Taft Community College - New Student Center

Fire and Life Safety Analysis

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Masters in Fire Protection Engineering

Culminating Project

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**Key Words**

- Fire Dynamics Simulator (FDS)
- International Building Code
- Life Safety Analysis
- Performance Based Design for Tenability
- Prescriptive Analysis
Acknowledgments

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To all those who hoped for my success, I thank you.
Abstract

The following report is a fire and life safety investigation into a new facility. The planned facility is a new Student Center at Taft Community College. The prescriptive requirements as set forth by the most up to date codes and standards chosen for the project are met. The building has been properly classified with respect to occupancy and construction type. Appropriate design for interior partitions and exterior walls have been identified. Interior finish requirements are elaborated so that adherence to these guidelines is made clear. The fire sprinkler system has an adequate supply of water from the municipal water supply alone to meet the calculated demand of the design area. A fire alarm system is proposed, but the proposed design does not make full use of the benefits of such a system due to reliance on fire sprinklers as a primary means of automatic detection. A third fire system proposed is a kitchen fire suppression system which will be dependent upon the competencies of the installing contractor in meeting the system manufacturer guidelines. Egress components are adequately sized and arranged, and occupant densities throughout the proposed floor plan allow for the fastest occupant movement based on the referenced literature. A performance based analysis has been conducted. Tenability was addressed with regards to visibility, exposure to carbon monoxide, temperature, and flashover conditions. Two design fire scenarios from the 2015 NFPA 101: Life Safety Code were chosen. The first involved Design Fire Scenario 1, which was modeled as a trash bag fire in an office. Results of this study found that the ASET exceeded RSET. ASET was set by tenability criteria for visibility while RSET was found using hydraulic calculation methods for the compartment where the fire was located. The second fire scenario involved Design Fire Scenario 6, which was modeled by burning bookcases located in a bookstore. ASET exceeded RSET for this study as well. ASET was set by visibility criteria while RSET was set by a full building egress time calculation based on hydraulic calculation methods. Recommendations for improving life safety at the Student Center include: (1) monitoring special events to ensure that neither decorations nor implements impede the means of egress or introduce materials which present a severe fire hazard; (2) resizing an exit within the Bookstore to match a second exit so that occupants can clearly identify this exit as an alternate means of egress; (3) monitoring for any changes in how areas in the Student Center are used to ensure adequacy of exits and egress components; (4) Adding redundancy for the fire sprinkler water flow switch to fire alarm monitor module connection.
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Taft Community College - New Student Center

Fire and Life Safety Analysis

Section 1: Project Introduction
Project Introduction

As a student in the Masters of Fire Protection Engineering program at California Polytechnic State University I have been tasked with investigating the fire and life safety features of a significant facility. For this project a new Student Center constructed at Taft Community College will be used. The purpose of this report is to consider the prescriptive fire protection and life safety requirements contained in the codes and standards applicable to the Student Center. Code and standard references are identified throughout this report when used.

A second major goal is to provide a performance-based analysis of key fire and life safety components: the fire alarm system, fire sprinkler system, and egress system. The goal is to discover whether the fire and life safety systems as proposed can ensure occupant safety under realistic fire scenarios.

The Student Center will provide an updated building to serve campus needs. It shall provide direct access to a newly remodeled on-campus courtyard and major walkway. The Student Center has public street access with the goal of allowing community members to utilize the building services along with students and faculty. Services at the student center are to include a kitchen, dining facility, student commons area, and a bookstore.

A rendering of the student center is provided in Figure 1.1 below.

![Student Center Rendering](image.png)

**Figure 1.1: Rendering of Student Center**
A plan view of the student center is provided in Figure 1.2 below. With this view one can see how the new facility is oriented with respect to the campus and the public ways. A county library is located due north of the Student Center. A public street, Wildcat Way, is located due east of the Student Center. The student dorms are to the South, and a campus courtyard is located to the West of the Student Center.

![Plan View of Student Center and Adjacent Facilities](image_url)

**Figure 1.2: Plan View of Student Center and Adjacent Facilities**

The Student Center is designed as a one-story building with a 21,000 sq. ft. floor area. The building height will be 35ft. There are three fire protection systems planned for this facility: fire alarm, fire sprinkler, and a kitchen fire suppression system. A floor plan of the Student Center is provided in Figure 1.3.
A number of codes and standards were used in evaluating the life safety systems of the Student Center. The 2015 International Building Code is the controlling document for the analysis that follows. Use of the most recent IBC edition satisfies the goal of proceeding with the project using the most up to date and widely accepted building practices in place for North America. Although many jurisdictions have versions of building codes based on amendments to the International Building Code, understanding the original document prepares one with a strong sense of acceptable building practices in general.

The following list is used to provide an overview and concise treatment of the codes, standards, and resources used for this project. Each document was chosen to provide the most up to date treatment of the relevant fire and life safety systems. Each document is followed in parenthesis by the term that it will be referred to henceforth when not fully named, where applicable.

- 2015 International Building Code (IBC)
- 2013 NFPA 72: National Fire Alarm Code (NFPA 72)
- 2015 International Mechanical Code (IMC)
- 2015 International Fire Code (IFC)
- 2013 NFPA 17A: Standard for Wet Chemical Extinguishing Systems (NFPA 17A)

Where one or more codes or standards conflict, the most stringent requirements will be enforced.

The main focus of this project is to understand whether the initial design satisfies the most current requirements and to enhance the fire and life safety of the building design with a performance based analysis. Where appropriate and beneficial, commentary will be provided to elaborate on fire and life safety requirements, systems, and practices.

This project is organized to follow the order of the topics presented in the IBC by chapter and then by section. Not all subjects contained in the IBC are applicable to this project. Starting with an
examination of the use and occupancy classification for the Student Center will set the ground work for discussing fire and life safety system requirements.
Section 2: Use and Occupancy Classification, Building Type, and

Fire and Smoke Protection Features
Use and Occupancy Classification, Building Type, and Fire and Smoke Protection Features

Designers must translate the intent of building stakeholders into a framework that satisfies the constraints that these same stakeholders place on the project. Selection of the building construction type based on the IBC categories is perhaps the next most important step in a project lifecycle after the location and intended function of the building are decided. Fire and life safety requirements are impacted substantially by the selection of a construction type and the arrangement of uses within a building. This section considers the uses that the Student Center must be able to accommodate to meet its campus functions, the building type selection chosen by the design team, and the ramifications that these selections have.

Use & Occupancy, and Building Construction Type

Occupancy Determination

Occupancy classification for the Student Center is identified on the project documents as A-2/F-1/M, non-separated occupancies. Group A-2 allows the use of cafeterias associated with commercial kitchens for food and/or drink consumption. The F-1 classification applies to the kitchen, which will use industrial style cooking equipment. Group M, mercantile, allows a portion of the student center to keep stock of goods and to sell such goods. The bookstore area fall under the Group M occupancy classification. Figure 2.1 below shows the relationship between the occupancies at the Student Center.

Given the use of multiple occupancies, Section 302.1 of the IBC refers one to Section 508 where mixed use and occupancy requirements are set forth. The Student Center is designed to follow Section 508.3 describing non-separated occupancies. The most restrictive occupancy is Group A-2.

With the Student Center falling under IBS Section 508.3, the most restrictive requirements of the occupancies present must be used when determining the total allowable building height and area. A major benefit of 508.3.3 it that no separation (fire resistance rated construction) is required between the occupancies.

Section 309.2 of the IBC addresses mercantile occupancies. It requires that hazardous materials be contained in a single control area of such occupancies and remain under the quantities listed in Table 414.2.5(1) of the IBC. At present, there are no control areas defined for the bookstore or food service area. Therefore, the Student Center must not store or display hazardous materials.
**Building Construction Type Classification**

Chapter 5 of the IBC provides guidance for determination of the appropriate construction type classification for the Student Center. Section 503.1.2 allows the Student Center to be treated separately from other campus buildings, even though such buildings may be on the same lot.

The following properties of the Student Center will be relevant to consider:

- Number of stories: 1
- Floor area: 21,000 sq. ft. or less
- Building Height: 35 ft. or less
- Automatic sprinklers: Yes
- Occupancy classification: A-2 (most restrictive), F-1, and M
- Frontage Area: Not used

Elimination of construction types does not occur with regards to the allowable building height, Table 504.3, or with the allowable number of stories, Table 504.4. In both cases the Student Center qualifies for all construction types, even with regard to 504.2.

The 2015 IBC includes area increase factors for fire sprinklers in Table 506.2. Here again the type of occupancy is not limited by the building properties, even when considering the most restrictive occupancy, A-2.

Ultimately, the design team chose Type II-B construction for the Student Center. This choice is in accordance with the code provisions as discussed above.

**Fire Resistance Requirements**

Selection of Type II-B construction means that IBC Table 601 does not place any requirements for fire resistance rated construction. The structural frame, interior walls, exterior walls, floor, and roof of the Student Center are not required to carry fire resistance ratings as shown by IBC Table 601. Moreover, IBC Table 602 shows that the Student Center is not required to have rated exterior walls since the fire separation distance is greater than 30 ft. for this Group A-2 occupancy.

Requirements for the construction assemblies falls to IBC Section 602.1.1, which requires the building elements to be of noncombustible materials. The Student Center follows this requirement without making use of exceptions for combustible elements in IBC Section 603.

**Incidental Use**

Use of a boiler room and a room for the storage of linens set in motion the need for the special treatment of such areas.

The boiler room is considered an incidental use per IBC Section 509 and Table 509. This requires a 1-hour fire resistance separation between the boiler room and other areas of the Student Center. Section 509.2 allows incidental uses to be classified under the same occupancy classification as the building occupancy where they are located, in this case Group A-2. IBC Section 509.3 limits the
area of incidental uses to ten percent of the building area. The boiler room has an area of 240 sq. ft., well below the ten percent threshold. It happens that the use of sprinkler protection in the boiler room as planned would negate the need for the 1-hour fire separation. However, the design team has chosen to install both sprinklers and the 1-hour fire separation. IBC Section 509.4.1 requires the 1-hour separation to consist of a fire barrier as defined in IBC Section 707.

