As Detailed On Plans

SYMBOLS AND ABBREVIATIONS

- NODE # FOR HYDR. CALC.
- PIPE # FOR HYDR. CALC.
- (12'-5") ℄ OF PIPE ABOVE FINISH FLOOR
- EARTHQUAKE BRACING- 2 & 4 WAY
- HANGER
- UNION
- SCREWED CAP
- GROOVED COUPLING
- GROOVED CAP
- GROOVED ELBOW
- GROOVED TEE
- SCREWED PLUG
- SYSTEM RISER
- FIRE HOSE RACK ASSEMBLY
- FLANGED CONNECTION

B-C	BOTTOM OF BEAM TO ℄ OF PIPE
J-C	BOTTOM OF JOIST (OR PURLIN) TO ℄ OF PIPE
S-C	BOTTOM OF SHEATHING TO ℄ OF PIPE
NTS	NOT TO SCALE
NIC	NOT IN CONTRACT
UNO	UNLESS NOTED OTHERWISE
N&C	NIPPLE AND CAP

- BULL HEADED TEE W/ 1" RISER TO UPRIGHT HEAD AND 1" DROP TO PENDENT HEAD
- BULL-HEADED TEE W/ UPRIGHT HEAD AND 1" DROP TO PENDENT HEAD

SPRINKLERS

QTY.	SYMB.	TYPE	TEMP.	FINISH	ORIF.	CANOPY	FINISH
7 / 10	○	UPRIGHT	165° / 212°	BRASS	½		
	⊗	UPRIGHT WITH RISER					
	⊖	PENDENT					
129	◉	PENDENT WITH DROP	165°	CHROME	½		
	●	UPRIGHT HIGH TEMP.					
	◁	SIDEWALL					

TOTAL SPRINKLERS THIS SHEET: 140

CONTRACT RESPONSIBILITIES

ITEM	BOYANCE	OTHERS
STREET WATER CONNECTION		✓
UNDERGROUND WATER MAINS	✓	
EXCAVATION	✓	
BACKFILL		✓
WIRING		✓
PAINTING		✓

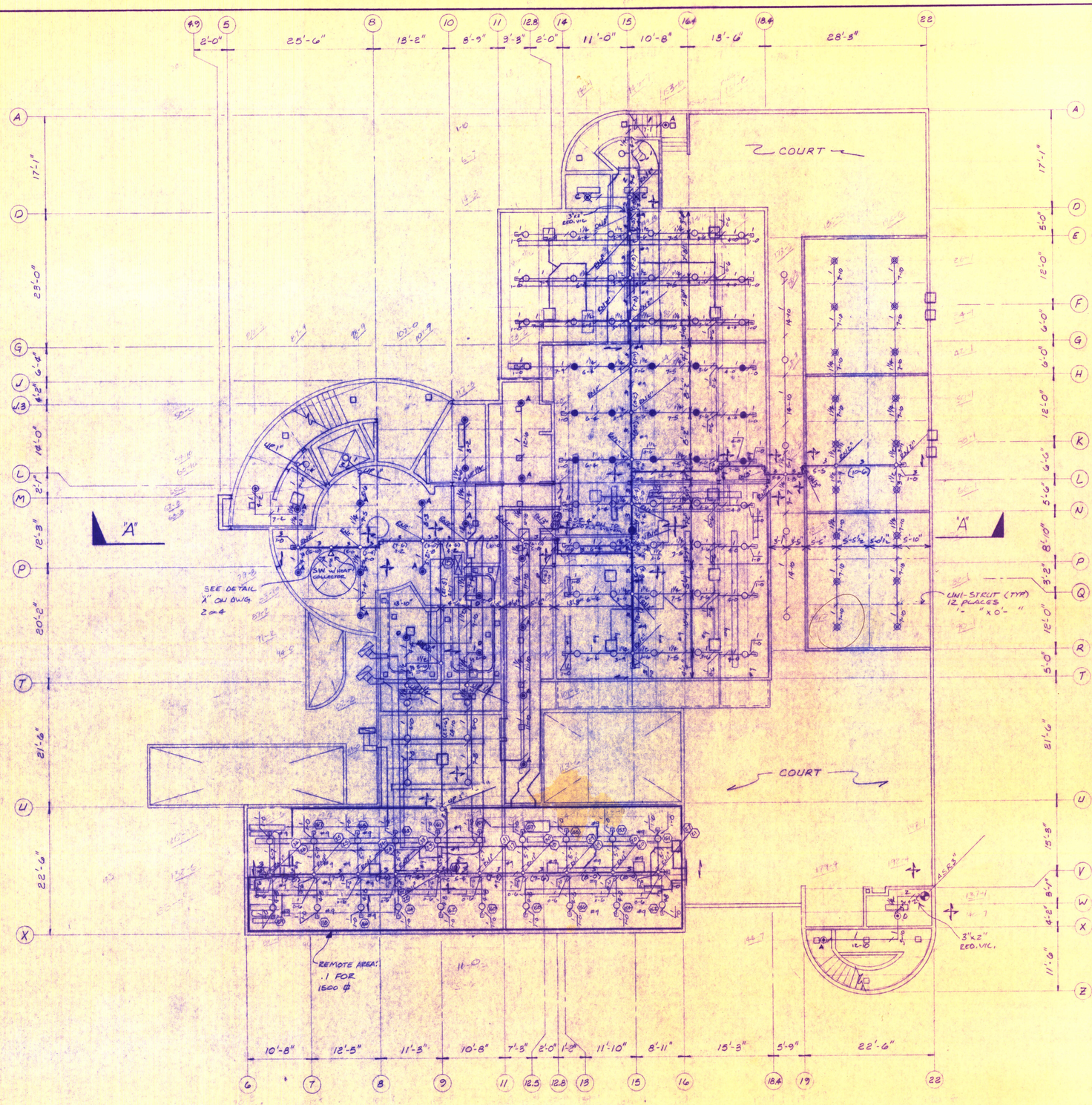
NO. | DATE | BY | REVISIONS - SEE FLAGGED AREA ON PLAN

THIS PLAN PREPARED BY THE BAKERSFIELD OFFICE FOR

AGRICULTURE SCIENCE BUILDING
CAL POLY STATE UNIVERSITY
SAN LOUIS OBISPO, CALIF.

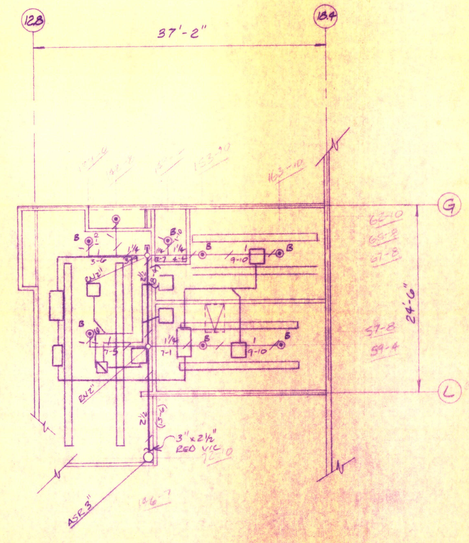
SCALE AS NOTED | DATE 10-1-86
DRAWN BY ES | CONTRACT NO. 720
SHT. 3 OF 5

BOYANCE AUTOMATIC SPRINKLER CO. INC.
1902 E. CALIFORNIA AVENUE
BAKERSFIELD, CALIFORNIA 93307
TELEPHONE 805 872-2386
LICENSE # 428039



3RD FLOOR

SCALE : 1/8" = 1'-0"



MEZZANINE

SCALE : 1/8" = 1'-0"

NOTES

DROP SCHEDULE

A =	10-10
B =	8-0
C =	8-6
D =	9-0

① ALL MAINS TO BE HUNG W/ #24 HANGERS 1- "
② MAINS HUNG FROM 2" PURLINS WILL USE #9 HANGERS 1- "
③ BRANCHLINES HUNG FROM 2" PURLINS WILL USE #9 HANGERS 1- "
④ ALL OTHER BRANCHLINES WILL BE HUNG W/ # 10 HANGERS 1- "

GENERAL NOTES:

1. Material and installation to conform with N.F.P.A. Pamphlet 13 and authority having jurisdiction.
2. Earthquake bracing designed and installed on the job.
3. Proper rodding and thrust blocking installed in underground.
4. This structure will be classed: Light Hazard X
   Ordinary Hazard Group 1. 2. 3. Extra Hazard Group 1. 2.
5. Water Supply Information: Static Pressure_____P.S.I.
   Residual_____G.P.M. flowing at_____P.S.I.
6. There are no unsprinklered buildings within 20'-0" of this structure.

3RD FLOOR

APPROVED FIRE AND PANIC FEB 4 1987 STATE FIRE MARSHAL SOUTHERN DISTRICT

N

LINE NO.	NO. OF LINES	LINE NO.	NO. OF LINES	LINE NO.	NO. OF LINES

HANGER NUMBERS AND DESCRIPTIONS

#1	U-Hook	#13	Eye-Rod, Expansion Shield For Concrete, And Hanger Ring
#2	Wrap-Around U-Hook	#13W	Eye-Rod, Drive Or Lag Screw, And Hanger Ring
#3	U-Hook w/ Uneven Legs	#14	J-Rod, Eye Rod, Nut And Washer, And Hanger Ring
#4	Threaded U-Bolt	#20	Powder-Driven Stud For Concrete, Rod Coupling, Machine-Thread Rod, And Hanger Ring
#5	Ceiling Plate, Machine Thread Rod, And Hanger Ring	#21S	Pipe Strap
#7	Concrete Insert, Machine-Thread Rod, And Hanger Ring	#24	C-Clamp, Machine Thread Rod, And Hanger Ring
#9	Double-Nut, Washers, Machine-Thread Rod, And Hanger Ring	#24A	Top-Beam Clamp, Machine Thread Rod, And Hanger Ring
#9SBB	Side-Beam Bracket, Double-Nut, Washers, Machine-Thread Rod And Hanger Ring	#88C	Angle-Iron Knee-Brace Attached To Concrete
#10	Lag-End Rod And Hanger Ring (Rod Button Optional)	#88W	Angle-Iron Knee-Brace Attached To Wood
#11	Toggle-Wing, Machine-Thread Rod, And Hanger Ring (Rod Button Optional)	#100	Riser-Brace w/ U-Bolt
#12	Expansion Shield For Concrete, Machine-Thread Rod, Hanger Ring	#101	Pipe Stand
		#110	Trapeze Bar
		#120	Denotes Non-Standard Hanger As Detailed On Plans

SYMBOLS AND ABBREVIATIONS

○	NODE # FOR HYDR. CALC.
□	PIPE # FOR HYDR. CALC.
12'-4"	℄ OF PIPE ABOVE FINISH FLOOR
	EARTHQUAKE BRACING: 2 & 4 WAY
	HANGER
	UNION
	SCREWED CAP
	GROOVED COUPLING
	GROOVED CAP
	GROOVED ELBOW
	GROOVED TEE
	SCREWED PLUG
	SYSTEM RISER
	FIRE HOSE RACK ASSEMBLY
	FLANGED CONNECTION

B-C	BOTTOM OF BEAM TO ℄ OF PIPE
J-C	BOTTOM OF JOIST (OR PURLIN) TO ℄ OF PIPE
S-C	BOTTOM OF SHEATHING TO ℄ OF PIPE
NTS	NOT TO SCALE
NIC	NOT IN CONTRACT
UNO	UNLESS NOTED OTHERWISE
N&C	NIPPLE AND CAP
◑	BULL HEADED TEE W/ 1" RISER TO UPRIGHT HEAD AND 1" DROP TO PENDENT HEAD
●	BULL-HEADED TEE W/ UPRIGHT HEAD AND 1" DROP TO PENDENT HEAD

SPRINKLERS

QTY.	SYMB.	TYPE	TEMP.	FINISH	ORIF.	CANOPY	FINISH
73	○	UPRIGHT	165°	BRASS	½	—	—
	⊗	UPRIGHT WITH RISER					
	⊖	PENDENT					
23	◉	PENDENT WITH DROP	165°	CHROME	½	—	—
15	●	UPRIGHT HIGH TEMP.	212°	BRASS	½	—	—
	◁	SIDEWALL					
18	⊠	PENDENT HIGH TEMP.	286°	BRASS	½	—	—
2	⊠	PENDENT (DRY)	165°	BRASS	½	—	—

TOTAL SPRINKLERS THIS SHEET: 133

NO.	DATE	BY	REVISIONS - SEE FLAGGED AREA ON PLAN

CONTRACT RESPONSIBILITIES

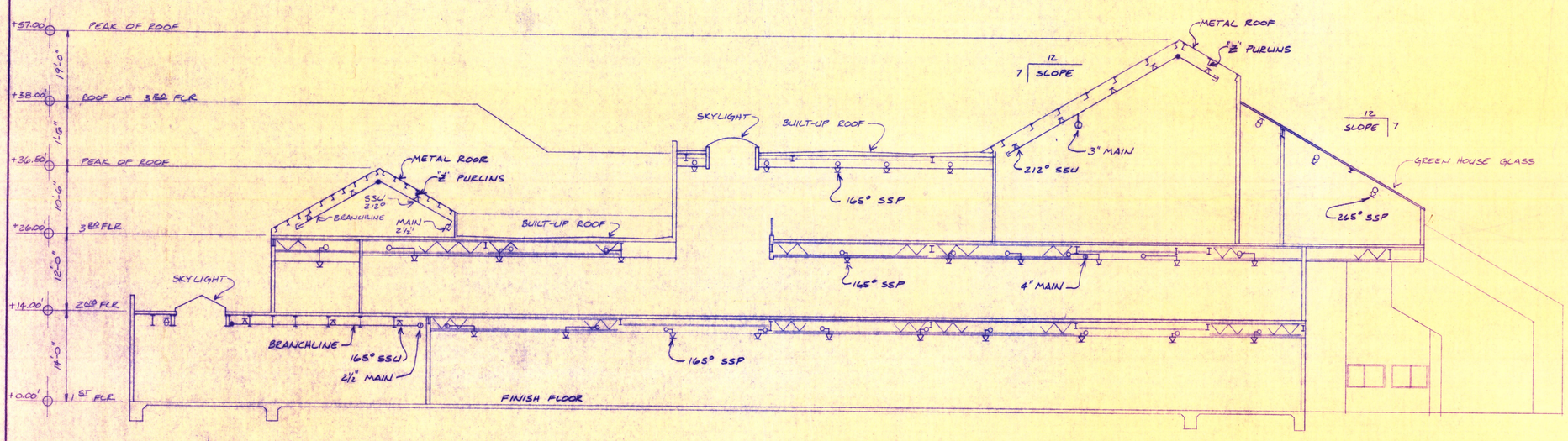
ITEM	BOYANCE	OTHERS
STREET WATER CONNECTION		✓
UNDERGROUND WATER MAINS	✓	
EXCAVATION	✓	
BACKFILL		✓
WIRING		✓
PAINTING		✓

THIS PLAN PREPARED BY THE BAKERSFIELD OFFICE FOR

AGRICULTURE SCIENCE BUILDING
CAL POLY STATE UNIVERSITY
SAN LOUIS OBISPO, CALIF.

SCALE AS NOTED | DATE 10-1-86
DRAWN BY BS | CONTRACT NO. 720 | SHT. 4 OF 5

BOYANCE AUTOMATIC SPRINKLER CO. INC.
1902 E. CALIFORNIA AVENUE
BAKERSFIELD, CALIFORNIA 93307
TELEPHONE 805 872-2386
LICENSE # 428039



SECTION "A"-"A"

SCALE: 1/8" = 1'-0"

GENERAL NOTES:

1. Material and installation to conform with N.F.P.A. Pamphlet 13 and authority having jurisdiction.
2. Earthquake bracing designed and installed on the job.
3. Proper rodding and thrust blocking installed in underground.
4. This structure will be classed: Light Hazard ___
   Ordinary Hazard Group 1. 2. 3. Extra Hazard Group 1. 2.
5. Water Supply Information: Static Pressure_____P.S.I.
   Residual_____G.P.M. flowing at____P.S.I.
6. There are no unsprinklered buildings within 20'-0' of this structure.

APPROVED FIRE AND FIRE ONLY
FEB 4 1987
STATE FIRE MARSHAL SOUTHERN DIST.

LINE NO.	NO. OF LINES	LINE NO.	NO. OF LINES	LINE NO.	NO. OF LINES

HANGER NUMBERS AND DESCRIPTIONS

#1	U-Hook	#13	Eye-Rod, Expansion Shield For Concrete, And Hanger Ring
#2	Wrap-Around U-Hook	#13W	Eye-Rod, Drive Or Lag Screw, And Hanger Ring
#3	U-Hook w/ Uneven Legs	#14	J-Rod, Eye-Rod, Nut And Washer, And Hanger Ring
#4	Threaded U-Bolt	#20	Powder-Driven Stud For Concrete, Rod Coupling, Machine-Thread Rod, And Hanger Ring
#5	Ceiling Plate, Machine Thread Rod, And Hanger Ring	#21S	Pipe-Strap
#7	Concrete Insert, Machine-Thread Rod, And Hanger Ring	#24	C-Clamp, Machine Thread Rod, And Hanger Ring
#9	Double-Nut, Washers, Machine-Thread Rod, And Hanger Ring	#24A	Top-Beam Clamp, Machine Thread Rod, And Hanger Ring
#9SBB	Side-Beam Bracket, Double-Nut, Washers, Machine-Thread Rod And Hanger Ring	#88C	Angle-Iron Knee-Brace Attached To Concrete
#10	Lag-End Rod And Hanger Ring (Rod Button Optional)	#88W	Angle-Iron Knee-Brace Attached To Wood
#11	Toggle-Wing, Machine-Thread Rod, And Hanger Ring (Rod Button Optional)	#100	Riser-Brace w/ U-Bolt
#12	Expansion Shield For Concrete, Machine-Thread Rod, Hanger Ring	#101	Pipe Stand
		#110	Trapeze Bar
		#120	Denotes Non-Standard Hanger As Detailed On Plans

SYMBOLS AND ABBREVIATIONS

- NODE # FOR HYDR. CALC.
- PIPE # FOR HYDR. CALC.
- 16'-4" ℄ OF PIPE ABOVE FINISH FLOOR
- EARTHQUAKE BRACING: 2 & 4 WAY
- HANGER
- UNION
- SCREWED CAP
- GROOVED COUPLING
- GROOVED CAP
- GROOVED ELBOW
- GROOVED TEE
- SCREWED PLUG
- SYSTEM RISER
- FIRE HOSE RACK ASSEMBLY
- FLANGED CONNECTION

B-C	BOTTOM OF BEAM TO ℄ OF PIPE
J-C	BOTTOM OF JOIST (OR PURLIN) TO ℄ OF PIPE
S-C	BOTTOM OF SHEATHING TO ℄ OF PIPE
NTS	NOT TO SCALE
NIC	NOT IN CONTRACT
UNO	UNLESS NOTED OTHERWISE
N&C	NIPPLE AND CAP

- BULL-HEADED TEE W/ 1" RISER TO UPRIGHT HEAD AND 1" DROP TO PENDENT HEAD
- BULL-HEADED TEE W/ UPRIGHT HEAD AND 1" DROP TO PENDENT HEAD

SPRINKLERS

QTY.	SYMB.	TYPE	TEMP.	FINISH	ORIF.	CANOPY	FINISH
	○	UPRIGHT					
	⊗	UPRIGHT WITH RISER					
	⊕	PENDENT					
	◉	PENDENT WITH DROP					
	●	UPRIGHT HIGH TEMP.					
	◁	SIDEWALL					
		TOTAL SPRINKLERS THIS SHEET:					

CONTRACT RESPONSIBILITIES

ITEM	OTHERS
STREET WATER CONNECTION	
UNDERGROUND WATER MAINS	
EXCAVATION	
BACKFILL	
WIRING	
PAINTING	

NO.	DATE	BY	REVISIONS - SEE FLAGGED AREA ON PLAN

THIS PLAN PREPARED BY THE BAKERSFIELD OFFICE FOR

AGRICULTURE SCIENCE BUILDING
CAL POLY STATE UNIVERSITY
SAN LOUIS OBISPO, CALIF.

SCALE AS NOTED | DATE 10-2-86
DRAWN BY B.S. | CONTRACT NO. 7015 | SHT 5 OF 5

BOYANCE AUTOMATIC SPRINKLER CO. INC.
1902 E. CALIFORNIA AVENUE
BAKERSFIELD, CALIFORNIA 93307
TELEPHONE 805 872-2386
LICENSE # 428039

Appendix H: Hazard Scenario FDS Files

HydClass3.fds

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&TIME SYNCHRONIZE=.FALSE. T_END=350.0 /
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/&MESH ID='MESH3', IJK=55,37,21, XB=-3.75,12.75,6.9,18.0,0.0,6.3 /

&BNDF QUANTITY='WALL TEMPERATURE'/

&PRES VELOCITY_TOLERANCE = .01, MAX_PRESSURE_ITERATIONS = 30 /

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&SPEC ID='OXYGEN' /
&SPEC ID='WATER VAPOR' /

&PART     ID                    ='Water_PART',
          SPEC_ID               ='WATER VAPOR',
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          MONODISPERSE          =.TRUE.,
          COLOR                 ='BLUE',
          AGE                   =4.0 /

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          FYI               ='SFPE Handbook, ABS - TABLE 3-4.16',
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          H                 =17.0,
          O                 =0.0,
          N                 =1.0,
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          ACTIVATION_TEMPERATURE          =100.0,
          RTI                             =100,
          PART_ID                         ='Water_PART',
          K_FACTOR                        =1.0,
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    DROPLET_VELOCITY=5.0/

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ORIENTATION=0.0,0.0,1.0/
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ORIENTATION=0.0,0.0,1.0/

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ORIENTATION=1.0,0.0,0.0/

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    MATL_MASS_FRACTION(1,1)         = 1.0,
    THICKNESS(1)                    = 0.2
    LEAK_PATH                       = 1,0 /

&SURF ID='TankWall',
    RGB=146,202,166,
    GEOMETRY='CYLINDRICAL',
    MATL_ID(1:2,1)='ALUMINUM','HYDROGEN'
    THICKNESS(1:2)=.0254,0.114
    LENGTH= 1.524 /

&SURF ID='Fire',
    FYI='Computer Fire - SFPE HB TABLE 3-1.19, TEST 12',
    COLOR='RED',
    HRRPUA=1870.0,
    TAU_Q=-400.0 /
   / RAMP_Q='FIRE' /

&OBST XB=0.0,9.64823,-1.77636E-15,0.2,0.0,4.2, COLOR='INVISIBLE', BNDF_OBST=.FALSE., SURF_ID='INERT'/ corridor wall
&OBST XB=2.0,8.0,2.33529,3.45062,0.0,1.0668, SURF_ID='INERT',BNDF_OBST=.FALSE./ main table
&OBST XB=1.63005,1.93485,3.03485,3.33965,0.0,1.524, SURF_ID='TankWall'/ vessel held
&OBST XB=0.576005,0.880805,4.49084,4.79564,0.0,1.524, SURF_ID='TankWall'/ vessel open
&OBST XB=0.2,1.34608,5.32056,14.1212,0.0,1.0668,BNDF_OBST=.FALSE., SURF_ID='INERT'/ side table
&OBST XB=2.25,3.25,2.40147,3.40147,1.0668,1.1668,BNDF_OBST=.FALSE., SURF_IDS='Fire','INERT','INERT'/ computer
&OBST XB=0.05,0.25,1.97065E-15,14.1,0.0,4.1,BNDF_OBST=.FALSE., SURF_ID='WALL'/ walls
&OBST XB=0.05,9.65,14.1,14.3,0.0,4.1,BNDF_OBST=.FALSE., SURF_ID='WALL'/ walls
&OBST XB=9.45,9.65,1.97065E-15,14.1,0.0,4.1,BNDF_OBST=.FALSE., SURF_ID='WALL'/ walls
&OBST XB=-0.05,0.05,1.97065E-15,1.97065E-15,0.0,4.1,BNDF_OBST=.FALSE., SURF_ID='WALL'/ walls
&OBST XB=7.65,7.75,-0.8,-0.1,0.0,0.0, COLOR='INVISIBLE',BNDF_OBST=.FALSE., SURF_ID='WALL'/ AcDbPolyline - 701
&OBST XB=3.75,4.65,-0.2,-0.1,0.0,0.0, COLOR='INVISIBLE',BNDF_OBST=.FALSE., SURF_ID='WALL'/ AcDbPolyline - 700
&OBST XB=-0.05,9.65,1.97065E-15,14.3,4.1,4.3, COLOR='INVISIBLE',BNDF_OBST=.FALSE., SURF_ID='WALL'/ ceiling

&SLCF PBY=3.2,          QUANTITY='MASS FRACTION', SPEC_ID='OXYGEN' /
&SLCF PBY=3.2,          QUANTITY='TEMPERATURE'/
&SLCF PBY=3.2,          QUANTITY='VISIBILITY'/
&SLCF PBY=3.2,          QUANTITY='PRESSURE'/
&SLCF PBZ=1.8288,       QUANTITY='MASS FRACTION', SPEC_ID='OXYGEN' /
&SLCF PBZ=1.0,          QUANTITY='TEMPERATURE'/
&SLCF PBZ=1.8288,       QUANTITY='VISIBILITY'/
&SLCF PBZ=1.8288,       QUANTITY='PRESSURE'/
&SLCF PBX=2.4,          QUANTITY='PRESSURE'/

&VENT SURF_ID='OPEN', MB='ZMAX', COLOR='INVISIBLE'/ Vent
```

```
&VENT SURF_ID='OPEN', MB='XMIN'/ Vent03
&VENT SURF_ID='OPEN', MB='XMAX'/ Vent04
&VENT SURF_ID='OPEN', MB='YMIN'/ Vent05
&VENT SURF_ID='OPEN', MB='YMAX'/ Vent06

&TAIL /
```

TrashCorrSprink.fds

```
&HEAD CHID='TrashCorrSprink'/
&TIME SYNCHRONIZE =.FALSE., T_END=300.0/
&DUMP RENDER_FILE='TrashCorrSprink.ge1', DT_RESTART=20.0 /
TrashCorrSprink.restart /
&MISC BAROCLINIC = FALSE, RESTART=.TRUE. /