The ASB Storage, Room 506A, also falls under the incidental use classification due to the expected storage of linens. The linens likely relate to student activities. There is a possibility, however, that the ASB Storage is intended for storing hazardous materials and must be considered a control area per IBC Section 414 rather than an incidental use. Although unlikely, at some point it will be helpful for the design documents to specifically detail the intended use of this space.

It also happens that another room, Electrical Room 522, is shown to have fire resistance rated walls. At this stage of analysis, and with the detail provided by the project plans, an exact reason or requirement for this construction cannot be identified.

One potential reason why Electrical Room 522 is required to have fire resistance-rated construction concerns IBC Section 1020.6. This section address corridor continuity and provides that “where the path of egress travel within a fire resistance-rated corridor to the exit includes travel along unenclosed exit access stairways or ramps, the fire resistance rating shall be continuous for the length of the stairway or ramp…”. This may be triggered if the doors leading to the Boiler Room and Electrical Room share a ramp, or share a platform. In this case, the design team may be taking extra caution to ensure that the egress from the boiler room is protected.

A second reason why Electrical Room 522 is required to have fire resistance-rated construction is that this may be necessary to comply with local Authority Having Jurisdiction practices.

Section 315.3.3 of the IFC prevents storage of combustible materials in the electrical and boiler rooms. It is also noted that the total areas of the Electrical Room 522, ASB Storage, and Boiler Room taken together do not exceed ten percent of the Student Center floor area.

Materials and Designs Related to Construction Assemblies

The following is an outline of the construction assemblies proposed for the Student Center.

Structural Framing

The structural frame for the Student Center is composed of steel W-shaped beams and columns. Such members are specified to conform to ASTM A-992 with a yield strength of 50 KSI. Open-web steel joists are used to support the roof decking.

Floor and Roof Assemblies

As a one-story building the first floor is composed of cast-in-place concrete. The concrete is to be reinforced with steel members with 1.5” of concrete cover. The total thickness of the concrete is to be 5”. This floor is to rest on a prepared subgrade foundation. The roof system is to consist of metal decking supported by steel joists and HSS tube steel columns.
**Exterior Walls**

Exterior walls are to utilize an EIFS system with interior gypsum that is Type X and min 5/8” thick. There are also curtain wall systems that provide vision glass and comprise the clerestory. The curtain walls are composed of aluminum framing.

**Interior Walls and Partitions**

A portion of interior walls are to be 12” thick, composed of concrete block filled with mortar, and are to rest on subgrade footings. A thin brick veneer is to be applied to both sides of these walls. A second subset of interior partitions are composed of steel stud framed wall assemblies using gypsum wall board.

**Fire Rated Assemblies**

Fire resistance rated assemblies for the incidental use areas are required to be fire barriers complying with IBC Section 707. One requirement with regards to fire barriers concerns continuity in Section 707.5. The fire barrier must extend from floor to the underside the metal deck assembly and must be continuous up through the concealed space above the gypsum ceiling.

IBC Section 703.2 provides that where a building element must be fire-resistance rated, the rating shall be determined in accordance with ASTM E119 or UL 263. UL provides an extensive online library of assemblies listed for fire resistance under UL 263. The project plans only specify a gypsum framed wall assembly with 6” wide steel studs for the fire barriers. This allows for many designs classified under the UL U400/V400 series.

Limits to openings in the fire barrier are provided in IBC Section 707.6.

IBC Sections 707.7 and 707.8 set requirements for penetrations through fire barriers and for joints between fire barriers, respectively. For penetrations, IBC Section 714 must be adhered to. This section specifies that penetrations must be protected with an approved through-penetration firestop system tested in accordance with ASTM E814/UL 1479. A similar provision is set for joints in Section 715 where the firestop joint system must be tested to ASTM E1966/UL 2079. These firestop requirements are mentioned specifically because they are an often overlooked aspect of fire protection systems. Poor planning on the part of architects and mechanical, electrical, drywall, and other contractors can result in penetrations or joints that unduly complicate firestop efforts.

The requirements of 714 will apply to the Student Center. Figures 2.2, 2.3, and 2.4 below contain common firestop systems for penetrations through gypsum framed wall assemblies.
1. **Wall Assembly** — The 1 or 2 hr fire-rated gypsum wallboard stud wall assembly shall be constructed of the materials and in the manner specified in the individual UL109 or U400 Series Wall and Partition Design in the UL Fire Resistance Directory and shall include the following construction features:

   A. **Studs** — Wall framing may consist of either wood studs or steel channel studs. Wood studs shall consist of nominal 2 by 4 in. (51 by 102 mm) lumber spaced 16 in. (406 mm) OC. Steel studs to be min 2-1/2 in. (64 mm) wide and spaced max 24 in. (610 mm) OC. When steel studs are used and the diam of opening exceeds the width of stud cavity, the opening shall be framed on all sides using lengths of steel stud installed between the vertical studs and screw-attached to the steel studs at each end. The framed opening in the wall shall be 4 to 6 in. (102 to 152 mm) wider and 4 to 6 in. (102 to 152 mm) higher than the diam of the penetrating item such that, when the penetrating item in installed in the opening, a 2 to 3 in. (51 to 76 mm) clearance is present between the penetrating item and the framing on all four sides.

   B. **Gypsum Board** — 9/16 in. (14 mm) thick, 4 ft (122 cm) wide with square or tapered edges. The gypsum board type, thickness, number of layers, fastener type and sheet orientation shall be as specified in the individual UL109 or U400 Series Design in the UL Fire Resistance Directory. Max diam of opening is 32-1/4 in. (819 mm) for steel stud walls. Max diam of opening is 14-1/2 in. (368 mm) for wood stud walls. The F and FH Ratings of the firestop system are equal to the fire rating of the wall assembly.

---

**Figure 2.2: Firestop System Detail**
System No. W·L·1389

<table>
<thead>
<tr>
<th>ANSI/UL1479 (ASTM E814)</th>
<th>CAN/ULC S115</th>
</tr>
</thead>
<tbody>
<tr>
<td>F Ratings — 1 and 2 Hr (See Items 1 and 3)</td>
<td>F Ratings — 1 and 2 Hr (See Items 1 and 3)</td>
</tr>
<tr>
<td>T Rating — 0 Hr</td>
<td>FT Rating — 0 Hr</td>
</tr>
<tr>
<td>FH Ratings — 1 and 2 Hr (See Items 1 and 3)</td>
<td>FTH Rating — 0 Hr</td>
</tr>
</tbody>
</table>

1. Wall Assembly — The 1 or 2 hr fire-rated gypsum board/stud wall assembly shall be constructed of the materials and in the manner described in the individual U400, V400 or W400 Series Wall and Partition Designs in the UL Fire Resistance Directory, and shall include the following construction features:
   A. Studs — Wall framing shall consist of min 3-3/4 in. (92 mm) wide steel studs spaced max 24 in. (610 mm) OC.
   B. Gypsum Board — Thickness, type, number of layers and fasteners, as specified in the Individual Wall and Partition Design. Max height of opening is 3-1/2 in. (89 mm), Max width of opening is 32 in. (813 mm).
   The hourly F, FH Ratings of the firestop system are equal to the hourly fire rating of the wall assembly in which it is installed.
2. Through Penetrants — Multiple pipes or conduits installed in single layer array within the firestop system. The annular space between the pipes and conduits and the edges of the opening shall be min 0 in. (0 mm, point contact) to max 1-3/8 in. (35 mm). The separation between pipes and conduits to be a min 0 in. (0 mm, point contact) to a max 1-1/4 in. (32 mm). Pipes and conduits to be rigidly supported on both sides of wall assembly. The following types and sizes of metallic pipes or conduits may be used:
   A. Steel Pipe — Nom 2 in. (51 mm) diameter (or smaller) Schedule 5 (or heavier) steel pipe.
   B. Conduit — Nom 2 in. (51 mm) diameter (or smaller) rigid steel conduit or steel electrical metallic tubing (EMT).
3. Fill Void or Cavity Materials* — Sealant — Min 5/8 in. (16 mm) thickness of fill material installed to completely fill annular space between pipes, conduits and gypsum flush with each surface of wall. Min 1/2 in. (13 mm) diam bead of fill material applied to through penetrant/wall interface at the point contact locations on both sides of the wall. The 2 hour F, FH Ratings apply only when FS-ONE Sealant is used.
   HILTI CONSTRUCTION CHEMICALS, DIV OF HILTI INC — HILTI CP 608 Flexible Firestop Sealant or FS-ONE Sealant, FS-ONE MAX Intumescent Sealant
   * Indicates such products shall bear the UL or cUL Certification Mark for jurisdictions employing the UL or cUL Certification (such as Canada), respectively.

Figure 2.3: Firestop System Detail
With a non-rated roof assembly, it would not be possible for head-of-wall joints to comply with Section 715. Fortunately, IBC Section 707.9 allows that joints between a fire barrier and non-rated roof or wall assemblies are to be protected with less stringent methods. It is only required that an approved system or material be installed that is secured in place, can retard the passage of flame and hot gases, and accommodate building movement. In practice, there are no readily available means to represent that these requirements have been met without referring to tested and listed...
assemblies. A performance-based design will be performed in Section 8 to offer a means of satisfying these requirements.

Summary

The selection of Type II-B construction exceeds the IBC requirements given the size and layout of the Student Center. It also seems to have allowed the designers more flexibility in specifying an aesthetically pleasing and functional space. This analysis concludes that the requirements of the 2015 IBC in regards to structural fire protection features have been satisfied.