&MESH ID='Mesh1', IJK=138,132,36, XB=6.2,20.0,23.0,36.2,0.0,3.6,/ MPI_PROCESS=0/
&MESH ID='Mesh2', IJK=30,140,25,  XB=20.0,29.0,5.0,47.0,0.0,7.5,/ MPI_PROCESS=1/
&MESH ID='Mesh3', IJK=20,20,28,   XB=29.0,35.0,25.1,31.1,0.0,8.4,/ MPI_PROCESS=2/
&MESH ID='Mesh4', IJK=46,140,20,  XB=6.2,20.0,5.0,47.0,3.6,9.6,/ MPI_PROCESS=3/
&MESH ID='Mesh5', IJK=30,39,16,   XB=20.0,29.0,24.2,35.9,7.5,12.3,/ MPI_PROCESS=4/

&SPEC ID='WATER VAPOR'/
&SPEC ID='OXYGEN' /

&PART ID                                    ='Water_PART',
      SPEC_ID                               ='WATER VAPOR',
      DIAMETER                              =500.0,
      MONODISPERSE                          =.TRUE.,
      COLOR                                 ='BLUE',
      AGE                                   =3.0/

&REAC       ID='POLYETHYLENE',
      FYI='SFPE Handbook, TABLE 3-4.15, 3-4.16',
      FUEL='TRASH_FUEL',
      C=2,
      H=4,
      CO_YIELD=0.024,
      SOOT_YIELD=0.102
      HEAT_OF_COMBUSTION=43600 /

&PROP ID                                    ='Default_SprayMod01',
      QUANTITY                              ='SPRINKLER LINK TEMPERATURE',
      ACTIVATION_TEMPERATURE                =74.0,
       PART_ID                              ='Water_PART',
       K_FACTOR                             =81.1322,
       OPERATING_PRESSURE                   =0.493462,
        DROPLET_VELOCITY                    =5.0/

&MATL       ID                              ='GYPSUM BOARD',
            FYI                             ='SFPE HandBook 4th Edn. Section 1 Ch. 10, Pg 1-190',
            DENSITY                         =930.0
```

```
                CONDUCTIVITY_RAMP           = 'k_ramp'
                SPECIFIC_HEAT_RAMP          = 'c_ramp' /
&RAMP ID='k_ramp', T=0.0 ,   F = 0.250 /
&RAMP ID='k_ramp', T=100 ,   F = 0.250 /
&RAMP ID='k_ramp', T=101 ,   F = 0.110 /
&RAMP ID='k_ramp', T=375 ,   F = 0.110 /
&RAMP ID='k_ramp', T=800 ,   F = 0.275 /
&RAMP ID='k_ramp', T=1000,   F = 0.540 /
&RAMP ID='c_ramp', T=25  ,   F = 2.000 /
&RAMP ID='c_ramp', T=80  ,   F = 2.250 /
&RAMP ID='c_ramp', T=110 ,   F = 18.00 /
&RAMP ID='c_ramp', T=150 ,   F = 1.500 /
&RAMP ID='c_ramp', T=602 ,   F = 1.000 /
&RAMP ID='c_ramp', T=650 ,   F = 3.000 /
&RAMP ID='c_ramp', T=660 ,   F = 3.000 /
&RAMP ID='c_ramp', T=675 ,   F = 1.000 /
&RAMP ID='c_ramp', T=1000,   F = 0.900 /

&DEVC ID='SPRK1', PROP_ID='Default_SprayMod01', XYZ=14.3341,27.979,3.37  /
&DEVC ID='SPRK2', PROP_ID='Default_SprayMod01', XYZ=9.76209,27.979,3.37  /
&DEVC ID='SPRK3', PROP_ID='Default_SprayMod01', XYZ=9.76209,31.408,3.37  /
&DEVC ID='SPRK4', PROP_ID='Default_SprayMod01', XYZ=14.3341,31.408,3.37  /
&DEVC ID='SPRK5', PROP_ID='Default_SprayMod01', XYZ=17.7884,30.9508,3.37 /

/TAU_Q=-450.0/

&SURF         ID                            ='BURN',
              FYI                           ='TRASH FIRE, NFPA HB - 2-50, 6-71   SFPE HB - 3-
                                             12 (Table 3-1.2 Sample F)',
              COLOR                         ='RED',
              HRRPUA                        =4280.0,
              RAMP_Q                        ='FIRE' /

&SURF         ID                            ='INERT1',
              COLOR                         ='SILVER'
              MATL_ID(1,1)                  = 'GYPSUM BOARD',
              MATL_MASS_FRACTION(1,1)       = 1.0,
              THICKNESS(1)                  = 0.2
              LEAK_PATH                     = 1,0
              BACKING                       = EXPOSED /

&RAMP ID='FIRE' T = 0.000, F=0.00 /
&RAMP ID='FIRE' T = 90.00, F=0.04 /
&RAMP ID='FIRE' T = 98.5,  F=0.33 /
```

&RAMP ID='FIRE' T = 300, F=0.33 /

&OBST XB=22.978,23.153,24.4767,26.9842,0.0,3.5052, SURF_ID='INERT1'/ Obstruction
&OBST XB=15.1122,16.1122,27.5125,28.5125,0.0,1.22, SURF_IDS='BURN','INERT','INERT'/ fuel
&OBST XB=21.0312,21.336,25.6032,26.5176,7.9248,7.9248, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 5EC
&OBST XB=21.0312,21.336,25.6032,26.5176,7.9248,7.9248, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 5EC
&OBST XB=21.9456,22.86,45.4152,45.72,4.2672,4.2672, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 661
&OBST XB=33.528,33.8328,15.8496,16.764,7.9248,7.9248, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 5D9
&OBST XB=8.8392,9.144,4.572,5.4864,4.2672,4.2672, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 4C0
&OBST XB=21.336,21.6408,28.0416,28.3464,7.9248,7.9248, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 5F1
&OBST XB=21.336,21.6408,28.0416,28.3464,7.9248,7.9248, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 5F1
&OBST XB=7.3152,8.2296,19.812,20.1168,4.2672,4.2672, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 49B
&OBST XB=7.3152,8.2296,27.432,27.7368,4.2672,4.2672, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 499
&OBST XB=4.7244,4.8768,49.9872,50.9016,4.2672,4.2672, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 417
&OBST XB=1.3716,1.524,48.6156,48.768,4.2672,4.2672, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 415
&OBST XB=1.524,1.6764,48.768,48.9204,4.2672,4.2672, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 415
&OBST XB=1.6764,1.8288,48.9204,49.0728,4.2672,4.2672, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 415
&OBST XB=1.8288,1.9812,49.0728,49.2252,4.2672,4.2672, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 415
&OBST XB=7.3152,8.2296,32.004,32.3088,4.2672,4.2672, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 48F
&OBST XB=7.3152,8.2296,44.8056,45.1104,4.2672,4.2672, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 480
&OBST XB=13.716,14.6304,17.0688,17.3736,0.0,0.0, COLOR='INVISIBLE', SURF_ID='INERT1'/ AcDbPolyline - 6DC
&OBST XB=19.2024,28.0416,30.48,30.7848,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=19.2024,28.3464,29.2608,30.48,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=19.5072,27.7368,31.0896,31.6992,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=19.5072,28.0416,30.7848,31.0896,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=19.812,27.432,31.6992,32.004,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=20.1168,26.5176,32.3088,32.6136,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=20.1168,27.1272,32.004,32.3088,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=20.4216,25.6032,32.6136,32.9184,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=20.7264,24.9936,32.9184,33.528,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=20.7264,27.432,25.2984,27.1272,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=21.0312,24.9936,33.528,33.8328,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=21.336,27.7368,27.1272,27.432,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
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&OBST XB=21.6408,27.7368,27.432,27.7368,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=21.6408,28.0416,28.0416,28.6512,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=21.6408,28.3464,28.6512,29.2608,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=21.9456,24.9936,34.1376,34.4424,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=21.9456,28.0416,27.7368,28.0416,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=22.5552,24.9936,34.4424,34.7472,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=23.1648,24.9936,34.7472,35.052,10.668,11.5824, COLOR='INVISIBLE', SURF_ID='INERT1'/ Obstruction
&OBST XB=24.9936,25.6032,32.6136,32.9184,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
&OBST XB=25.908,26.5176,32.3088,32.6136,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
&OBST XB=26.8224,27.1272,32.004,32.3088,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
&OBST XB=27.1272,27.432,31.6992,32.004,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
&OBST XB=27.432,27.7368,31.3944,31.6992,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
&OBST XB=27.7368,28.0416,30.7848,31.0896,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
&OBST XB=28.0416,28.3464,29.8704,30.48,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
&OBST XB=25.6032,25.908,32.6136,32.6136,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
&OBST XB=26.5176,26.8224,32.3088,32.3088,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
&OBST XB=28.3464,28.956,29.8704,29.8704,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
&OBST XB=24.9936,24.9936,32.9184,37.7952,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
&OBST XB=27.7368,27.7368,31.0896,31.3944,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
&OBST XB=28.0416,28.0416,30.48,30.7848,0.0,3.3528, SURF_ID='INERT1'/ Obstruction

&OBST XB=30.48,30.7848,29.2608,29.8704,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
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&OBST XB=19.2024,19.5072,29.5656,30.7848,7.9248,10.668, SURF_ID='INERT1'/ Obstruction
&OBST XB=19.2024,23.7744,29.2608,29.5656,7.9248,10.668, SURF_ID='INERT1'/ Obstruction
&OBST XB=19.5072,19.812,31.0896,31.6992,7.9248,10.668, SURF_ID='INERT1'/ Obstruction
&OBST XB=19.812,20.1168,31.6992,32.004,7.9248,10.668, SURF_ID='INERT1'/ Obstruction
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&OBST XB=20.4216,20.7264,32.6136,32.9184,7.9248,10.668, SURF_ID='INERT1'/ Obstruction
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&OBST XB=20.7264,21.0312,33.2232,33.528,7.9248,10.668, SURF_ID='INERT1'/ Obstruction
&OBST XB=20.7264,27.432,25.2984,25.6032,7.9248,10.668, SURF_ID='INERT1'/ Obstruction
&OBST XB=21.0312,21.336,33.528,33.8328,7.9248,10.668, SURF_ID='INERT1'/ Obstruction
&OBST XB=21.336,21.6408,27.1272,27.432,7.9248,10.668, SURF_ID='INERT1'/ Obstruction
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&OBST XB=23.7744,24.0792,29.5656,30.1752,7.9248,10.668, SURF_ID='INERT1'/ Obstruction
&OBST XB=24.0792,24.384,30.1752,30.48,7.9248,10.668, SURF_ID='INERT1'/ Obstruction
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&OBST XB=27.1272,27.432,25.6032,27.1272,7.9248,10.668, SURF_ID='INERT1'/ Obstruction
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&OBST XB=5.4864,27.432,5.4864,5.7912,4.2672,7.9248, SURF_ID='INERT1'/ Obstruction
&OBST XB=5.7912,22.86,43.8912,44.196,0.0,3.3528, SURF_ID='INERT1'/ Obstruction

&OBST XB=5.7912,27.1272,5.7912,7.0104,7.0104,7.9248, SURF_ID='INERT1'/ Obstruction
&OBST XB=6.7056,7.0104,13.4112,19.812,4.2672,7.9248, SURF_ID='INERT1'/ Obstruction
&OBST XB=7.0104,22.86,13.4112,19.812,7.0104,7.9248, SURF_ID='INERT1'/ Obstruction
&OBST XB=7.62,9.144,35.6616,35.9664,0.0,3.3528, SURF_ID='INERT1'/ Obstruction
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&TAIL /
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Appendix I: Hazardous Materials

Hydrogen

Hydrogen is classified as a flammable gas and therefore a hazardous material. There are five cylinders full of compressed hydrogen in the plant physiology lab. Each cylinder is a 300 rated size. These cylinders, when pressurized at 2400 psi, hold about 261 cubic feet of hydrogen. From Table 307.1(1) in the IBC the maximum allowable quantity for flammable gases is 2000 cubic feet when an automatic suppression system is installed in the building.

Characteristics of Hydrogen

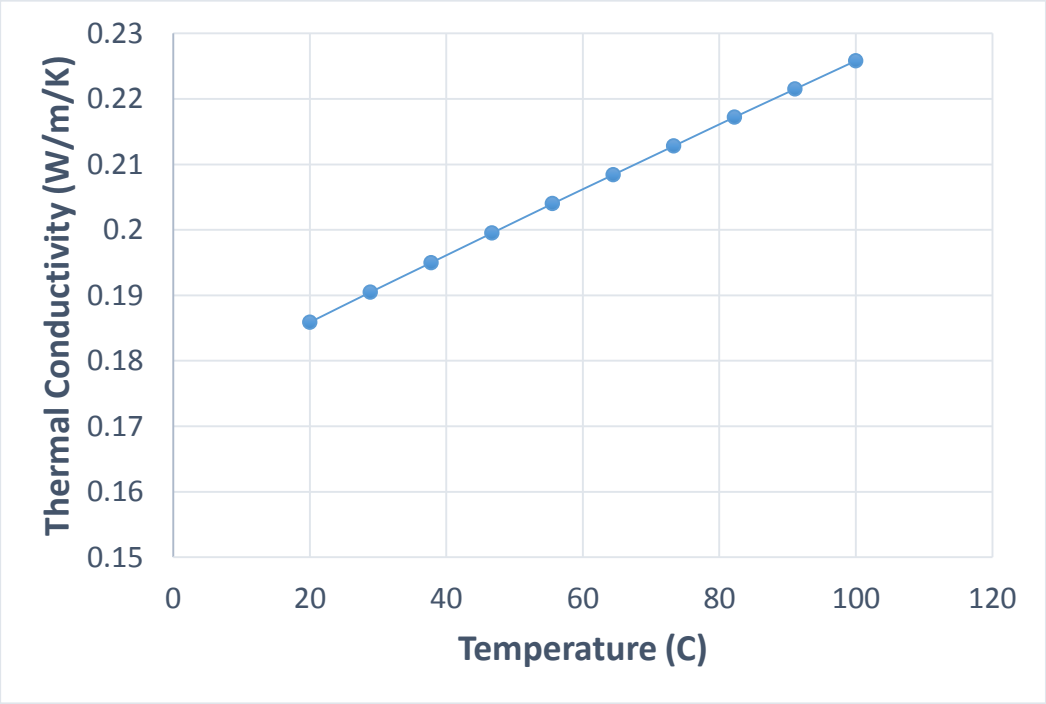


Figure 66 – Thermal Conductivity of Hydrogen with Constant Specific Volume of 0.081 m^3/kg

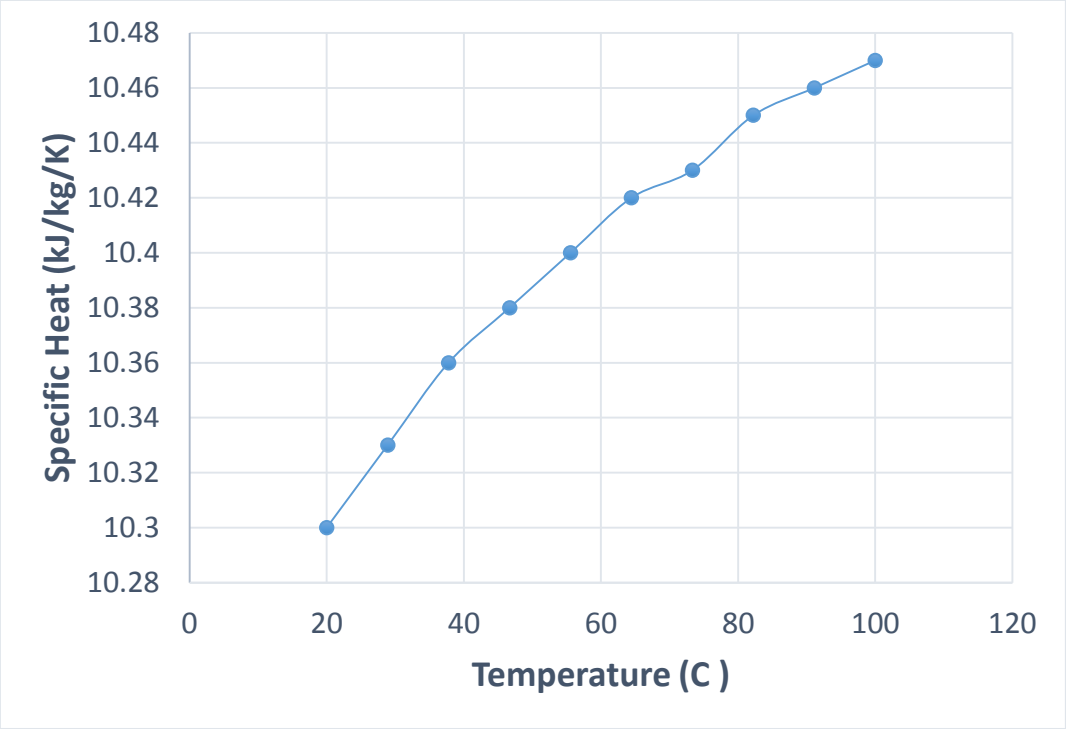


Figure 67 – Specific Heat of Hydrogen with Constant Specific Volume of 0.081 m^3/kg

Material Safety Data Sheet

Hydrogen

Section 1. Chemical product and company identification

Product name : Hydrogen

Supplier : AIRGAS INC., on behalf of its subsidiaries
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

Product use : Synthetic/Analytical chemistry.

Synonym : Dihydrogen; o-Hydrogen; p-Hydrogen; Molecular hydrogen; H2; UN 1049; UN 1966; Liquid hydrogen (LH2 or LH2)

MSDS # : 001026

Date of Preparation/Revision : **3/7/2013.**

In case of emergency : 1-866-734-3438

Section 2. Hazards identification

Physical state : Gas or Liquid.

Emergency overview : WARNING!

GAS:
CONTENTS UNDER PRESURE.
Extremely flammable
Do not puncture or incinerate container.
Can cause rapid suffocation.
May cause severe frostbite.
LIQUID:
Extremely flammable
Extremely cold liquid and gas under pressure.
Can cause rapid suffocation.
May cause severe frostbite.

Do not puncture or incinerate container. May cause target organ damage, based on animal data.

Contact with rapidly expanding gases or liquids can cause frostbite.

Target organs : May cause damage to the following organs: lungs.

Routes of entry : Inhalation

Potential acute health effects

Eyes : Contact with rapidly expanding gas may cause burns or frostbite. Contact with cryogenic liquid can cause frostbite and cryogenic burns.

Skin : Contact with rapidly expanding gas may cause burns or frostbite. Contact with cryogenic liquid can cause frostbite and cryogenic burns.

Inhalation : Acts as a simple asphyxiant.

Ingestion : Ingestion is not a normal route of exposure for gases Contact with cryogenic liquid can cause frostbite and cryogenic burns.

Potential chronic health effects

Chronic effects : May cause target organ damage, based on animal data.

Target organs : May cause damage to the following organs: lungs.

Medical conditions aggravated by over-exposure : Pre-existing disorders involving any target organs mentioned in this MSDS as being at risk may be aggravated by over-exposure to this product.

See toxicological information (Section 11)

Section 3. Composition, Information on Ingredients

Name	CAS number	% Volume	Exposure limits
Hydrogen	1333-74-0	100	Oxygen Depletion [Asphyxiant]

Section 4. First aid measures

No action shall be taken involving any personal risk or without suitable training.If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus.It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

Eye contact : Check for and remove any contact lenses. Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical attention immediately.

Skin contact : In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Clean shoes thoroughly before reuse. Get medical attention immediately.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Inhalation : Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Ingestion : As this product is a gas, refer to the inhalation section.

Section 5. Fire-fighting measures

Flammability of the product : Flammable.

Auto-ignition temperature : 500 to 571°C (932 to 1059.8°F)

Flammable limits : Lower: 4% Upper: 76%

Products of combustion : No specific data.

Fire hazards in the presence of various substances : Extremely flammable in the presence of the following materials or conditions: oxidizing materials.

Fire-fighting media and instructions : Use an extinguishing agent suitable for the surrounding fire.

Apply water from a safe distance to cool container and protect surrounding area. If involved in fire, shut off flow immediately if it can be done without risk.

Contains gas under pressure. In a fire or if heated, a pressure increase will occur and the container may burst or explode.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions : Immediately contact emergency personnel. Keep unnecessary personnel away. Use suitable protective equipment (section 8). Shut off gas supply if this can be done safely. Isolate area until gas has dispersed.

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Methods for cleaning up : Immediately contact emergency personnel. Stop leak if without risk. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

Handling : High pressure gas. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.

Never allow any unprotected part of the body to touch uninsulated pipes or vessels that contain cryogenic liquids. Prevent entrapment of liquid in closed systems or piping without pressure relief devices. Some materials may become brittle at low temperatures and will easily fracture.