Given a safe framework, the next task is to consider the interior environment in which occupants will reside. For most occupants the structural design of a building is of little importance when compared to interior finishes used. In a similar fashion, these interior finishes can be the first factor that determines the ultimate severity of fire or emergency events.
Taft Community College - New Student Center

Fire and Life Safety Analysis

Section 3: Interior Finish and Flammability Assessment
Interior Finish and Flammability Assessment

All the efforts to provide a safe built environment against fire can be undone if a relatively small fire event negatively impacts occupant well-being. One potential hazard that could precipitate this scenario involves the interior finish materials used within the built environment. Flammability of interior finish materials must be taken into account to avoid the use of materials that would generate excessive amounts of toxic products, smoke, and heat in the presence of a fire exposure. In this section the prescriptive code requirements regulating the use of interior finish materials are examined and applied to the Student Center.

While it is beneficial to apply the prescriptive requirements to interior finish, a life safety design professional should also be aware of the test standards that provide the foundation for the code requirements. Many times, the ratings assigned to wall assemblies or to wall coverings are hard to appreciate without understanding the means by which such ratings are granted. Therefore, this section will also provide comments on those test standards which have the largest footprint on the built environment: ASTM E84 and ATSM E119/UL 263.

Code Requirements for Interior Ceiling and Wall Finishes

Chapter 8 of the IBC details interior finish requirements. Section 803.1 requires wall and ceiling finishes to be classified by one of three test methods: ASTM E84, NFPA 286, or NFPA 265. NFPA 286 and NFPA 265 have pass/fail criteria and do not rank materials. ASTM E84 indexes materials into one of three categories. Figure 3.1 below is an excerpt from the IBC showing the ASTM E84 index categories.

803.1.1 Interior wall and ceiling finish materials.
Interior wall and ceiling finish materials shall be classified in accordance with ASTM E84 or UL 723. Such interior finish materials shall be grouped in the following classes in accordance with their flame spread and smoke-developed indexes.

Class A: = Flame spread index 0-25; smokedeveloped index 0-450.
Class B: = Flame spread index 26-75; smokedeveloped index 0-450.
Class C: = Flame spread index 76-200; smokedeveloped index 0-450.

Figure 3.1: IBC Section 803.1.1 Excerpt

There is an exemption in Section 803.2 that could apply to wall and ceiling coverings at the Student Center. The exemption states that materials with a thickness less than 0.036” need not be tested to the aforementioned standards and can be used without limitation.

Other requirements of Chapter 8 should be considered if any of the following wall or ceiling finishes are used:

- Foam Plastics
- Textile Coverings
- Vinyl Coverings
- High-density Polyethylene Coverings
Polypropylene Coverings

IBC Section 803.11 and Table 803.11 specify the finish requirements with respect to ASTM E84 based on occupancy. A snapshot of Table 803.11 with red markups to indicate the applicable requirements is provided in Table 3.1 below.

**Table 3.1: IBC Table 803.11 Excerpt**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>SPRINKLERED</th>
<th>NONSPRINKLERED</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1 &amp; A-2</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>A-3</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>B, E, M, R-1</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>R-4</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>F</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>H</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>I-1</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>I-2</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>I-3</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>I-4</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>R-2</td>
<td>C</td>
<td>C</td>
</tr>
</tbody>
</table>

Finish materials must be securely attached to walls and ceilings per 803.12, and when attached to fire-resistance rated construction must be attached to comply with 803.13.

**Code Requirements for Interior Floor Finishes**

Interior finish requirements for floors are provided in IBC Section 804. It happens that the IBC exempts what are defined as traditional floor coverings – wood, vinyl, linoleum, or terrazzo – along with resilient floor coverings and floor coverings without fibers from the requirements of 804.2 to 804.4.2.

The IBC requires floor finish and floor covering material to be tested to NFPA 253, which provides a Class I or Class II rating to floor coverings. All occupancies shall have interior floor finish materials comply with the “pill test” (CPSC 16 CFR Part 1630). The Student Center floor finish materials must also gain a Class II rating per NFPA 253.

**Code Requirements for Acoustical Ceiling Systems**

The use of a drop-ceiling in the Student Center triggers the need to adhere to IBC Section 808. This section is not prohibitive, specifying that installation of such ceilings, “shall conform to generally
accepted engineering practice.” Given that the drop-ceiling is not part of a fire resistance rated floor/ceiling assembly, IBC Section 808.1.1.1 requires installation in accordance with ASTM C635 and ASTM C636.

**Flammability Assessment**

Design professionals are faced with a multitude of test requirements when planning for fire and life safety. This makes it difficult to be fully aware of the test procedures and the resources that the testing and listing agencies provide for understanding the test results. In this section ASTM E84 and ASTM E119/UL 263 are examined more closely. The goal is to motivate an appreciation for a better understanding of the test standards governing the built environment.

**ASTM E84**

ASTM E84, also known as the Steiner Tunnel Test, is a flame spread assessment test. Equivalent test standards include NFPA 255. The result of the test is a flame spread and smoke development index that is assigned to the material tested.

The test procedure involves a specimen at a standard size mounted to the ceiling of the test enclosure. On one end, the sample is exposed to a 79 kW gas burner, and air is forced through the apparatus at a rate of 1.2 meters/second. The test ranks materials along an index of 0 to 100. The rating of 0 is set by the flame spread and smoke development character exhibited by inorganic cement board. The rating of 100 relates to the flame spread and smoke development of red oak flooring.

The NFPA Handbook, in Section 2 Chapter 5, raises the following concerns with ASTM E84: the requirement to mount the test specimen on the ceiling, limited ability to test materials which may melt and drip, and limited ventilation for polymer foams (ventilation limited conditions). The Handbook states: “While values obtained from this apparatus have been used for regulatory purposes over the last several decades, its relationship to real-world applications has not been established.”

Moreover, ASTM E84 does not test specimens in the configuration or size in which the materials are expected to be produced and/or used.

These notes should make a life safety design professional cautious when considering the flammability of materials which he or she is unfamiliar with. Although ASTM E84 is currently the most established tool for comparing flammability characteristics, the test standard may not provide a reasonable degree of assessment in high-risk situations.


ASTM E119/UL 263 is perhaps the most influential test standard in the construction industry. It is responsible for assigning fire resistance ratings to entire assemblies and to construction materials. Underwriters Laboratories (UL) provides an extensive online database of assemblies tested to this standard, and even provides guide information that helps users understand the test, exceptions, and clarifications. This test involves exposing construction assemblies or materials to a test enclosure.
held at specific temperature, pressure, and loading conditions. The time during which the test specimens perform to a satisfactory level determines the fire resistance rating of the specimen. ASTM E119 uses what is called the “standard time-temperature curve” as shown in Figure 3.2 below taken from the NFPA Handbook.

The time-temperature curve itself is ubiquitous in fire testing, forming the basis of other test standards such as UL 1479 for firestop through penetration systems and UL 2079 for fire resistance rated joint systems.

Acceptance criteria can vary depending on what is being tested. For example, wall assemblies are subject what is called a hose stream test after the furnace test has been completed. Wall assemblies also are evaluated for the passage of flame. Beams, columns, and other structural members are tested primarily for temperature and loading criteria.

The main idea to emphasize is that ASTM E119 has many requirements specific to the assembly or material being tested. For this reason, the design professional should consult the test agency’s guide information to understand how the assembly he or she must evaluate is handled. Over time, one can develop a sense for what the fire resistance ratings actually mean for the many different types of assemblies encountered.

Summary

Interior finishes will need to be monitored to ensure compliance with the basic prescriptive requirements discussed above throughout the life of the building. Moreover, if materials that can
pose significant fire risk are used, the assessment of their impact on fire safety should go beyond the prescriptive requirements. It may be necessary to limit the use of materials that are otherwise acceptable to prescriptive requirements.

Discussion so far has encompassed the elements that comprise a built environment. It is now time to consider the fire protection systems that are used to safeguard the built environment. Automatic fire sprinklers will be the first topic in this category.
Taft Community College - New Student Center

Fire and Life Safety Analysis

Section 4: Automatic Fire Sprinkler System
Automatic Fire Sprinkler System

Contemporary fire sprinkler design is based upon the principle of preventing the spread of fire beyond the immediate area of origin until the fire can be extinguished, either by the fire sprinkler system alone or with intervention from firefighting personnel. The term “fire control” is used in Section 16, Chapter 1 of the NFPA Handbook. This text discusses the need for an energy balance to exist between the combined cooling and heat absorption effects from fire sprinklers with the evolution of heat from the combustion process. This section will review the fire sprinkler system design requirements for the Student Center to verify that the sprinkler system can meet prescriptive code requirements.

Code Requirements for Automatic Sprinklers in New Buildings

Group A-2 occupancy classification means that the Student Center is required to have an automatic sprinkler system as provided in IBC Section 903.2.1.2 (1) and (2).

IBC Section 903.3.1.1 provides that NFPA 13 shall be the controlling standard for fire sprinkler design where sprinklers are required.

A wet pipe fire sprinkler system has been designed for the Student Center. The wet pipe style of system uses sprinklers fed by a network of piping which is continuously filled with water under pressure. Energy is imparted to the water from the pressure of the water source(s) feeding the system. In this case the municipal water supply is the sole source for water. Details regarding these components will be visited within this report. Fire sprinkler system design documents are provided in Figure 4.1 below. These documents detail the layout, components, and installation practices of the sprinkler system.
Water Supply Analysis

Water will be supplied to the sprinkler system by the municipal water system only, which is justified with NFPA 13 Section 24.2.1 (1). The tie-in occurs on the East side of the building and utilizes a 6” PVC pipe. Figure 4.2 illustrates this connection.

![Figure 4.2: Fire Sprinkler Tie-in to Municipal Water Source](image_url)

A backflow preventer is installed and also shown on the above graphic. This device prevents polluted fire sprinkler water from flowing into the domestic water lines. A manufacturer of such pipe, PW Pipe, publishes a Hazen-Williams C-value of 150 for the PVC C900 pipe. The internal diameter of the pipe depends on the class of pipe chosen. The hydraulic calculations to follow later assume the use of Class 100 DR 25 6” PVC pipe, which has an internal diameter of 6.31”. Use of this internal diameter is also in agreement with NFPA 13 Table 23.4.4.8.1 for plastic pipes.