Storage : Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F).
For additional information concerning storage and handling refer to Compressed Gas Association pamphlets P-1 Safe Handling of Compressed Gases in Containers and P-12 Safe Handling of Cryogenic Liquids available from the Compressed Gas Association, Inc.

Section 8. Exposure controls/personal protection

Engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.

Personal protection

Eyes : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists or dusts.

When working with cryogenic liquids, wear a full face shield.

Skin : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

The applicable standards are (US) 29 CFR 1910.134 and (Canada) Z94.4-93

Hands : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.

Insulated gloves suitable for low temperatures

Personal protection in case of a large spill : Self-contained breathing apparatus (SCBA) should be used to avoid inhalation of the product.

Product name

hydrogen	Oxygen Depletion [Asphyxiant]

Consult local authorities for acceptable exposure limits.

Section 9. Physical and chemical properties

Molecular weight : 2.02 g/mole

Molecular formula : H2

Boiling/condensation point : -253°C (-423.4°F)

Melting/freezing point : -259.15°C (-434.5°F)

Critical temperature : -240.15°C (-400.3°F)

Vapor density : 0.07 (Air = 1) Liquid Density@BP: 4.43 lb/ft3 (70.96 kg/m3)

Specific Volume (ft^3/lb) : 191.9386

Gas Density (lb/ft^3) : 0.00521

Section 10. Stability and reactivity

Stability and reactivity : The product is stable.

Incompatibility with various substances : Extremely reactive or incompatible with the following materials: oxidizing materials.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Toxicity data

Chronic effects on humans : May cause damage to the following organs: lungs.

Other toxic effects on humans : No specific information is available in our database regarding the other toxic effects of this material to humans.

Specific effects

Carcinogenic effects : No known significant effects or critical hazards.

Mutagenic effects : No known significant effects or critical hazards.

Reproduction toxicity : No known significant effects or critical hazards.

Section 12. Ecological information

Aquatic ecotoxicity

Not available.

Environmental fate : Not available.

Environmental hazards : No known significant effects or critical hazards.

Toxicity to the environment : Not available.

Section 13. Disposal considerations

Product removed from the cylinder must be disposed of in accordance with appropriate Federal, State, local regulation.Return cylinders with residual product to Airgas, Inc.Do not dispose of locally.

Section 14. Transport information

Regulatory information	UN number	Proper shipping name	Class	Packing group	Label	Additional information
DOT Classification	UN1049 UN1966	HYDROGEN, COMPRESSED Hydrogen, refrigerated liquid	2.1	Not applicable (gas).		**Limited quantity** Yes. **Packaging instruction** **Passenger aircraft** Quantity limitation: Forbidden. **Cargo aircraft** Quantity limitation: 150 kg
TDG Classification	UN1049 UN1966	HYDROGEN, COMPRESSED Hydrogen, refrigerated liquid	2.1	Not applicable (gas).		**Explosive Limit and Limited Quantity Index** 0.125 **ERAP Index** 3000 **Passenger Carrying Ship Index** Forbidden

						Passenger Carrying Road or Rail Index Forbidden
Mexico Classification	UN1049 UN1966	HYDROGEN, COMPRESSED Hydrogen, refrigerated liquid	2.1	Not applicable (gas).		-

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Section 15. Regulatory information

United States

U.S. Federal regulations :

TSCA 8(a) IUR: This material is listed or exempted.
United States inventory (TSCA 8b): This material is listed or exempted.

SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: hydrogen
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: hydrogen: Fire hazard, Sudden release of pressure

Clean Air Act (CAA) 112 accidental release prevention - Flammable Substances: Hydrogen

Clean Air Act (CAA) 112 regulated flammable substances: hydrogen

State regulations :

Connecticut Carcinogen Reporting: This material is not listed.
Connecticut Hazardous Material Survey: This material is not listed.
Florida substances: This material is not listed.
Illinois Chemical Safety Act: This material is not listed.
Illinois Toxic Substances Disclosure to Employee Act: This material is not listed.
Louisiana Reporting: This material is not listed.
Louisiana Spill: This material is not listed.
Massachusetts Spill: This material is not listed.
Massachusetts Substances: This material is listed.
Michigan Critical Material: This material is not listed.
Minnesota Hazardous Substances: This material is not listed.
New Jersey Hazardous Substances: This material is listed.
New Jersey Spill: This material is not listed.
New Jersey Toxic Catastrophe Prevention Act: This material is not listed.
New York Acutely Hazardous Substances: This material is not listed.
New York Toxic Chemical Release Reporting: This material is not listed.
Pennsylvania RTK Hazardous Substances: This material is listed.
Rhode Island Hazardous Substances: This material is not listed.

Canada

WHMIS (Canada) :

Class A: Compressed gas.
Class B-1: Flammable gas.

CEPA Toxic substances: This material is not listed.
Canadian ARET: This material is not listed.
Canadian NPRI: This material is not listed.
Alberta Designated Substances: This material is not listed.
Ontario Designated Substances: This material is not listed.
Quebec Designated Substances: This material is not listed.

Section 16. Other information

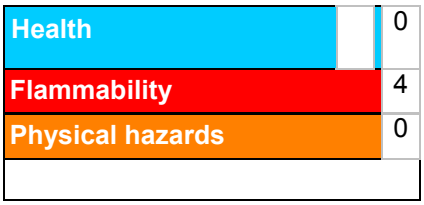
United States

Label requirements : GAS:
CONTENTS UNDER PRESURE.
Extremely flammable
Do not puncture or incinerate container.
Can cause rapid suffocation.
May cause severe frostbite.
LIQUID:
Extremely flammable
Extremely cold liquid and gas under pressure.
Can cause rapid suffocation.
May cause severe frostbite.

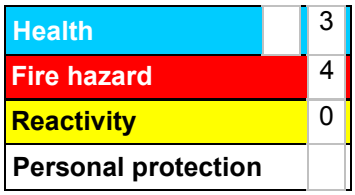
Canada

Label requirements : Class A: Compressed gas.
Class B-1: Flammable gas.

Hazardous Material Information System (U.S.A.) :



liquid:



National Fire Protection Association (U.S.A.) :

liquid:

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Appendix J: Compressed Cylinder Specifications

Hydrogen (H_2)

A flammable, colorless, odorless, compressed gas.

Product Specifications	Minimum Purity	O_2	H_2O	THC	Ar	CO	CO_2	N_2
Research	99.9999%	≤ 0.5	≤ 0.5	≤ 0.1	≤ 0.5	≤ 0.1	≤ 0.1	≤ 0.5
Ultra Pure Carrier (UPC)	99.9995%	≤ 1	≤ 1	≤ 0.5		* ≤ 1	* ≤ 1	≤ 3
Ultra High Purity (UHP)	99.999%	≤ 1	≤ 2	≤ 0.5		* ≤ 1	* ≤ 1	≤ 5
Zero	99.998%	≤ 5	≤ 3	≤ 0.5				
High Purity / High Pressure	99.995%	≤ 4	≤ 3					
Prepurified	99.99%	≤ 10	≤ 5					

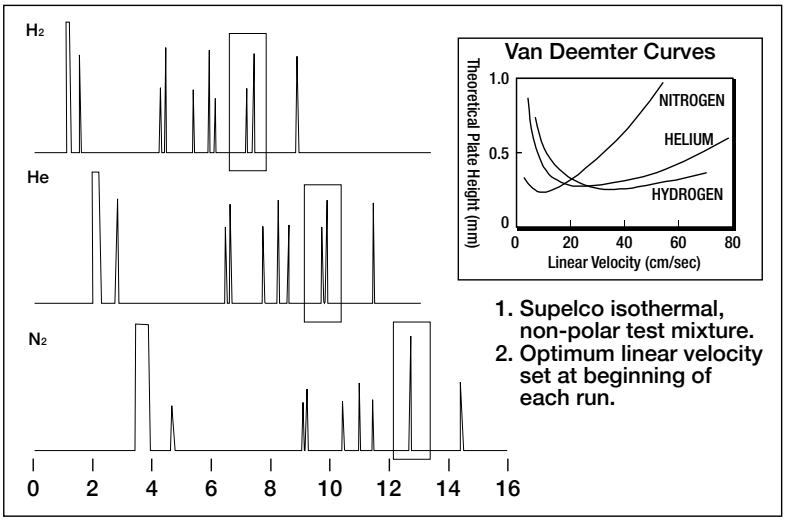
Concentrations given are ppm by volume unless otherwise specified.
* $CO + CO_2$ ≤ 1 ppm

PRODUCT	Ordering Information					Equipment Recommendations		
	Cylinder Size	Contents ft^3	Standard Valve Outlet (CGA)	Product Number	Cylinder Pressure at 70°F (psig)	Description Product Number	Delivery Pressure Range (psig)	Page Number
Research	300 200 80 35	261 197 74 31	350 350 350 350	HY R300 HY R200 HY R80 HY R35	2,400 2,000 2,000 2,000	**Two-Stage Regulators** Y12-N145 * 350 Y12-244 * 350 Y12-N245 * 350 Y12-T265 * 350 **Single-Stage Regulators** Y11-N145 * 350 Y11-244 * 350 Y11-T265 * 350 Y11-N245 * 350	**A = 0-25** **B = 0-50** **D = 0-100** ***E = 0-150** **†F = 0-250** ***G = 0-500** * Only available for the N245 series †Not available for the N145 series	**E21** **E12** **E21** **E23**
	Certificate of Analysis included.							
Ultra Pure Carrier (UPC)	300 200 80 35	261 197 74 31	350 350 350 350	HY UPC300 HY UPC200 HY UPC80 HY UPC35	2,400 2,000 2,000 2,000			
	Individual or Batch Certificate of Analysis available upon request.							
Ultra High Purity (UHP)	300 200 80 35	261 197 74 3`	350 350 350 350	HY UHP300 HY UHP200 HY UHP80 HY UHP35	2,400 2,000 2,000 2,000			
	Individual or Batch Certificate of Analysis available upon request.							
Zero	300 200 80 35	261 197 74 31	350 350 350 350	HY Z300 HY Z200 HY Z80 HY Z35	2,400 2,000 2,000 2,000			**E20** **E11** **E22** **E20**
	Individual or Batch Certificate of Analysis available upon request.							
High Purity / High Pressure	300 200 80 35 6K 3K	261 197 74 31 482 325	350 350 350 350 703 695	HY HP300 HY HP200 HY HP80 HY HP35 HY HP6K HY HP3K	2,400 2,000 2,000 2,000 6,000 3,500			
	Individual or Batch Certificate of Analysis available upon request.							
Prepurified	300 200 80 35	261 197 74 31	350 350 350 350	HY PP300 HY PP200 HY PP80 HY PP35	2,400 2,000 2,000 2,000			
	Individual or Batch Certificate of Analysis available upon request.					* Insert Delivery Pressure Range Code		

Hydrogen (H_2) Cont.

A flammable, colorless, odorless, compressed gas.

Technical Data & Shipping Information	
Molecular Weight	2.01588
Specific Volume	191.9 cf/lb @70° F & 1 ATM
Flammability Limits in Air	4.0 - 75% in Air
U.S. DOT Name	Hydrogen, Compressed
ID Number	UN 1049
U.S. DOT Hazard Class	2.1
U.S. DOT Label	Flammable Gas
CAS Registry	1333-74-0



When used as a carrier gas, hydrogen typically provides higher resolution at higher linear velocities than both helium and nitrogen.

Consider using a hydrogen generator to supply your FID carrier gas and/or fuel gas.

Airgas Quality Policy

The purpose of the Airgas Quality System is to continually improve our manufacturing and related processes to provide our customers with the highest product purity, consistency, and service.

''extension under load'' method described in ASTM E 8 (IBR, see § 171.7 of this subchapter).

(ii) For the ''extension under load'' method, the total strain (or extension under load) corresponding to the stress at which the 0.2 percent permanent strain occurs may be determined with sufficient accuracy by calculating the elastic extension of the gage length under appropriate load and adding thereto 0.2 percent of the gage length. Elastic extension calculations must be based on an elastic modulus of 30,000,000. However, when the degree of accuracy of this method is questionable the entire stress-strain diagram must be plotted and the yield strength determined from the 0.2 percent offset.

(iii) For the purpose of strain measurement, the initial strain must be set with the specimen under a stress of 12,000 p.s.i. and the strain indicator reading set at the calculated corresponding strain.

(iv) The cross-head speed of the testing machine may not exceed ⅛ inch per minute during the determination of yield strength.

(4) Each impact specimen must be Charpy V-notch type size 10 mm × 10 mm taken in accordance with paragraph 11 of ASTM A 333 (IBR, see § 171.7 of this subchapter). When a reduced size specimen is used, it must be the largest size obtainable.

(k) *Acceptable physical test results.* Results of physical tests must conform to the following:

(1) The tensile strength may not exceed 155,000 p.s.i.

(2) The elongation must be at least 16 percent for a two-inch gage length.

(3) The Charpy V-notch impact properties for the three impact specimens which must be tested at 0 °F may not be less than the values shown as follows:

Size of specimen (mm)	Average value for acceptance (3 specimens)	Minimum value (1 specimen only of the 3)
10.0×10.0	25.0 ft. lbs.	20.0 ft. lbs.
10.0×7.5	21.0 ft. lbs.	17.0 ft. lbs.
10.0×5.0	17.0 ft. lbs.	14.0 ft. lbs.

(4) After the final heat treatment, each vessel must be hardness tested on the cylindrical section. The tensile strength equivalent of the hardness number obtained may not be more than 165,000 p.s.i. (Rc 36). When the result of a hardness test exceeds the maximum permitted, two or more retests may be made; however, the hardness number obtained in each retest may not exceed the maximum permitted.

(l) *Rejected cylinders.* Reheat treatment is authorized for rejected cylinders. However, each reheat treated cylinder must subsequently pass all the prescribed tests. Repair by welding is not authorized.

(m) *Markings.* Marking must be done by stamping into the metal of the cylinder. All markings must be legible and located on a shoulder.

(n) *Inspector's report.* In addition to the requirements of § 178.35, the inspector's report for the physical test report, must indicate the average value for three specimens and the minimum value for one specimen for each lot number.

[Amdt. 178–114, 61 FR 25942, May 23, 1996, as amended at 66 FR 45385, 43588, Aug. 28, 2001; 67 FR 51652, Aug. 8, 2002; 68 FR 48571, Aug. 14, 2003; 68 FR 75748, 75749, Dec. 31, 2003]

§ 178.46 Specification 3AL seamless aluminum cylinders.

(a) *Size and service pressure.* A DOT 3AL cylinder is a seamless aluminum cylinder with a maximum water capacity of 1000 pounds and minimum service pressure of 150 psig.

(b) *Authorized material and identification of material.* The material of construction must meet the following conditions:

(1) Starting stock must be cast stock or traceable to cast stock.

(2) Material with seams, cracks, laminations, or other defects likely to weaken the finished cylinder may not be used.

(3) Material must be identified by a suitable method that will identify the alloy, the aluminum producer's cast number, the solution heat treat batch number and the lot number.

(4) The material must be of uniform quality. Only the following heat treatable aluminum alloys in table 1 and 2 are permitted as follows:

TABLE 1—HEAT OR CAST ANALYSIS FOR ALUMINUM; SIMILAR TO "ALUMINUM ASSOCIATION"[1] ALLOY 6061

[CHEMICAL ANALYSIS IN WEIGHT PERCENT[2]]

Si min/max	Fe max	Cu min/max	Mn max	Mg min/max	Cr min/max	Zn max	Ti max	Pb max	Bi max	Other		A1
										each max	total max	
0.4/0.8	0.7	0.15/0.4	0.15	0.8/1.2	0.04/0.35	0.25	0.15	0.005	0.005	0.05	0.15	Bal.

[1] The "Aluminum Association" refers to "Aluminum Standards and Data 1993", published by the Aluminum Association Inc.
[2] Except for "Pb" and "Bi", the chemical composition corresponds with that of Table 1 of ASTM B 221 (IBR, see § 171.7 of this subchapter) for Aluminum Association alloy 6061.

TABLE 2—MECHANICAL PROPERTY LIMITS

Alloy and temper	Tensile strength—PSI		Elongation—percent minimum for 2" or 4D[1] size specimen
	Ultimate—minimum	Yield—minimum	
6061–T6	38,000	35,000	[2]14

[1] "D" represents specimen diameters. When the cylinder wall is greater than 3/16 inch thick, a retest without reheat treatment using the 4D size specimen is authorized if the test using the 2 inch size specimen fails to meet elongation requirements.
[2] When cylinder wall is not over 3/16-inch thick, 10 percent elongation is authorized when using a 24t×6t size test specimen.

(5) All starting stock must be 100 percent ultrasonically inspected, along the length at right angles to the central axis from two positions at 90° to one another. The equipment and continuous scanning procedure must be capable of detecting and rejecting internal defects such as cracks which have an ultrasonic response greater than that of a calibration block with a 5/64-inch diameter flat bottomed hole.

(6) Cast stock must have uniform equiaxed grain structure not to exceed 500 microns maximum.

(7) Any starting stock not complying with the provisions of paragraphs (b)(1) through (b)(6) of this section must be rejected.

(c) *Manufacture.* Cylinders must be manufactured in accordance with the following requirements:

(1) Cylinder shells must be manufactured by the backward extrusion method and have a cleanliness level adequate to ensure proper inspection. No fissure or other defect is acceptable that is likely to weaken the finished cylinder below the design strength requirements. A reasonably smooth and uniform surface finish is required. If not originally free from such defects, the surface may be machined or otherwise conditioned to eliminate these defects.

(2) Thickness of the cylinder base may not be less than the prescribed minimum wall thickness of the cylindrical shell. The cylinder base must have a basic torispherical, hemispherical, or ellipsoidal interior base configuration where the dish radius is no greater than 1.2 times the inside diameter of the shell. The knuckle radius may not be less than 12 percent of the inside diameter of the shell. The interior base contour may deviate from the true torispherical, hemispherical or ellipsoidal configuration provided that—

(i) Any areas of deviation are accompanied by an increase in base thickness;

(ii) All radii of merging surfaces are equal to or greater than the knuckle radius;

(iii) Each design has been qualified by successfully passing the cycling tests in this paragraph (c); and

(iv) Detailed specifications of the base design are available to the inspector.

(3) For free standing cylinders, the base thickness must be at least two times the minimum wall thickness along the line of contact between the cylinder base and the floor when the cylinders are in the vertical position.

(4) Welding or brazing is prohibited.

(5) Each new design and any significant change to any acceptable design must be qualified for production by testing prototype samples as follows:

(i) Three samples must be subjected to 100,000 pressure reversal cycles between zero and service pressure or 10,000 pressure reversal cycles between zero and test pressure, at a rate not in

excess of 10 cycles per minute without failure.

(ii) Three samples must be pressurized to destruction and failure may not occur at less than 2.5 times the marked cylinder service pressure. Each cylinder must remain in one piece. Failure must initiate in the cylinder sidewall in a longitudinal direction. Rate of pressurization may not exceed 200 psig per second.

(6) In this specification ''significant change'' means a 10 percent or greater change in cylinder wall thickness, service pressure, or diameter; a 30 percent or greater change in water capacity or base thickness; any change in material; over 100 percent increase in size of openings; or any change in the number of openings.

(d) *Wall thickness.* The minimum wall thickness must be such that the wall stress at the minimum specified test pressure will not exceed 80 percent of the minimum yield strength nor exceed 67 percent of the minimum ultimate tensile strength as verified by physical tests in paragraph (i) of this section. The minimum wall thickness for any cylinder with an outside diameter greater than 5 inches must be 0.125 inch. Calculations must be made by the following formula:

$$S = [P(1.3D^2 + 0.4d^2)] / (D^2 - d^2)$$

Where:

S = Wall stress in psi;
P = Prescribed minimum test pressure in psig (see paragraph (g) of this section);
D = Outside diameter in inches; and
d = Inside diameter in inches.

(e) *Openings.* Openings must comply with the following requirements:

(1) Openings are permitted in heads only.

(2) The size of any centered opening in a head may not exceed one-half the outside diameter of the cylinder.

(3) Other openings are permitted in the head of a cylinder if:

(i) Each opening does not exceed 2.625 inches in diameter, or one-half the outside diameter of the cylinder; whichever is less;

(ii) Each opening is separated from each other by a ligament; and

(iii) Each ligament which separates two openings must be at least three times the average of the diameters of the two openings.

(4) All openings must be circular.

(5) All openings must be threaded. Threads must comply with the following:

(i) Each thread must be clean cut, even, without checks, and to gauge.

(ii) Taper threads, when used, must conform to one of the following:

(A) American Standard Pipe Thread (NPT) type, conforming to the requirements of NBS Handbook H–28 (IBR, see § 171.7 of this subchapter);

(B) National Gas Taper Thread (NGT) type, conforming to the requirements of NBS Handbook H–28; or

(C) Other taper threads conforming to other standards may be used provided the length is not less than that specified for NPT threads.

(iii) Straight threads, when used, must conform to one of the following:

(A) National Gas Straight Thread (NGS) type, conforming to the requirements of NBS Handbook H–28;

(B) Unified Thread (UN) type, conforming to the requirements of NBS Handbook H–28;

(C) Controlled Radius Root Thread (UN) type, conforming to the requirements of NBS Handbook H–28; or

(D) Other straight threads conforming to other recognized standards may be used provided that the requirements in paragraph (e)(5)(iv) of this section are met.

(iv) All straight threads must have at least 6 engaged threads, a tight fit, and a factor of safety in shear of at least 10 at the test pressure of the cylinder. Shear stress must be calculated by using the appropriate thread shear area in accordance with NBS Handbook H–28.

(f) *Heat treatment.* Prior to any test, all cylinders must be subjected to a solution heat treatment and aging treatment appropriate for the aluminum alloy used.

(g) *Hydrostatic test.* Each cylinder must be subjected to an internal test pressure using the water jacket equipment and method or other suitable equipment and method and comply with the following requirements:

(1) The testing apparatus must be operated in a manner so as to obtain accurate data. The pressure gauge used

must permit reading to an accuracy of one percent. The expansion gauge must permit reading the total expansion to an accuracy of either one percent or 0.1 cubic centimeter.

(2) The test pressure must be maintained for a sufficient period of time to assure complete expansion of the cylinder. In no case may the pressure be held less than 30 seconds. If, due to failure of the test apparatus, the required test pressure cannot be maintained, the test may be repeated at a pressure increased by 10 percent or 100 psig, whichever is lower. If the test apparatus again fails to maintain the test pressure, the cylinder being tested must be rejected. Any internal pressure applied to the cylinder before any official test may not exceed 90 percent of the test pressure.

(3) The minimum test pressure is the greatest of the following:

(i) 450 psig regardless of service pressure;

(ii) Two times the service pressure for cylinders having service pressure less than 500 psig; or

(iii) Five-thirds times the service pressure for cylinders having a service pressure of at least 500 psig.

(4) Permanent volumetric expansion may not exceed 10 percent of total volumetric expansion at test pressure.

(h) *Flattening test.* One cylinder taken at random out of each lot must be subjected to a flattening test as follows:

(1) The test must be between knife edges, wedge shaped, having a 60° included angle, and rounded in accordance with the following table. The longitudinal axis of the cylinder must be at an angle 90° to the knife edges during the test. The flattening test table is as follows:

TABLE 3—FLATTENING TEST TABLE

Cylinder wall thickness in inches	Radius in inches
Under .150	.500
.150 to .249	.875
.250 to .349	1.500
.350 to .449	2.125
.450 to .549	2.750
.550 to .649	3.500
.650 to .749	4.125

(2) An alternate bend test in accordance with ASTM E 290 using a mandrel diameter not more than 6 times the wall thickness is authorized to qualify lots that fail the flattening test of this section without reheat treatment. If used, this test must be performed on two samples from one cylinder taken at random out of each lot of 200 cylinders or less.

(3) Each test cylinder must withstand flattening to nine times the wall thickness without cracking. When the alternate bend test is used, the test specimens must remain uncracked when bent inward around a mandrel in the direction of curvature of the cylinder wall until the interior edges are at a distance apart not greater than the diameter of the mandrel.

(i) *Mechanical properties test.* Two test specimens cut from one cylinder representing each lot of 200 cylinders or less must be subjected to the mechanical properties test, as follows:

(1) The results of the test must conform to at least the minimum acceptable mechanical property limits for aluminum alloys as specified in paragraph (b) of this section.

(2) Specimens must be 4D bar or gauge length 2 inches with width not over 1½ inch taken in the direction of extrusion approximately 180° from each other; provided that gauge length at least 24 times thickness with width not over 6 times thickness is authorized, when cylinder wall is not over 3⁄16 inch thick. The specimen, exclusive of grip ends, may not be flattened. Grip ends may be flattened to within one inch of each end of the reduced section. When the size of the cylinder does not permit securing straight specimens, the specimens may be taken in any location or direction and may be straightened or flattened cold by pressure only, not by blows. When such specimens are used, the inspector's report must show that the specimens were so taken and prepared. Heating of specimens for any purpose is forbidden.