Project plans indicate that flow test data for the water supply reported a static pressure of 63psi and a residual pressure of 28 psi with approximately 1540 gpm flowing. The test was made at a fire hydrant near the property line of the Student Center. The fire sprinkler plans need to be supplemented with a summary of the test details in order to comply with Section NFPA 13 23.2.1. Given that this is the best data available, it will be used for this report. The reader should note that if the reported data changes, the remainder of the supply vs. demand analysis will be impacted.

Given that the water supply information is based on a fire hydrant flow test, NFPA 291 is used to provide the basis for water supply analysis. Section 4.10.1.2 and Equation 4.10.1.2 make it possible to generate a water supply curve based on the information from the fire hydrant flow test. Table 4.1 provides a summary of the data generated.

This data is reported on Figure 4.3 below, which is designed to be in accordance with NFPA 13 23.3.5.3 and to be a satisfactory substitute to the Figure 23.3.5.1.2(b): Flow Test Summary Sheet.
### Table 4.1: Hydrant Flow Test Results

<table>
<thead>
<tr>
<th>Static Pressure (PSIG):</th>
<th>62</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual Pressure (PSIG):</td>
<td>28</td>
</tr>
<tr>
<td>Flow Rate (GPM):</td>
<td>1540</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expected Flow (GPM)</th>
<th>Residual Pressure (PSIG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>62</td>
</tr>
<tr>
<td>547</td>
<td>57</td>
</tr>
<tr>
<td>795</td>
<td>52</td>
</tr>
<tr>
<td>990</td>
<td>47</td>
</tr>
<tr>
<td>1156</td>
<td>42</td>
</tr>
<tr>
<td>1304</td>
<td>37</td>
</tr>
<tr>
<td>1439</td>
<td>32</td>
</tr>
<tr>
<td>1564</td>
<td>27</td>
</tr>
<tr>
<td>1681</td>
<td>22</td>
</tr>
<tr>
<td>1792</td>
<td>17</td>
</tr>
</tbody>
</table>

#### Figure 4.3: Water Supply Curve

![Water Supply Curve Graph](image)

**FIGURE A.23.3-4** Sample Graph Sheet.

**Figure 4.3: Water Supply Curve**
Fire Sprinkler System Design Requirements

NFPA 13 provides the requirements for the design of fire sprinkler systems. The basic framework to fire sprinkler design is to:

1. Identify the occupancy/hazard group for the most hazardous conditions expected. This occupancy/hazard classification is to apply to the fire sprinkler system only in accordance with NFPA 13 Sections 5.1.1 and 5.1.2.
2. Select a design approach for determining water demand. NFPA 13 Section 11.1.4.1 provides three different approaches available for selection.
3. Provide hydraulic calculations demonstrating that the available water supply(s) are adequate to meet the calculated demand. Calculation guidelines are provided in NFPA 13 Chapter 23.

Given that the Student Center will contain a moderate amount of temporary storage and permanent displays, the building is classified as Ordinary Hazard (Group 2) in accordance with NFPA 13 5.3.2.1. For operational purposes the maximum storage height for books, cooking oils, and other items with high heat release rates must be limited to 8 ft. in height. Other items having moderate heat release rates may be stored up to 12 ft. in height.

The design team has chosen an occupancy hazard fire control approach as allowed in Section 11.1.4. Furthermore, the design team will use the hydraulic calculation method per Section 11.2.1.1 and detailed in Section 11.2.3. This section then provides three methods for determining sprinkler water demand in Section 11.2.3.1.1. Method (1) is chosen, which involves the use of density/area curves and the density/area method of Section 11.2.3.2.

Sprinkler demand can then be determined by selecting any point on the appropriate curve presented in Figure 11.2.3.1.1 in accordance with Section 11.2.3.2.1.2. The selection made is illustrated in Figure 4.4 below, and gives a theoretical sprinkler demand of 300 gpm.

![Figure 11.2.3.1.1 Density/Area Curves.](image)

**Figure 4.4: NFPA 13 Figure 11.2.3.1.1**
Quick response sprinklers are planned for the Student Center, and Section 11.2.3.2.3.1 provides an opportunity to reduce the design area of the figure above. However, the design team has not indicated that this factor is to be used, and hydraulic calculations were done based upon the full 1500 sq. ft. design area.

Section 11.2.3.1.2 also requires additional water supply requirements in Table 11.2.3.1.2. The portions of that table relevant to this project are shown in Table 4.2 below.

**Table 4.2: NFPA 13 Figure 11.2.3.1.1**

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>Inside Hose</th>
<th>Total Combined Inside and Outside Hose</th>
<th>Duration (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gpm</td>
<td>L/min</td>
<td>gpm</td>
</tr>
<tr>
<td>Light hazard</td>
<td>0, 50, or 100</td>
<td>0, 190, or 380</td>
<td>100</td>
</tr>
<tr>
<td>Ordinary hazard</td>
<td>0, 50, or 100</td>
<td>0, 190, or 380</td>
<td>250</td>
</tr>
<tr>
<td>Extra hazard</td>
<td>0, 50, or 100</td>
<td>0, 190, or 380</td>
<td>500</td>
</tr>
</tbody>
</table>

Table 4.2 shows the need to consider an additional demand for fire hose streams that must be a 250 gpm minimum. Therefore, total theoretical system demand is 550 gpm. Now that the demand requirements are met it is useful to consider the equipment that will be used in the fire sprinkler system prior to reviewing the hydraulic calculations.

**Fire Sprinkler System Component Identification**

Identification of critical sprinkler system components follows.

Sprinklers are to be installed above and below the drop ceiling as shown in Figure 4.5 below.
Sprinkler distribution piping is to consist of Dyna-Flow steel pipe manufactured by National Fire Equipment Ltd. Sizes consist of 1”, 2” and 4” pipe.

The diagram of the riser is unsatisfactory due to the blurred condition. The fire sprinkler designer should provide a better graphic of the riser. What is available is presented in Figure 4.6 below with markups to help distinguish pipe sizes and types. It should be noted that the 6” stainless steel pipe is regular schedule 40 steel pipe, not the Dyna-Flow series of pipe.
Figure 4.7 shows the location of the system riser at the north of the building, branch lines, cross-main, and sprinklers.

IBC Section 903.4 sets forth requirements for sprinkler supervision and alarms. The main control valve and the water flow switch must both be electrically supervised by a control unit listed for that purpose. These devices are discussed in more detail when the fire alarm system is considered.
Hydraulic Calculations

Calculations are to follow the procedures set forth in NFPA 13 Chapter 23. Section 23.4.4.2 provides that the design area is a rectangle with a dimension equal to 1.2 times the square root of the protected area.

\[ L = 1.2 \times \sqrt{1500\,[sq.\,ft.]} = 46.48\,[ft] \]

Ideally, the spacing of sprinklers in the most hydraulically remote area would fall on a nice grid pattern, such as 10 ft. between sprinklers on a branch line and 10 ft. between branch lines. However, this is not the case for the most remote area in the Student Center. The area chosen by the design team is shown on a portion of the sprinkler plans in Figure 4.8 below.

![Figure 4.8: Selection of Remote Area for Hydraulic Calculations](image)

This 1500 sq. ft. area is in the Student Center TV Lounge and includes 19 sprinklers. The calculations show a system demand of 535 gpm and a pressure of 45 psi, but a calculation worksheet was not provided. To verify what the fire sprinkler designer has reported the correct demand, hydraulic calculations for the remote area chosen were performed. These hydraulic calculations are shown in Table 4.3 below.
Table 4.3: Fire Sprinkler Hydraulic Calculations (1 of 4)

<table>
<thead>
<tr>
<th>Step No.</th>
<th>Node Ident and Location</th>
<th>Flow in gpm (q)</th>
<th>Pipe size (in)</th>
<th>Pipe Fittings and Devices</th>
<th>Equivalent Pipe Length (L)</th>
<th>Friction loss (psi/ft)</th>
<th>Pressure Summary</th>
<th>Normal Pressure</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>106-24</td>
<td>q</td>
<td>2&quot;Tee</td>
<td></td>
<td>L 9.3</td>
<td>G= 120</td>
<td>Pt 7.0</td>
<td>Pt</td>
<td>k= 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F 10</td>
<td>Pe</td>
<td>Pv</td>
<td>Q</td>
<td>8 q = k * (Pt)^1/2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T 19.3</td>
<td>Pf 0.145</td>
<td>Pt 2.8</td>
<td>Pn</td>
<td>Q= 21.2</td>
</tr>
<tr>
<td>2</td>
<td>23-24</td>
<td>q 21.2</td>
<td>2</td>
<td></td>
<td>L 2.583</td>
<td>G= 120</td>
<td>Pt 9.8</td>
<td>Pt</td>
<td>k_eq 6.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F</td>
<td>Pe</td>
<td>Pn</td>
<td>Q= 21.16601049</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T 2.583</td>
<td>Pf 0.019</td>
<td>Pt 0.049</td>
<td>Pn</td>
<td>Q=</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>24-21</td>
<td>q 0.0</td>
<td>2</td>
<td></td>
<td>L 5.92</td>
<td>G= 120</td>
<td>Pt 9.8</td>
<td>Pt</td>
<td>NOT USED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F</td>
<td>Pe</td>
<td>Pn</td>
<td>Q= 0.0</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T 5.92</td>
<td>Pf 0.02</td>
<td>Pt 0.1</td>
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<td>Q=</td>
</tr>
<tr>
<td>4</td>
<td>21-22</td>
<td>q 25.2</td>
<td>2</td>
<td></td>
<td>L 6.46</td>
<td>G= 120</td>
<td>Pt 10.0</td>
<td>Pt</td>
<td>Q= 8 25.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td>Pn</td>
<td>Q=</td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td>Pn</td>
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<td>5</td>
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<td>q 24.2</td>
<td>2</td>
<td></td>
<td>L 2.25</td>
<td>G= 120</td>
<td>Pt 12.8</td>
<td>Pt</td>
<td>Flow from branch</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F</td>
<td>Pe</td>
<td>Pn</td>
<td>Q= 24.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T 2.25</td>
<td>Pf 0.08</td>
<td>Pt 0.18</td>
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<td>Q=</td>
</tr>
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<td>6</td>
<td>1-2</td>
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<td>2</td>
<td></td>
<td>L 8.5</td>
<td>G= 120</td>
<td>Pt 13.0</td>
<td>Pt</td>
<td>Q= 8 28.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F</td>
<td>Pe</td>
<td>Pn</td>
<td>Q=</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T 8.5</td>
<td>Pf 0.133</td>
<td>Pt 1.1</td>
<td>Pn</td>
<td>Q=</td>
</tr>
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<td>7</td>
<td>2-3</td>
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<td>2</td>
<td></td>
<td>L 8.46</td>
<td>G= 120</td>
<td>Pt 14.1</td>
<td>Pt</td>
<td>Q= 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F</td>
<td>Pe</td>
<td>Pn</td>
<td>Q=</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T 8.46</td>
<td>Pf 0.13</td>
<td>Pt 1.12</td>
<td>Pn</td>
<td>Q=</td>
</tr>
<tr>
<td>8</td>
<td>3-4</td>
<td>q 31.2</td>
<td>2</td>
<td></td>
<td>L 8.5</td>
<td>G= 120</td>
<td>Pt 15.2</td>
<td>Pt</td>
<td>Q= 8 31.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td>F</td>
<td>Pe</td>
<td>Pn</td>
<td>Q=</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T 8.5</td>
<td>Pf 0.20</td>
<td>Pt 1.73</td>
<td>Pn</td>
<td>Q=</td>
</tr>
<tr>
<td>9</td>
<td>4-5</td>
<td>q 32.9</td>
<td>2</td>
<td></td>
<td>L 25.4</td>
<td>G= 120</td>
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Notes:
- Design Density = 0.20
- K = 5.6
- Hazen-Williams C-value:
Table 4.3: Fire Sprinkler Hydraulic Calculations (2 of 4)

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Table 4.3: Fire Sprinkler Hydraulic Calculations (3 of 4)

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Notes:
Design Density = 0.20
K = 5.6
Hazen-Williams C-value:

Flow in gpm
Node Identification
Pipe size (in)
Pipe Fittings and Devices
Equivalent Pipe Length
Friction loss (psi/ft)
Pressure Summary
Normal Pressure
Notes:
Design Density = 0.20
K = 5.6
Hazen-Williams C-value:
## Table 4.3: Fire Sprinkler Hydraulic Calculations (4 of 4)

Calculated sprinkler demand was found to be 491 gpm with a residual pressure of 48.5 psig at the riser. Calculated demand is lower than reported on the project sheets, which shows 535 gpm demand. The calculated residual pressure is higher than reported on the project sheets which report a residual pressure of 46.1 psig. It is not possible to identify the difference between the two calculations without the original hydraulic calculation forms corresponding to the project sheets. For now, the more stringent demand will be used. This demand is plotted along with the water supply curve and the hose stream allowance curve on Figure 4.9. The result is that the available supply meets the calculated water demand of the fire sprinkler system and hose streams.

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<th>Flow in gpm</th>
<th>Pipe size (in)</th>
<th>Pipe Fittings and Devices</th>
<th>Equivalent Pipe Length</th>
<th>Friction loss (psi/ft)</th>
<th>Pressure Summary</th>
<th>Normal Pressure</th>
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<td>k_eq 0.0 Q= 0.0</td>
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Taft Community College - New Student Center Fire and Life Safety Analysis 45
Inspection, Testing, and Maintenance Requirements

NFPA 13 Chapter 25 provides the guidelines for acceptance testing of fire sprinkler systems. A hydrostatic test will be required for wet pipe system at the Student Center. The test procedure is outlined in NFPA 13 Section 25.2.1.

The water flow switch will need to be tested via the inspector’s test valve per Section 25.2.3.1. This device should generate an audible alarm from the fire alarm system and trigger the electric bell installed by the riser.

The sprinkler control valve should be operated, and it should be verified that a tamper switch is installed on this valve and indicates a trouble condition on the fire alarm panel when the valve is closed.

Plans and forms will need to be submitted that detail the fire sprinkler system characteristics and building information.

Routine inspection and maintenance requirements are detail in NFPA 25. Table 5.1.1.2 provides a summary of the system components that must be inspected, the frequency of inspection, and a reference to specific inspection requirements. For the wet pipe sprinkler system, inspections will need to follow a schedule of 4 inspections per year, with 3 quarterly inspections and one annual inspection. Every 5 years, the annual inspection is to be replaced by a 5-year inspection. The names
quarterly, annual, and 5-year all designate increasing levels of inspection with regards to fire sprinkler system components.

Summary

The fire sprinkler system designed for the Student Center is adequate based upon the system supply exceeding the expected demand. System supply is shown in Table 4.1 and Figure 4.3. Demand is calculated as being 535 gpm at a residual pressure of 46.1 psig. The supply was based upon fire hydrant flow testing that produced a static pressure of 62 psig, and residual pressure of 28 psig, and flow of 1540 gpm at the residual pressure. It will be necessary for the original designer to submit full calculations with regards to the fire sprinkler demand. It will also be necessary to re-verify the water supply requirements and include the results with the fire sprinkler design plan. It is now time to consider the second fire suppression system proposed for the Student Center designed to protect commercial cooking equipment.
Taft Community College - New Student Center

Fire and Life Safety Analysis

Section 5: Kitchen Fire Suppression System
Kitchen Fire Suppression System

Commercial cooking operations present a severe fire hazard. The gas or electricity used to power the commercial appliances provide significant amounts of power. Gas can present explosion hazards. Electricity can present shock hazards. Both have been shown to be a reason for life loss of fire service personnel as well as building occupants. For this reason, the need to have a kitchen fire suppression system that suppresses the fire hazard and removes the hazard from gas and electricity is of great importance.

Code Requirements

The IFC makes fire suppression as a means to protect commercial cooking operations mandatory in section 609. Section 904.12 of the IBC provides additional requirements for such systems. For example, Section 904.12.1 provides that a manual pull station that operates the kitchen fire suppression system must be installed, but this pull station should not activate other fire suppression systems.

IBC Section 904.2.2 requires that the exhaust hoods service commercial kitchen equipment also be protected.

Further requirements are provided in NFPA 96 and NFPA 17A. Commercial kitchen fire suppression systems are not the most visible fire suppression system type within the fire protection community. Therefore, the author finds it be helpful to point out important design features for such systems that those unpracticed with their design may overlook.

1. All sources of fuel and heat serving protected cooking appliances must be shut off upon activation of the fire suppression system per NFPA 96 Section 10.4. This is very important because it helps to prevent run-away involvement of the significant fuel loads - oils, fats, and grease – present with commercial cooking appliances. In the case of appliances using gas, shutdown of the gas supply helps prevent an explosion. In the case of appliances powered by electricity, shut down of electrical power helps prevent shock to occupants due to migration of wet chemical agent, and it helps prevent shock to firefighting personnel responding to such fire with hose streams.

2. Requirements for portable fire extinguishers are outlined in NFPA 96 Section 10.10. Notably, a Class K fire extinguisher must be provided when fats and oils are associated with cooking operations.

Kitchen Fire Suppression System Selection

The design team has identified that an Ansul R-102 fire suppression system shall be installed to protect the commercial cooking operations. Figure 5.1 shows an agent cylinder, control unit enclosure, and wet chemical agent of such a system.
This system involves a wet chemical agent store under normal pressure in a cylinder. An expellant gas cylinder provides the driving force for the chemical agent via a releasing mechanism. The releasing mechanism is tied into the detection line and manual pull station line.

Figure 5.2 shows a typical R-102 System Layout

The appliances to be installed at the Student Center involve fryers, a griddle, a wok, and multiple ranges. Figure 5.3 shows a schematic of the appliance arrangement.
NFPA 17A details the requirements for inspection, testing, and maintenance of kitchen fire suppression systems.

Plans must be submitted to and approved by the authority having jurisdiction. At the time of the acceptance test all components of the system must be visually inspected and pipes checked for tightness. It is also important to verify that the same size and types of cooking appliances that appear on the plans are present onsite, and installed at the same locations as indicated on the plans.

An operational test shall be conducted in accordance with the system manufacturer’s guidelines but shall include tests of the automatic detection system, gas shut-off valve, make-up air shut off, and electrical power (to the kitchen hood/appliances) shut off.

Certified technicians must inspect the kitchen fire suppression system at intervals not exceeding six months. Section 7.3.3 provides the minimum requirements of these inspections. Recurring hydrostatic tests of agent cylinders and pressure containers shall occur at least every 12 years.

**Summary**

The Ansul R-102 is a proprietary pre-engineered fire suppression system. Specific requirements for performing the installation and maintenance of such systems will be contained in the manufacturer’s instructions. Only personnel qualified by the manufacturer should perform work on this system.
Both the fire sprinkler system and kitchen fire suppression system having limited means, local horns/bells, to notify building occupants of system activation in response to a fire event. However, both systems are integrated into a fire alarm system. The fire alarm system provides notification throughout the premise and will be discussed in the following section.
Taft Community College - New Student Center

Fire and Life Safety Analysis

Section 6: Fire Alarm System
Fire Alarm System

Fire alarm system designs must fulfill important tasks. These include: meaningfully enhance an overall life safety program for the protected location, operate in tandem with multiple building systems, and provide a degree of survivability to guard against failure. This section is aimed at considering the fire alarm system as planned for the new Student Center at Taft Community College.

A fire alarm system can be described as a set of integrated components designed to detect the onset of fire at the earliest stage possible, notify occupants to the danger of a fire, and interact with building processes or components appropriately. The manner in which the system is designed can be guided by three basic protection goals as discussed in the NFPA Fire Protection Handbook, 20th Edition (NFPA Handbook): the preservation of an overall building mission, the protection of property, and a focus on life safety for building occupants. Some element from all three of these goals will be addressed by any fire alarm system, but there are occupancies that may require particular attention to a single item. In the case of the Student Center, the most important protection goal is the life safety of building occupants.