(3) The yield strength in tension must be the stress corresponding to a permanent strain of 0.2 percent of the gauge length.

(i) The yield strength must be determined by either the ''offset'' method or the ''extension under load'' method as prescribed in ASTM B 557 (IBR, see § 171.7 of this subchapter).

(ii) In using the ''extension under load'' method, the total strain (or ''extension under load'') corresponding to the stress at which the 0.2 percent permanent strain occurs may be determined with sufficient accuracy by calculating the elastic extension of the gauge length under appropriate load and adding thereto 0.2 percent of the gauge length. Elastic extension calculations must be based on an elastic modulus of 10,000,000 psi. In the event of controversy, the entire stress-strain diagram must be plotted and the yield strength determined from the 0.2 percent offset.

(iii) For the purpose of strain measurement, the initial strain must be set while the specimen is under a stress of 6,000 psi, the strain indicator reading being set at the calculated corresponding strain.

(iv) Cross-head speed of the testing machine may not exceed ⅛ inch per minute during yield strength determination.

(j) *Rejected cylinder.* Reheat treatment of rejected cylinders is authorized one time. Subsequent thereto, cylinders must pass all prescribed tests to be acceptable.

(k) *Duties of inspector.* In addition to the requirements of § 178.35, the inspector shall:

(1) Verify compliance with the provisions of paragraph (b) of this section by:

(i) Performing or witnessing the performance of the chemical analyses on each melt or cast lot or other unit of starting material; or

(ii) Obtaining a certified chemical analysis from the material or cylinder manufacturer for each melt, or cast of material; or

(iii) Obtaining a certified check analysis on one cylinder out of each lot of 200 cylinders or less, if a certificate containing data to indicate compliance with the material specification is obtained.

(2) The inspector shall verify ultrasonic inspection of all material by inspection or by obtaining the material producer's certificate of ultrasonic inspection. Ultrasonic inspection must be performed or verified as having been performed in accordance with paragraph (c) of this section.

(3) The inspector must also determine that each cylinder complies with this specification by:

(i) Selecting the samples for check analyses performed by other than the material producer;

(ii) Verifying that the prescribed minimum thickness was met by measuring or witnessing the measurement of the wall thickness; and

(iii) Verifying that the identification of material is proper.

(4) Prior to initial production of any design or design change, verify that the design qualification tests prescribed in paragraph (c)(6) of this section have been performed with acceptable results.

(l) *Definitions.* (1) In this specification, a ''lot'' means a group of cylinders successively produced having the same:

(i) Size and configuration;

(ii) Specified material of construction;

(iii) Process of manufacture and heat treatment;

(iv) Equipment of manufacture and heat treatment; and

(v) Conditions of time, temperature and atmosphere during heat treatment.

(2) In no case may the lot size exceed 200 cylinders, but any cylinder processed for use in the required destructive physical testing need not be counted as being one of the 200.

(m) *Inspector's report.* In addition to the information required by § 178.35, the record of chemical analyses must also include the alloy designation, and applicable information on iron, titanium, zinc, magnesium and any other applicable element used in the construction of the cylinder.

[Amdt. 178–114, 61 FR 25942, May 23, 1996, as amended at 66 FR 45386–45388, Aug. 28, 2001; 67 FR 51652, Aug. 8, 2002; 68 FR 75749, Dec. 31, 2003]

§ 178.47 Specification 4DS welded stainless steel cylinders for aircraft use.

(a) *Type, size, and service pressure.* A DOT 4DS cylinder is either a welded stainless steel sphere (two seamless hemispheres) or circumferentially welded cylinder both with a water capacity of not over 100 pounds and a

Safetygram-15

Cylinder Pressure-Relief Devices

General

Pressure-relief devices are installed on most cylinders to prevent the rupture of a normally pressurized cylinder when it is inadvertently exposed to fire or high temperatures. There are many types of pressure-relief devices; each has a designated use. Types of pressure-relief device designs include fusible plugs, rupture disks, rupture disks with fusible metal backing, and spring-loaded relief valves.

This Safetygram identifies the pressure-relief devices used to provide cylinder protection for various compressed gases. The specific pressure-relief device designated for a compressed gas cylinder depends on many factors, including the type of gas, the Department of Transportation (DOT) rated service, test pressures of the cylinder, and the cylinder size.

The Compressed Gas Association (CGA) lists the pressure-relief devices to be used on specific products in their Pamphlet S-1.1 "Pressure-Relief Device Standards Part 1: Cylinders for Compressed Gases." DOT regulations require compliance with this document for the selection and use of pressure-relief devices to be used on compressed gas cylinders.

CAUTION: Pressure-relief devices do not permit the user to exercise any less care in following proper handling, use, and storage procedures for cylinders.

Types of Cylinder Pressure-Relief Devices

The CGA has identified several types of pressure-relief devices:

Type CG-1: The Rupture Disk Device

A rupture disk device is a nonreclosing pressure-relief device actuated by static pressure and designed to function by the bursting of a pressure-containing disk. The disk is the operating part of the device. It is a flat disk, typically made of metal, designed to a specification that will allow it to burst at a predetermined pressure to permit the release of gas. Rupture disks relieve overpressure in cylinders that may result from an external fire or from overfilling. The burst pressure of rupture disks may not exceed the minimum DOT-required test pressure of the cylinder, which is generally 5/3 of the cylinder service pressure. Some exceptions to this rule are:

- The burst pressure must not exceed 4500 psig for DOT-3E or CTC-3E specification cylinders.
- The burst pressure must not be less than 105% of the cylinder test pressure or greater than 80% of the minimum burst pressure for DOT-39 cylinders.

The pressure rating of the disk is typically stamped onto the face of the device.

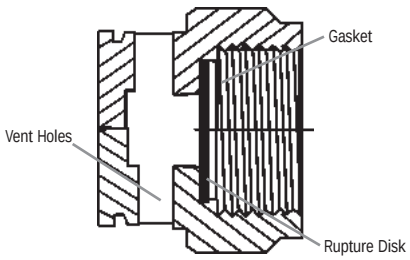


Fig. 1 Type CG-1 Pressure-Relief Device

Type CG-2: Fusible Plug Device Rated at 165°F

The fusible plug device is a nonreclosing pressure relief device designed to function by the yielding or melting of a plug of fusible metal. The type CG-2 plugs use an alloy that yields at a temperature not exceeding 170°F, nor less than 157°F (165°F nominal). These devices are not suitable for service pressures exceeding 500 psig. Pressures above 500 psig may cause the fusible alloy to extrude and eventually release the product.

Failures from excess pressure are time- and pressure-dependent. These devices cannot be relied upon to protect from overpressurization at temperatures below their melting point.

They are designed to protect the cylinder from overpressurization caused by exposure to excessive heat only. In the event a cylinder is exposed to fire or other sources of excess heat, the fusible plug is designed to melt and release the cylinder contents. This prevents product within the cylinder from creating excessively high pressures, caused by high external temperatures, and rupturing the cylinder. The plugs may use one of several designs to hold the fusible alloy in place. (See Fig. 2.) The temperature rating of the fusible metal is stamped into the face of the device.

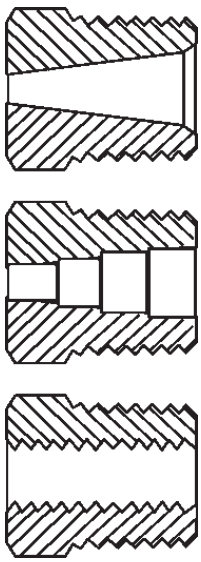


Fig. 2 Type CG-2, 3 Pressure-Relief Device

Type CG-3: Fusible Plug Device Rated at 212°F

This device is similar to the CG-2 pressure-relief device except that it uses a fusible metal with a higher melting temperature. The CG-3 device uses a fusible alloy with a melting point not exceeding 220°F, nor less than 208°F (212°F nominal). This device is most commonly found on acetylene cylinders.

Type CG-4: Combination Rupture Disk/ Fusible Alloy Rated at 165°F

The CG-4 consists of a rupture disk backed by a fusible plug on the atmospheric side of the disk. The burst pressure of the disk must not exceed the minimum DOT required test pressure of the cylinder (except as noted under Type CG-1); the fusible metal must yield between 157-170°F (165°F nominal).

The combination pressure-relief device provides protection against cylinder rupture caused by fire or high temperatures. If a fire occurs, the fusible metal yields or melts and cylinder overpressure caused by the heated gas is relieved by the bursting of the rupture disk. Both the pressure and temperature requirements of the device must be satisfied before the device can function.

This device will not protect a cylinder from overpressurization if the fusible alloy is not heated to its yield temperature. The fusible alloy will prevent the disk from rupture if it remains in place. The fusible metal prevents premature rupture disk failure from momentary overpressurization and also protects the disk from external corrosion which could cause premature failure of the rupture disk.

The face of these devices is marked with the burst pressure rating of the disk and the yield temperature of the fusible alloy.

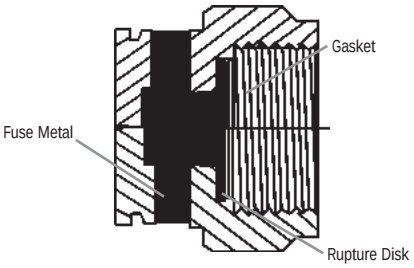


Fig. 3 Type CG-4, 5 Pressure-Relief Device

Type CG-5 Combination Rupture Disk/ Fusible Alloy Rated at 212°F

This device is the same as the CG-4 pressure-relief device except that it uses a fusible metal with a higher melting temperature. The CG-5 device uses a fusible alloy with a melting point not exceeding 220°F, nor less than 208°F (212°F nominal).

Type CG-7: Pressure-Relief Valve

Pressure-relief valves are spring-loaded valves that are normally closed. When the cylinder pressure exceeds the pressure setting of the spring in the relief valve, the valve opens and begins discharging the cylinder contents. Once the cylinder pressure decreases to the relief valve's pressure setting, the valve will normally reseat—without leakage—after venting sufficient gas to control the internal cylinder pressure. The pressure setting of the pressure-relief valve must not be less than 75%, nor more than 100% of the minimum test pressure of the cylinder. The reseating pressure must not be less than the pressure in a normally charged cylinder at 130°F.

An exception is the relief valve on DOT-39 cylinders. With these, the set pressure must not exceed 80% of the minimum burst pressure of the cylinder and must not be less than 105% of the cylinder test pressure.

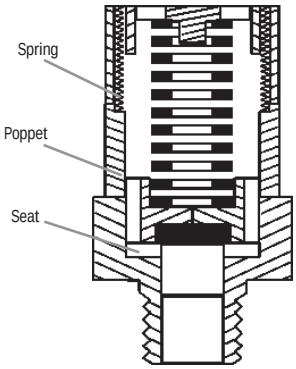


Fig. 4 Type CG-7 Pressure-Relief Device

Cylinder Pressure-Relief Devices for Several Gases

Cylinder pressure-relief devices for several common industrial gases are described below. For information about relief devices on other gas cylinders, consult your supplier.

Air, Argon, Helium, Nitrogen, Oxygen

These gases are nonflammable and stored in cylinders as high-pressure gases. The pressure-relief device used on these gas cylinders is normally Type CG-1.

Carbon Dioxide, Nitrous Oxide

These products are nonflammable and are stored in cylinders as liquefied compressed gases. Cylinders are normally protected by Type CG-1 pressure-relief devices. Small medical cylinders with post-type valves may be protected by Type CG-1 rupture disks or by Type CG-4 combination rupture disk/fusible plug relief devices.

Hydrogen

Hydrogen is flammable and stored in cylinders as a high-pressure gas. Cylinders under 65" long must be equipped with rupture disk/fusible alloy Type CG-4 or Type CG-5 devices. Cylinders greater than 65" in length and 9 5/8" in diameter must be equipped with Type CG-4, Type CG-5, or Type CG-1 rupture-disk devices. Cylinders over 65" in length and 22" in diameter must use Type CG-1 rupture disk devices.

Propane, APACHI™ Gas

Propane and Air Products' APACHI gas are flammable. They are stored in cylinders as liquefied compressed gases. Cylinders containing these products are usually protected by Type CG-7 spring-loaded, pressure-relief valves. A Type CG-3 212°F fusible metal plug may be used, but only when in combination with the Type CG-7 pressure-relief valve.

Acetylene

Acetylene is a flammable gas stored in cylinders as a dissolved gas. The cylinders are filled with a porous material saturated with a solvent, usually acetone. The acetylene dissolves into the solvent as it is placed into the cylinder. These cylinders are protected by Type CG-3 fusible metal plugs with a nominal yield temperature of 212°F. The devices are usually an integral part of the cylinder rather than being installed in the cylinder valve. Some small acetylene cylinders, Type B or MC size cylinders, are equipped with fusible plugs in the valve body.

Medical Gas Cylinders with Post-Type Valves

Post-type valves on small medical cylinders are generally equipped with Type CG-4 rupture disks with 165°F fusible metal backing. Carbon dioxide and nitrous oxide cylinders may be equipped with the CG-4 or the CG-1 devices.

Safety Considerations

Cylinder pressure-relief devices must be maintained in proper operating condition to function correctly.

- **NEVER** tamper with pressure-relief devices in valves or cylinders.
- Only qualified gas supplier personnel should service pressure-relief devices.
- Care should be taken when handling and storing cylinders to prevent damage to the pressure-relief devices.
- Do not obstruct any pressure-relief device. Dirt, paint, corrosion, or other materials prevent pressure-relief devices from functioning properly.
- If any obstruction, deformation, or extrusion of fusible metal is observed in a pressure-relief device, notify the supplier. The cylinder should be removed from service immediately and appropriate action arranged through the supplier.
- Any problem with pressure-relief devices should be immediately reported to your supplier.

Emergency Response System

- Call: **+1 (800) 523-9374** (Continental U.S. and Puerto Rico)
- Call: **+1 (610) 481-7711** (Other locations)
- 24 hours a day, 7 days a week
- For assistance involving Air Products and Chemicals, Inc. gases and equipment.

Product Safety Information

- For MSDS and Safetygrams: **www.airproducts.com/productstewardship**
- Fax-on-Demand: Call: **+1 (800) 245-2746**
- Enter MSDS Index No. 1000 for a complete list of available safety literature.
- 24 hours a day, 7 days a week

Technical Information Center

- Call: **+1 (800) 752-1597** (U.S.)
- Call: **+1 (610) 481-8565** (Other locations)
- Fax: **+1 (610) 481-8690**
- E-mail: **gasinfo@apci.com**
- Monday–Friday, 8:00 a.m.–5:00 p.m. EST

Information Sources

- Compressed Gas Association
  1725 Jefferson Davis Highway, Suite 1004
  Arlington, VA 22202-4102
  Phone: +1 (703) 412-0900
- National Fire Protection Association
  1 Batterymarch Park, P.O. Box 9101
  Quincy, MA 02269-9101
  Phone: +1 (800) 344-3555

Air Products and Chemicals, Inc., 7201 Hamilton Boulevard, Allentown, PA 18195-1501
Phone: +1 (800) 654-4567, +1 (610) 481-4911. Fax: +1 (800) 880-5204. www.airproducts.com

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Appendix K: Hydraulic Calculations for Fire Suppression System

Project name:			Agriculture Science Building (MRA1)										Date	20-Mar-13
Step No.	Nozzle Ident and Location		Flow in gpm		Pipe size	Pipe Fittings and Devices	Equivalent Pipe Length		Friction loss (psi/ft)		Pressure Summary		Notes	
	169		q		1	2E	L	5.75	C=	120	Pt	7.0	k=5.6	q = k * (Pt)^1/2
1						T	F	9			Pe	0.0		K_eq = Q/P^0.5
	36		Q	14.8	1.049		T	14.75	pf	0.075	Pf	1.1	Pt=8.1	K_eq = 5.2
	36	Down	q	0.0	1		L	0.5	C=	120	Pt	8.1		
2		RN				T	F	5			Pe	0.2		
	26		Q	14.8	1.049		T	5.5	pf	0.085	Pf	0.1	Pt=8.4	
	26		q		3		L	5.67	C=	120	Pt	8.4		
3							F	0			Pe			K_eq = Q/P^0.5
	25		Q	14.8	3.26		T	5.67	pf	0.000	Pf	0.0	Pt=8.4	K_eq = 5.1
	167		q		1		L	5.58	C=	120	Pt	7.0		
4						T	F	5			Pe			K_eq = Q/P^0.5
	35		Q	14.8	1.049		T	10.58	pf	0.075	Pf	0.8	Pt=7.8	K_eq = 5.3
	168		q	14.8	1	2E	L	5.75	C=	120	Pt	7.0		
5						T	F	9			Pe			Q=K*P^0.5
	35		Q	14.8	1.049		T	14.75	pf	0.075	Pf	1.1	Pt=8.1	
	35	Down	q	15.1	1		L	0.5	C=	120	Pt	8.1	k=5.3	q = k * (Pt)^1/2
6		RN				T	F	5			Pe	0.2		K_eq = Q/P^0.5
	25		Q	29.9	1.049		T	5.5	pf	0.274	Pf	1.5	Pt=9.8	K_eq = 9.55
	25		q	16.0	3		L	7.75	C=	120	Pt	9.8	k=5.1	q = k * (Pt)^1/2
7							F	0			Pe			
	24		Q	45.9	3.26		T	7.75	pf	0.002	Pf	0.0	Pt=9.8	
	24		q	29.9	3		L	7.5	C=	120	Pt	9.8	k=9.55	q = k * (Pt)^1/2
8							F	0			Pe			
	23		Q	75.8	3.26		T	7.5	pf	0.006	Pf	0.1	Pt=9.9	
	23		q	30.1	3		L	7.33	C=	120	Pt	9.9	k=9.55	q = k * (Pt)^1/2
9							F	0			Pe			
	22		Q	105.9	3.26		T	7.33	pf	0.011	Pf	0.1	Pt=10.0	
	22		q	30.2	3		L	1.17	C=	120	Pt	10.0	k=9.55	q = k * (Pt)^1/2
10						T	F	15			Pe			
	16		Q	136.1	3.26		T	16.17	pf	0.018	Pf	0.3	Pt=10.3	K_eq = 42.4
	27	Down	q		1		L	0.5	C=	120	Pt	8.1		
11		RN				T	F	5			Pe	0.2		K_eq = Q/P^0.5
	21		Q	29.9	1.049		T	5.5	pf	0.274	Pf	1.5	Pt=9.8	K_eq = 9.55
	21		q		3		L	8	C=	120	Pt	9.8		
12							F	0			Pe			
	20		Q	29.9	3.26		T	8	pf	0.001	Pf	0.0	Pt=9.8	
	20		q	29.9	3		L	8	C=	120	Pt	9.8	k = 9.55	q = k * (Pt)^1/2
13							F				Pe			
	19		Q	59.8	3.26		T	8	pf	0.004	Pf	0.0	Pt=9.8	
	19		q	29.9	3		L	7.5	C=	120	Pt	9.8	k = 9.55	q = k * (Pt)^1/2
14							F				Pe			
	18		Q	89.7	3.26		T	7.5	pf	0.008	Pf	0.1	Pt=9.9	
	18		q	30.0	3		L	7.33	C=	120	Pt	9.9	k = 9.55	q = k * (Pt)^1/2

15							F				Pe			
	17		Q	119.7	3.26		T	7.33	pf	0.014	Pf	0.1	Pt=10.0	
	17		q	30.2	3		L	5.33	C=	120	Pt	10.0	k = 9.55	q = k * (Pt)^1/2
16						T	F	15			Pe			
	16		Q	150.0	3.26		T	20.33	pf	0.022	Pf	0.4	Pt=10.4	
	16		q	136.7	3	3E	L	57.9	C=	120	Pt	10.4	k = 42.4	q = k * (Pt)^1/2
17						T	F	36			Pe	0.9		
	15		Q	286.7	3.26		T	93.9	pf	0.072	Pf	6.7	Pt=18.0	
	15		q		3	3E	L	41	C=	120	Pt	18.0		
18						2T	F	51			Pe	0.9		
	14		Q	286.7	3.26		T	92	pf	0.072	Pf	6.6	Pt=25.5	
	14	RN	q		4	E	L	12	C=	120	Pt	25.5		
19		2nd flr					F	10			Pe	5.2		
	13		Q	286.7	4.26		T	22	pf	0.019	Pf	0.4	Pt=31.1	
	13		q		3		L	21	C=	120	Pt	31.1		
20						T	F	15			Pe			
	12		Q	286.7	3.26		T	36	pf	0.072	Pf	2.6	Pt=33.7	
	12		q		4	E	L	45.16	C=	120	Pt	33.7		
21							F	10			Pe			
	11		Q	286.7	4.26		T	55.16	pf	0.019	Pf	1.1	Pt=34.8	
	11		q		4	2E	L	42.5	C=	120	Pt	34.8		
22							F	20			Pe			
	10		Q	286.7	4.26		T	62.5	pf	0.019	Pf	1.2	Pt=36.0	
	10	TOR	q		4	LE	L	28	C=	120	Pt	36.0		
23							F	6			Pe	12.1		6*0.433=2.6 psi
	3	BOR	Q	286.7	4.26		T	34	pf	0.019	Pf	0.7	Pt=48.8	
	3		q		4	2E	L	9.25	C=	140	Pt	48.8		
24						T	F	66			Pe			
	2		Q	286.7	4.26	CV 2GV	T	75.25	pf	0.015	Pf	1.1	Pt=49.9	
	2		q		6		L	60	C=	150	Pt	49.9		
25						T	F	33			Pe			
	1		Q	286.7	6.357	GV	T	93	pf	0.002	Pf	0.2	Pt=50.1	

HYDRAULIC DESIGN INFORMATION SHEET

Name: **MRA2**
Location: **Cal Poly**
1 Grand Ave SLO 93407
Building: **Agricultural Sciences Building**
Contractor:
File Name: **2ndflrcalc.the**
Construction: ☐ Combustible ☐ Noncombustible
Occupancy: **Business**
AHJ:

Date: **June 07, 2014**
System No.: **1**
Contract No.:
Drawing No.:
Calculated by: **Jonathan Schram**
Ceiling Height: ft

SYSTEM DESIGN

☐ NFPA 13: ☒ Light Hazard ☐ Ordinary Hazard Group: ☐ Extra Hazard Group:
Figure: Curve:
☐ Other (Specify):
☐ Specific Rulling:
Made By: Date:

Area of Sprinkler Operation: **225** sqft
Density: **0.1** gpm/sqft
Area per Sprinkler: **148** sqft
Hose Allowance Inside: gpm
Hose Allowance Outside: **250** gpm
Rack Sprinkler Allowance: gpm

System Type: ☒ Wet ☐ Dry ☐ Deluge ☐ Pre-Action

SPRINKLER or NOZZLE
Make: **Viking** Model: **VK100**
Size: **1/2** in K-factor: **5.6**
Temperature Rating: **212** ℉

CALCULATION SUMMARY

Flow Required: **420.31** gpm Pressure Required: **77.52** psi At: POC
"C" Factor Used: Overhead: Underground:

WATER SUPPLY

WATER FLOW TEST
Date: 1/31/02
Time:
Static: 85 psi
Residual: 65 psi
Flowing: 1045 gpm
Elevation: ft
Location:
Source of Information:

PUMP DATA
Rated Capacity: gpm
At: psi
Elevation: ft

TANK OR RESERVOIR
Capacity: gals
Elevation: ft

WELL
Proof Flow: gpm

COMMODITY STORAGE

Commodity: Class: Location:
Storage Height: Area: Aisle Width:
Storage Method: Solid Pile: % Palletized: % Rack: %

RACK STORAGE

☐ Single Row ☐ Conventional Pallet ☐ Automatic Storage ☐ Encapsulated
☐ Double Row ☐ Slave Pallet ☐ Solid Shelving ☐ Nonencapsulated
☐ Multiple Row ☐ Open

FLUE SPACING
Longitudinal: in Transverse: in

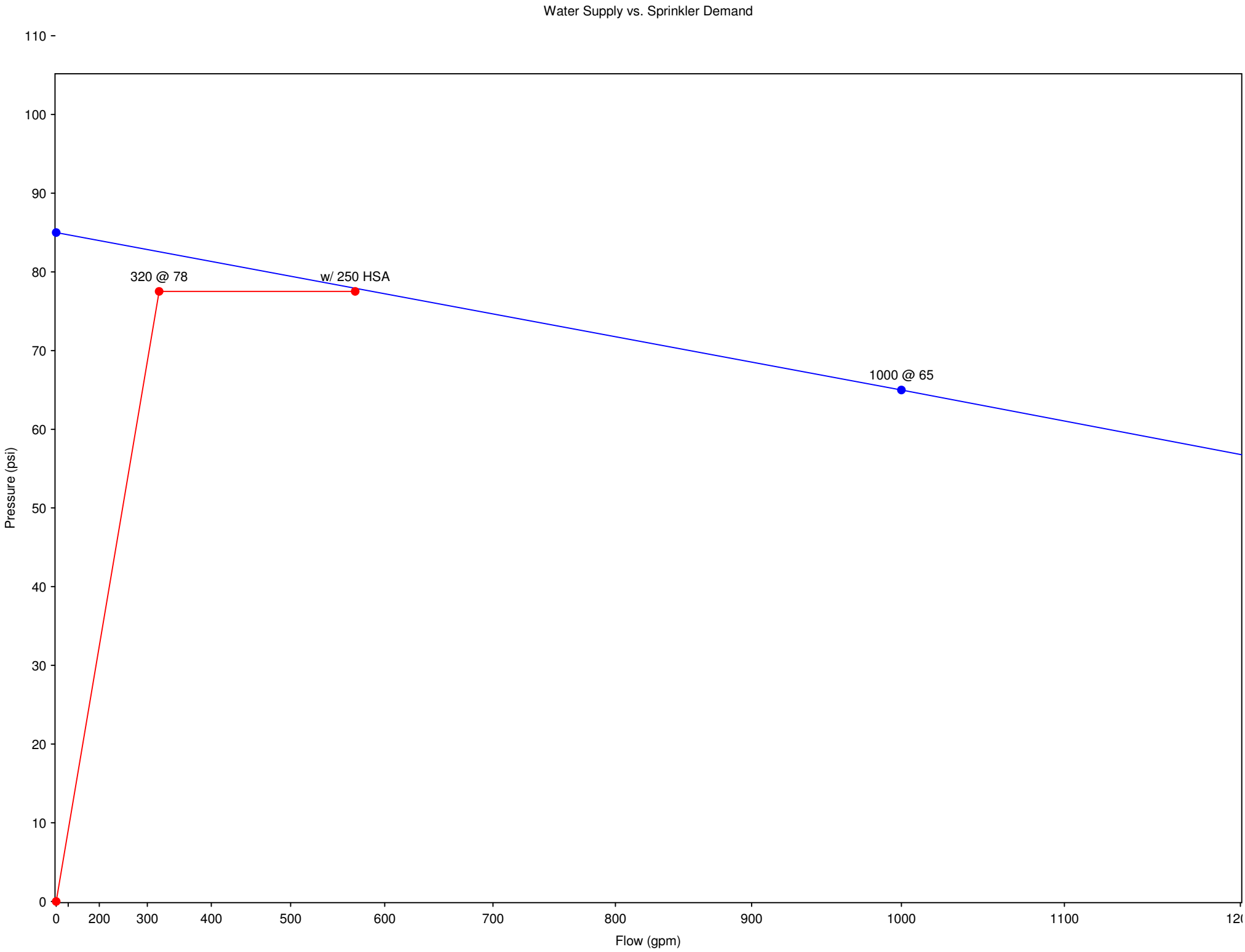
CLEARANCE FROM TOP OF STORAGE TO CEILING
ft in

Horizontal Barriers Provided:

Reference	Nozzle Type & Location		Flow in gpm	Pipe Size inches	Fittings & Devices		Pipe Eqiv. Length	Friction Loss psi/ft		Req. psi	Notes
2		q	0.00	5.349		lgth	60.000		Pt	77.06	
to		Q	320.31	150	GV T	ftg	27.046	0.005	Pf	0.45	
1	Source					tot	87.050		Pe	0.00	
3		q	0.00	4.444		lgth	20.000		Pt	73.40	
to		Q	320.31	140	Lt.E 2E CV 2GV	ftg	111.887	0.015	Pf	1.93	
2						tot	131.890		Pe	1.73	
10		q	0.00	4.260		lgth	24.000		Pt	62.86	
to		Q	320.31	120		ftg	0.000	0.024	Pf	0.57	
3						tot	24.000		Pe	9.97	
11		q	0.00	4.260		lgth	42.000		Pt	61.23	
to		Q	320.31	120	2E	ftg	26.334	0.024	Pf	1.63	
10						tot	68.330		Pe	0.00	
12		q	0.00	4.260		lgth	41.200		Pt	59.93	
to		Q	320.31	120	E	ftg	13.167	0.024	Pf	1.30	
11						tot	54.370		Pe	0.00	
13		q	0.00	2.635		lgth	50.000		Pt	41.38	
to		Q	320.31	120	T E	ftg	24.711	0.248	Pf	18.54	
12						tot	74.710		Pe	0.00	
14		q	0.00	2.635		lgth	19.250		Pt	41.30	
to		Q	35.63	120		ftg	0.000	0.004	Pf	0.08	
13						tot	19.250		Pe	0.00	
15		q	0.00	2.067		lgth	0.500		Pt	40.94	
to		Q	35.63	120	T	ftg	10.000	0.014	Pf	0.15	
14						tot	10.500		Pe	0.22	
166		q	0.00	1.610		lgth	15.700		Pt	39.83	
to		Q	35.63	120	T	ftg	8.000	0.047	Pf	1.11	
15						tot	23.700		Pe	0.00	
165		q	0.00	1.380		lgth	11.830		Pt	38.65	
to		Q	35.63	120		ftg	0.000	0.100	Pf	1.18	
166						tot	11.830		Pe	0.00	
163	6.53	q	35.63	1.049		lgth	23.400		Pt	29.78	
to		Q	35.63	120		ftg	0.000	0.379	Pf	8.86	
165						tot	23.400		Pe	0.00	
16		q	0.00	2.635		lgth	55.700		Pt	26.98	
to		Q	284.68	120	T	ftg	16.474	0.200	Pf	14.40	
13						tot	72.170		Pe	0.00	

Reference	Nozzle Type & Location		Flow in gpm	Pipe Size inches	Fittings & Devices		Pipe Eqiv. Length	Friction Loss psi/ft		Req. psi	Notes
17		q	0.00	2.635		lgth	7.900		Pt	25.92	
to		Q	229.81	120		ftg	0.000	0.134	Pf	1.06	
16						tot	7.900		Pe	0.00	
18		q	0.00	2.635		lgth	10.000		Pt	25.42	
to		Q	134.67	120		ftg	0.000	0.050	Pf	0.50	
17						tot	10.000		Pe	0.00	
19		q	0.00	2.067		lgth	0.500		Pt	26.44	
to		Q	54.87	120	T	ftg	10.000	0.031	Pf	0.32	
16						tot	10.500		Pe	0.22	
20		q	0.00	2.067		lgth	0.500		Pt	24.81	
to		Q	95.14	120	T	ftg	10.000	0.086	Pf	0.90	
17						tot	10.500		Pe	0.22	
21		q	0.00	2.067		lgth	0.500		Pt	23.50	
to		Q	134.67	120	T	ftg	10.000	0.163	Pf	1.71	
18						tot	10.500		Pe	0.22	
162	6.53	q	28.15	1.049		lgth	4.333		Pt	18.59	
to		Q	54.87	120	T	ftg	5.000	0.842	Pf	7.85	
19						tot	9.330		Pe	0.00	
161	6.53	q	26.71	1.049		lgth	8.333		Pt	16.74	
to		Q	26.71	120		ftg	0.000	0.222	Pf	1.85	
162						tot	8.330		Pe	0.00	
160	6.53	q	29.78	1.610		lgth	5.833		Pt	20.81	
to		Q	95.14	120	T	ftg	8.000	0.289	Pf	4.00	
20						tot	13.830		Pe	0.00	
159	6.53	q	26.34	1.380		lgth	14.833		Pt	16.27	
to		Q	65.36	120		ftg	0.000	0.306	Pf	4.54	
160						tot	14.830		Pe	0.00	
158	6.53	q	20.25	1.049		lgth	14.833		Pt	9.62	
to		Q	39.02	120		ftg	0.000	0.448	Pf	6.65	
159						tot	14.830		Pe	0.00	
157	6.56	q	18.77	1.049		lgth	10.416		Pt	8.19	
to		Q	18.77	120	E	ftg	2.000	0.116	Pf	1.44	
158						tot	12.420		Pe	0.00	
156	6.56	q	27.90	1.610		lgth	1.833		Pt	18.09	
to		Q	134.67	120	T	ftg	8.000	0.550	Pf	5.41	
21						tot	9.830		Pe	0.00	

Reference	Nozzle Type & Location		Flow in gpm	Pipe Size inches	Fittings & Devices		Pipe Eqiv. Length	Friction Loss psi/ft		Req. psi	Notes
155	6.56	q	25.44	1.610		lgth	8.500		Pt	15.04	
to		Q	106.78	120		ftg	0.000	0.358	Pf	3.04	
156						tot	8.500		Pe	0.00	
154	6.56	q	23.80	1.610		lgth	8.667		Pt	13.17	
to		Q	81.34	120		ftg	0.000	0.216	Pf	1.88	
155						tot	8.670		Pe	0.00	
153	6.56	q	21.81	1.380		lgth	8.740		Pt	11.05	
to		Q	57.54	120		ftg	0.000	0.242	Pf	2.11	
154						tot	8.740		Pe	0.00	
152	6.56	q	18.37	1.049		lgth	8.433		Pt	7.84	
to		Q	35.73	120		ftg	0.000	0.381	Pf	3.21	
153						tot	8.430		Pe	0.00	
151	6.56	q	17.36	1.049		lgth	8.433		Pt	7.00	
to		Q	17.36	120		ftg	0.000	0.100	Pf	0.84	
152						tot	8.430		Pe	0.00	
		Qt	570.31						Pt	77.52	


Water Supply vs. Sprinkler Demand
Pressure (psi)
Flow (gpm)
110
100
90
80
70
60
50
40
30
20
10
0
0
200
300
400
500
600
700
800
900
1000
1100
320 @ 78
w/ 250 HSA
1000 @ 65