Importance must also be given to designing a fire alarm system so that the system operation is not unduly complicated and maintenance can be performed without disruption of building processes. There must also be a degree of resistance to potential failures of individual components so that the system does not become inoperable. Finally, a number of other considerations, such as future expansion needs, may need to be addressed.

At the Student Center, the scope of the fire alarm project involves adding a new fire alarm system. Specifications for the project require adherence to NFPA 72 and NFPA 90A. Evaluation of the project will be based on the 2013 and 2012 editions of these codes, respectively. In addition, the fire alarm system requirements will be based upon the 2015 International Building Code. The design team has chosen to install an intelligent, addressable fire alarm system controled by a single Notifier NFS2-640 Fire Alarm Control Panel (FACP) shown in Figure 6.1.
Fire Alarm Signals

Fire alarm systems are subject to a variety of conditions that can be detected or monitored. Rather than provide a single response to each of the different conditions NFPA 72 Section 10.9 defines four types of signals that fire alarms can generate in response to the monitored conditions: alarm, pre-alarm, supervisory, and trouble. Moreover, Section 10.10.1 mandates that such signals shall be clearly and descriptively distinguished. Each of these signals are discussed in more detail below. Here it should also be noted that accomplishment of the distinctive signals requirement can, in some cases, be satisfied by having the FACP display provide appropriate details as suggested in NFPA 72 Appendix A.10.10.4.

Alarm Signal

A basic requirement of alarm signals is that they be a three-pulse temporal pattern as identified in NFPA 72 Section 18.4.2.1. However, Appendix A.18.4.2.1 provides allowance for fire alarm systems commissioned prior to the 1996 enactment of the three-pulse temporal pattern to continue use of those alarm signals previously installed. The appendix also points out that alarm signals are intended to be used for partial evacuation, building evacuation, and relocation of building occupants.
Pre-Alarm Signal

The requirements for these signals falls to NFPA 72 Section 10.10.8 where it is stated that they shall be distinctive. An example of a usefulness for pre-alarm signals considers a special hazard clean agent fire suppression system. Such systems are designed to protect high value equipment, such as the electronic equipment in a server room. A pre-alarm signal with such a system would allow an operator or the appropriate personnel to assess the situation prior to the release of fire suppression agents. Requirements in such cases are further defined within the relevant standards, such as NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems.

Supervisory Signal

These signals also receive treatment in NFPA 72 Section 10.10.5. A supervisory signal is appropriate for a condition that does not threaten the performance of life safety systems, but is related to such systems. Section 10.13.6 provides further details regarding supervisory signals. However, there is one concept that is not discussed directly: latching versus non-latching supervisory signals. Latching signals are handled in Section 23.8.5.8.2 where it is deemed that latching signals as a response to off-normal conditions and requiring a manual reset of the system to restore them shall not be permitted.

Trouble Signal

Trouble signals are also required to be distinctive per NFPA 72 Section 10.10.6. Section 10.14 provides more substantial detail. This section provisions for intermittent trouble signals, restoration of trouble signals, and deactivation of trouble signals. As described in NFPA 72 Appendix A.10.14.9, trouble signals are designed to remind owners and occupants that the fire alarm system is in fault, which could possibly result in failure.

Fire Alarm System Code Requirements

IBC Chapter 9 provides the requirements for fire protection systems. This includes the requirements for fire alarm systems in new buildings. Section 907.2 requires that new buildings and structures shall have a fire alarm system installed in accordance with NFPA 72. This section also requires that at least one manual pull box (pull station) be installed for fire alarm systems using automatic fire detectors or sprinklers for a means of system initiation.

IBC Section 907.2.1 allows for Group A occupancies with an occupant load between 300 and 1,000 persons to not be designed as a manual fire alarm system when the building is equipped with an automatic sprinkler system. The sprinkler system must be installed in accordance with Section 903.1.1, which the analysis from Section 4 above demonstrates to be the case for the Student Center.

An interesting note is that it is often assumed that fire alarm systems will be equipped with smoke or heat detectors throughout the building. It happens that installation of such devices is not always a code requirement as IBC Section 907.2.1 demonstrates. Nonetheless, there are some minimum requirements that result in the installation of smoke detection at special locations. IBC Section 907.4 contains provisions for such requirements. Section 907.4.1 provides that at least one smoke
detector be installed where a fire alarm control panel, notification appliance circuit extender, and supervising station transmitting equipment is located. Figure 6.2 shows the location of smoke detector installation at the fire alarm control unit and at the notification appliance circuit extenders.

The broad requirements for the fire alarm system in accordance with the 2015 IBC have been identified. Additional requirements for the fire alarm system and fire alarm system components will be discussed in the following sections and will focus on the requirements set forth in NFPA 72 and additional IBC requirements.

![Figure 6.2: Smoke Detector Layout](image-url)
Fire Alarm System Initiation Devices

Plans submitted for this project contain the description and location of the fire detection devices. Based upon the IBC requirements discussed above, the fire alarm system will contain automatic detection/initiation consisting primarily of fire sprinklers via a water flow switch, manual pull stations at select locations, a fire alarm switch integrated into the Ansul kitchen fire suppression system.

Smoke detectors consist of photoelectric addressable detectors. They are to be Notifier model FSP-851 and are shown in Figure 6.3

![Photoelectric Smoke Detector by Notifier](image)

Figure 6.3: Photoelectric Smoke Detector by Notifier

The automatic sprinkler system includes the fire sprinkler flow switch installed on the riser and a fire sprinkler tamper switch installed on the main control valve. The flow switch is designed as a means to indicate an alarm condition due to sprinkler flow. An example flow switch is shown in Figure 6.4 below. The tamper switch, Figure 6.5 below, is designed to allow for a trouble condition to be indicated on the FACP should the main control valve be closed. Monitoring of the main sprinkler control valve is important because a closure of the main control valve would disrupt water flow into the fire sprinkler system and render the system ineffective.
The water flow and tamper switch, along with the alarm initiating switch installed on the Ansul kitchen fire suppression system, will connect to the fire alarm system via monitor modules. These modules allow for devices having electrical contacts to be given a unique function, including a device address, within the fire alarm system. The goal is to allow the fire sprinkler and kitchen fire suppression systems to function independently of the fire alarm system, but relay relevant events to the fire alarm system. The monitor module to be used is a Notifier FMM-1 shown in Figure 6.6 below.
Figure 6.6: FMM-1 Monitor Module

Manual pull stations shall consist of addressable Notifier pull stations model NGB 12 LX shown in Figure 6.7 below.

Figure 6.7: NGB-12LX Pull Station
Location, Spacing, and Placement of Fire Alarm Initiation Devices

Smoke detector placement meets the minimum requirements found in NFPA 72 and the IBC. As discussed above smoke detectors have been located in the two electrical rooms: 522 and 507 where fire alarm equipment is located. This includes the FACP, fire alarm terminal cabinet (FATC), and the notification appliance circuit extenders in accordance with NFPA72 10.4.4 and the IBC Section 907.4.1. The location of smoke detectors was shown above in Figure 6.2.

Manual pull stations are installed throughout the building to meet the minimum requirements set forth in IBC Section 907.4.2. Section 907.4.2 mandates pull stations be spaced so that walking distance to the nearest pull station is 200ft or less, and that pull stations be located within 5ft from the entrance to each exit. The result is that not every room contains a manual pull station. Pull stations must also be mounted so that the activating lever is between 42” and 48” from the floor assembly. Figure 6.8 shows the location of manual pull stations in the Student Center.

![Figure 6.8: Pull Station Layout](image)
Smoke Control

Smoke control system provisions in IBC Chapter 9 do not apply to the Student Center because this facility does not meet the thresholds that require the use of smoke control systems. Nonetheless, there exists a means of smoke control via the fire alarm system. Duct smoke detectors are required based on the provisions of IMC Section 606. Section 606.2.1 requires duct detectors as a result of the return air capacity in some areas of the Student Center exceeding 2000 cfm.

Operational requirements of duct smoke detections are specified in subsequent sections of the IMC. Section 606.3 requires that duct detectors be installed to comply with NFPA 72. IMC Section 606.4 requires that the air distribution system shut down upon activation of duct smoke detectors and that the duct detectors must be connected to the fire alarm system.

The function of the duct smoke detectors is to prevent the spread of combustion products from an area involved in fire to the remainder of the building. Locations of duct smoke detectors at the Student Center are outlined in Figure 6.9 below.

Fire Alarm Notification Devices

Notification of occupants to fire emergencies should be distinct and clearly recognizable in order to be most effective. The discussion with regards to fire alarm signal types above lays a groundwork for understanding how code requirements address this goal.

Notification appliances are generally non-intelligent, meaning that such devices are not monitored or controlled individually by the fire alarm system. Traditional wiring is used to create electrical circuits containing a set amount of notification appliances. When a malfunction, such as a short circuit, occurs the entire circuit must be evaluated since the FACP does not provide for which device the condition starts (or ends) at. These circuits are also termed “non-power limited”. In contrast, the circuits for initiation devices and other addressable devices will be power limited. Therefore, there is a need to separate the non-power limited and power limited wiring of the fire alarm system, which results in separate conduits for initiation and notification conduction media in most cases.

Devices used for notification of occupants in the Student Center include the System Sensor P2R wall-mount horn/strobe, PC2R ceiling-mount horn/strobe, and SR strobe.

Location, Spacing, and Placement of Fire Alarm Notification Devices

Chapter 18 of NFPA 72 provides the requirements applicable to the location, spacing, and placement of notification appliances. The traits relevant to device spacing include: (1) light intensity to satisfy NFPA 72 18.5.4.4, 18.4.5.3.1(a), figure 18.4.5.3.1, and 18.5.4.3.1(a); (2) audibility output in decibels to satisfy NFPA 18.4.3 in conjunction with the decibel loss rule given in 18.4.3. Unfortunately, the device layout on the project plans does not identify the decibel and/or candela ratings. However, the rated capacities for the P2R, PC2R, and SR devices are more than capable of meeting the spacing requirements given the proper settings. Ultimately the fire alarm
design must incorporate these settings, and it is preferable to be accomplished prior to providing these documents to the installing contractor.

Mounting of the strobes and combination horn/strobe devices must meet the requirements of 18.5. Given ceiling heights of 14’ or more this should be accomplished. There is one device located outside, and it is protected to agree with 18.3.3.1 because a listed weather resistant back box is to be provided.

Figure 6.10 below provides the fire alarm system layout and identification of notification appliance locations.

Mass Notification System

A public announcement (PA) system is provided in the student center as part of the campus PA system. There are no indications on the plans showing shared equipment between the fire alarm system and the PA system. Therefore, the PA system cannot interrupt the fire alarm system signal directly. There is the possibility to allow the PA system to serve as an emergency alarm communication system as introduced in NFPA 72 10.7.1, which would require a risk analysis based on many factors described in 10.7.1, 25.1.8, and 24.5.7. Overall, the goal would be development of a consensus on the conditions that warrant interruption of fire alarm signals along with a standard set of procedures for doing so.

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Figure 6.10: Notification Appliance Layout
Power Requirements

Requirements for secondary power sources serving protected premises fire alarm systems fall under NFPA 72 10.6.7.3. In this project it was decided to use battery power as the secondary source. Section 10.6.7.2 requires the batteries to sustain system operation in the normal state for 24 hours followed by 5 minutes of continuous operation of all notification appliances. Section 10.6.7 identifies a 20% margin of safety for battery calculations.

For this project there are three devices that are responsible for powering the fire alarm system components: the FACP, and two remote power supplies. The remote power supplies are Notifier FCPS-24S8. They are dedicated to running the notification appliance circuits (NAC) for the fire alarm system. The fire alarm design plans correctly handle the battery calculations given the stated appliance settings for the power supplies. However, the settings for the NAC devices need to be accurately demarcated on the drawings. The calculations are provided in Table 6.1 and Table 6.2 below.

Table 6.1: Battery Calculations for NAC Extender Panel

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</tr>
<tr>
<td>HORNS/STROBE 110CD</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>STROBE 15CD</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>STROBE 30CD</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>STROBE 75CD</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>STROBE 110CD</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>STROBE 135CD</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>SUBTOTAL</td>
<td></td>
<td>0.080</td>
</tr>
</tbody>
</table>

STANDBY CURRENT X 24HRS: 1.920
ALARM CURRENT X 5 MINUTES: 0.133
TOTAL BATTERY AH REQUIRED: 2.053
STANDBY BATTERY (AMP-HR): 7.0
Calculations for the FACP appear slightly incorrect per the drawings provided. These calculations have been redone and are shown in Table 6.3 below. The reason for the difference is due to selection of current draws for the appliances. However, the updated calculations do not differ materially from what is provided on the fire alarm plan sheets.

All three sets of batteries are capable secondary power supplies and exceed the requirements.
Voltage drop calculations are also required per NFPA 70 Section 7.4.10. Guidance for acceptable voltage drops is gained by considering the installation manuals for the NFS2-640 fire alarm control unit and the FCPS-24S8 remote power supply. The former limits voltage drops to 2 VDC, while the former recommends a maximum 10% voltage drop. Table 6.4 below is an example of the voltage drop calculations performed. Based on these calculations, the voltage drop for the fire alarm control panel and the two remote power supplies do not exceed recommended values.

Table 6.3: Battery Calculations for the FACP

<table>
<thead>
<tr>
<th>STANDBY LOAD MODEL #</th>
<th>DESCRIPTION</th>
<th>QTY</th>
<th>CURRENT EACH (AMPS)</th>
<th>TOTAL CURRENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU2-640E</td>
<td>FACAP CIRCUIT BOARD</td>
<td>1</td>
<td>0.25000 AMPS</td>
<td>0.25000</td>
</tr>
<tr>
<td></td>
<td>FACAP POWER PER NAC</td>
<td>3</td>
<td>0.03500 AMPS</td>
<td>0.10500</td>
</tr>
<tr>
<td>KDM-R2</td>
<td>PRIMARY DISPLAY/KEYBOA</td>
<td>1</td>
<td>0.10000 AMPS</td>
<td>0.10000</td>
</tr>
<tr>
<td>NCM-F</td>
<td>NETWORK CONTROL MODU</td>
<td>1</td>
<td>0.11000 AMPS</td>
<td>0.11000</td>
</tr>
<tr>
<td>LCD-80TM</td>
<td>REMOTE ANNUNCIATOR PA</td>
<td>1</td>
<td>0.10000 AMPS</td>
<td>0.10000</td>
</tr>
<tr>
<td>FMM-101</td>
<td>MONITOR MODULE</td>
<td>8</td>
<td>0.00040 AMPS</td>
<td>0.00320</td>
</tr>
<tr>
<td>NGB-12 LX</td>
<td>MANUAL PULL STATION</td>
<td>10</td>
<td>0.00038 AMPS</td>
<td>0.00038</td>
</tr>
<tr>
<td>FSP-851</td>
<td>SMOKE DETECTOR - PHOTO</td>
<td>2</td>
<td>0.00030 AMPS</td>
<td>0.00060</td>
</tr>
<tr>
<td>DNR</td>
<td>DUCT DETECTOR W/RELAY</td>
<td>5</td>
<td>0.02600 AMPS</td>
<td>0.13000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.4476 AMPS</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ALARM LOAD MODEL #</th>
<th>DESCRIPTION</th>
<th>QTY</th>
<th>CURRENT EACH (AMPS)</th>
<th>TOTAL CURRENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU2-640E</td>
<td>FACAP CIRCUIT BOARD</td>
<td>1</td>
<td>0.25000 AMPS</td>
<td>0.25000</td>
</tr>
<tr>
<td></td>
<td>FACAP POWER PER NAC</td>
<td>3</td>
<td>0.03500 AMPS</td>
<td>0.10500</td>
</tr>
<tr>
<td>KDM-R2</td>
<td>PRIMARY DISPLAY/KEYBOA</td>
<td>1</td>
<td>0.10000 AMPS</td>
<td>0.10000</td>
</tr>
<tr>
<td>NCM-F</td>
<td>NETWORK CONTROL MODU</td>
<td>1</td>
<td>0.11000 AMPS</td>
<td>0.11000</td>
</tr>
<tr>
<td>LCD-80TM</td>
<td>REMOTE ANNUNCIATOR PA</td>
<td>1</td>
<td>0.10000 AMPS</td>
<td>0.10000</td>
</tr>
<tr>
<td>FMM-101</td>
<td>MONITOR MODULE</td>
<td>8</td>
<td>0.00040 AMPS</td>
<td>0.00320</td>
</tr>
<tr>
<td>NGB-12 LX</td>
<td>MANUAL PULL STATION</td>
<td>10</td>
<td>0.00038 AMPS</td>
<td>0.00038</td>
</tr>
<tr>
<td>FSP-851</td>
<td>SMOKE DETECTOR - PHOTO</td>
<td>2</td>
<td>0.00030 AMPS</td>
<td>0.00060</td>
</tr>
<tr>
<td>DNR</td>
<td>DUCT DETECTOR W/RELAY</td>
<td>5</td>
<td>0.09700 AMPS</td>
<td>0.48500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.2162 AMPS</td>
<td></td>
</tr>
</tbody>
</table>

Provide 24 hour of standby plus 5 minutes of alarm

0.4476 AMPS x 24.00 hours = 10.7424 AmpHours
1.2162 AMPS x 0.0840 hours = 1.022 AmpHours
Total AmpHours = 10.8446 AmpHours
Derate factor x 1.2
Required AmpHours = 13,0136 AmpHours

Supply two batteries, Power Sonic part # PS-12180, 12 Volts, 18 AmpHours*

*A18 AH BATTERIES ARE CHOSEN BECAUSE THAT IS THE MINIMUM BATTERY SIZE
ALLOWED FOR THE NOTIFIER NFS2-640 PER THE SPECIFICATION SHEET
Fire Alarm System Commissioning, Inspection, Testing, and Maintenance

NFPA section 10.5 sets forth these requirements for having qualified persons perform inspection, testing, and maintenance of fire alarm systems. In calling for “persons who are experienced in the proper design, application, installation, and testing of the systems” this section stresses the need for consulting applicable laws and procedures set forth in the relevant jurisdiction. For example, some states require that system designers be licensed engineers.

Chapter 14 of NFPA 72 contains the requirements for fire alarm system commissioning, testing, inspection, and maintenance. NFPA 72 Table 14.3 gives detailed information concerning when the various fire alarm system components are to be inspected. Table 14.4.2.2 provides testing requirements. Generally, the owner of a building equipped with a fire alarm system will need to have a licensed fire alarm contractor perform annual and semi-annual inspection and testing of the fire alarm system. However, the relevant codes sections should be reviewed, and administrative controls put in place to satisfy the more frequent requirements, which can sometimes require weekly attention.

Table 6.4: Voltage Drop Calculations

<table>
<thead>
<tr>
<th>Component</th>
<th>QUAN</th>
<th>EACH AMPS</th>
<th>SUBTOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>HORNS</td>
<td>1</td>
<td>0.075</td>
<td>0.075</td>
</tr>
<tr>
<td>HORN/STROBE 15CD</td>
<td>0</td>
<td>0.079</td>
<td>0.000</td>
</tr>
<tr>
<td>HORN/STROBE 30CD</td>
<td>3</td>
<td>0.107</td>
<td>0.321</td>
</tr>
<tr>
<td>HORN/STROBE 75CD</td>
<td>1</td>
<td>0.176</td>
<td>0.176</td>
</tr>
<tr>
<td>HORN/STROBE 110CD</td>
<td>0</td>
<td>0.212</td>
<td>0.000</td>
</tr>
<tr>
<td>STROBE 15CD</td>
<td>3</td>
<td>0.071</td>
<td>0.213</td>
</tr>
<tr>
<td>STROBE 30CD</td>
<td>0</td>
<td>0.096</td>
<td>0.000</td>
</tr>
<tr>
<td>STROBE 75CD</td>
<td>0</td>
<td>0.153</td>
<td>0.000</td>
</tr>
<tr>
<td>STROBE 110CD</td>
<td>0</td>
<td>0.195</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
<td></td>
<td><strong>0.785</strong></td>
<td><strong>0.785</strong></td>
</tr>
<tr>
<td><strong>RESISTANCE FOR #12 AWG PER 1000-FT</strong></td>
<td>2.010</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DISTANCE OF LAST DEVICE FROM PANEL</strong></td>
<td>160</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VD = (LOAD X 2.01 X 2 X DISTANCE)/1000</strong></td>
<td>0.505</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VD PERCENTAGE AT 24V</strong></td>
<td>2.104</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Maintenance of fire alarm system components is mostly deferred to the recommendations of the fire alarm system manufacturer in NFPA 72 Section 14.5. The important thing to recognize here is that manufacturers of fire alarm systems provide listings showing what devices are compatible for use with their product. The fire alarm components used the Student Center are listed as being compatible with one another. The exception concerns the fire alarm switch for the Ansul kitchen system, the fire sprinkler tamper switch, and the fire sprinkler flow switch, none of which are considered fire alarm system components proper. The owner should set forth administrative controls to ensure that contractors performing work on the fire alarm system during initial installation or afterwards verify that any components added to the system as new or as replacements should be listed for use with the original system components.

Summary

Smoke detectors are not the primary means of automatic fire detection, but photoelectric type smoke detectors are planned for locations involving sensitive fire alarm equipment. Fire sprinklers are the primary means of detection as these devices are located throughout the Student Center. The integration of the fire sprinklers in to the fire alarm system is via a water flow switch installed on the sprinkler system riser which is connected to a monitor module installed on the fire alarm system. There is a similar connection between the fire alarm system and the kitchen fire suppression system. Duct smoke detectors are installed as a means of smoke control and are intended to limit the spread of combustion products via the HVAC system. Duct smoke detectors are connected to the fire alarm system.

Notification appliances are installed in the correct orientation and with the correct spacing throughout the Student Center. Power requirements for the fire alarm control panel and the two notification appliance circuit extender panels, with regards to a secondary power source, are satisfied by batteries, which calculations show are properly sized. Similarly, the voltage drop of these three devices when servicing all connected devices does not exceed acceptable limits.

Having shown that the fire alarm system is capable of alerting building occupants to fire emergencies now requires an examination of how the Student Center is designed to accommodate the reaction of occupants to such notification. This involves analysis of the planned egress system and egress system components, which is provided for in the next section.
Taft Community College - New Student Center

Fire and Life Safety Analysis

Section 7: Egress System and Components
Egress System and Components

Buildings need to be designed so that the occupants and egress system components work in harmony, which can be satisfied by ensuring that the egress components are clearly identifiable, are accessible, and are adequately designed to allow for movement of occupants. This section will consider the prescriptive code requirements designed to meet these three requirements with respect to the Student Center.

Occupant Load Analysis

Ensuring that the built environment is able to accommodate the movement of persons during emergency situations begins with a benchmark of the number of persons expected to occupy this environment at any given time. Contemporary prescriptive requirements, as set forth in Chapter 10 of the IBC, define a maximum number of persons allowed to use a building as the occupant load. IBC Section 1004.1.2 and Table 1004.1.2 provide the means for determining the occupant load for each area within a building. A function is assigned to each area based on the expected use of that area. Each function defined in Table 1004.1.2 has an occupant load factor that is applied to the area in question as shown by the relation below to obtain the occupant load.

\[
\text{Occupant Load} = \frac{\text{Area of space considered}}{\text{Occupant load factor based on function of space}}
\]

An example of this is shown on Figure 7.1, and a summary of the occupant load for each area of the Student Center is provided in Table 7.1.

Figure 7.1: Example of Occupant Load Information

On Project Plans
An exit analysis floor plan showing the location of each area and the respective occupant loads is found in Figure 7.2.
Egress Component Capacity

Sizing of egress components shall accommodate the occupant load of the space(s) served in accordance with IBC Section 1005.3. Exits in the Student Center consist of doorways and corridors. Determining the capacity of exits complies with IBC Section 1005.2 and 1005.3.2, where the latter section provides that the capacity of these components are to be determined by the following relation:

\[
\text{Capacity (Occupant Load)} = \frac{\text{Component Width (in.)}}{0.2 \text{ in.} \text{ Occupant}}
\]

Doors

The door schedule provided shows that doors serving as entry/exit doors to the building are to be at least 32 in. wide, and that the doors used in the interior of the building are to also be 32” wide. Figures 7.3 and 7.4 show a snapshot of the door schedule on the project drawings.

Figure 7.3: Door Detail
The result is that one can expect each door to provide a capacity of 180 occupants. A 36” door width satisfies the requirements of IBC Section 1010.1.1, which requires a minimum 32” clear width.

**Corridors**

There is one true corridor in the Student Center, and it serves as a connection point between the East entry vestibule, the bookstore, restrooms, and the game area. Figure 7.5 shows this location and indicates that the corridor width at the narrow point is approximately 80”, which results in a capacity of 400 occupants for the corridor. A 400 occupant capacity exceeds the 113 occupants that are expected to pass through this corridor when using the East exit.

IBC Section 1020.2 and Table 1020.2 are satisfied with respect to the corridor width. It is also worth noting that IBC Section 1020.1 and Table 1020.1 do not require fire resistance ratings for the corridors.
At this point, the capacity of egress paths for the Student Center have been considered. Such paths consist of doorways and a single corridor. All these paths are adequate for the designed occupant load that is to be served under full usage.

**Egress Component Accessibility**

Door hardware includes a latch, lock, and door closer. The location of such hardware shall be installed between 34” and 48” above the finished floor to satisfy hardware height requirements in IBC Section 1010.1.9.2 and to satisfy a lower limit of 34” per Section 10.10.1.1.1. This section restricts the hardware from extending more than 4” into the doorway. The door closer must be located at least 78” above the finished floor if it will extend more than 4” into the doorway.

There are restrictions with regards to the force required to operate door latches, to set the door in motion, to push/pull the door between open/closed positions, and to have the door swing to a full open position: 15-pound, 30-pound, 5-pound, and 15-pound forces respectively. IBC Section 1010.1.3 defines these requirements.

Locks installed on doors may consist of panic hardware or fire exit hardware. Since the Student Center is designed as a Group A-2 occupancy, this requirement applies per IBC Section 1010.1.10. The goal is to prevent doors being unusable during emergency events, which could happen since visitors to the Student Center would not have keys to open locked doors. Moreover, locked doors would delay egress times. Provisions for panic hardware installation are provided in IBC Section 1010.1.10.1 which requires installation and listing per UL 305 or UL 10C for panic or fire exit hardware.

There is an allowance for electromagnetic locking mechanisms for egress doors in Group A occupancies. Design plans indicate the use of electromagnetic door closers/locks. In this case, IBC
Section 10.10.1.9.9 requires that such hardware be designed so that the electromagnetic lock is released when the panic or exit hardware is operated.

All doors must swing in the direction of egress travel per IBC Section 10.10.1.2.1 when the areas served by such doors have an occupant load of 50 or more persons. The exit analysis floor plan shown on Figure 7.2 shows that doors are designed to comply with this provision.

Consideration is now given to the minimum number of exits required and the maximum travel distance to such exits. IBC Section 1006.2.1 and Table 1006.2.1, shown in Table 7.2 below, provides that each space within the Student Center shall have at least two exits and have a maximum travel distance to an exit of 75 feet when the occupant load of that space exceeds 49. Group A occupancy classification and the use of a sprinkler system provide the selection criteria within Table 7.2. The travel distance discussed above must be applied to the game area (occupant load of 73), the food service area (occupant load of 144), the student commons (occupant load of 167), and the dining area (occupant load of 247).

<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>MAXIMUM OCCUPANT LOAD OF SPACE</th>
<th>MAXIMUM COMMON PATH OF EGRESS TRAVEL DISTANCE (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Without Sprinkler System</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Occupant Load</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OL ≤ 30</td>
</tr>
<tr>
<td>A, E, M</td>
<td>49</td>
<td>75</td>
</tr>
<tr>
<td>B</td>
<td>49</td>
<td>100</td>
</tr>
<tr>
<td>F</td>
<td>49</td>
<td>75</td>
</tr>
<tr>
<td>H-1, H-2, H-3</td>
<td>3</td>
<td>NP</td>
</tr>
<tr>
<td>With Sprinkler System</td>
<td>75&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

The minimum number of exits for the entire Student Center is three based on IBC Section 1006.3.1 and Table 1006.3.1, shown in Table 7.3 below.

<table>
<thead>
<tr>
<th>OCCUPANT LOAD PER STORY</th>
<th>MINIMUM NUMBER OF EXITS OR ACCESS TO EXITS FROM STORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-500</td>
<td>2</td>
</tr>
<tr>
<td>501-1,000</td>
<td>3</td>
</tr>
<tr>
<td>More than 1,000</td>
<td>4</td>
</tr>
</tbody>
</table>
Doors serving each space in the Student Center are arranged so that the distance between them complies with IBC Section 1007.1.1 and 1007.1.2. These requirements are meant to ensure that doors are not spaced too close or too far from one another.

Figure 7.6 shows the maximum possible distance from an occupied area to an exit within the Student Center. This travel distance is from the ASB Office to the exit door located in the Student Commons.

**Figure 7.6: Student Center Max Travel Distance**

The maximum travel distance is approximately 125 feet. A 125 ft. travel distance complies with IBC Section 1017.2 and Table 1017.2, shown in Table 7.4 below, where the travel distance is limited to 250 ft.

**Table 7.4: IBC Table 1006.2.1**

<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>WITHOUT SPRINKLER SYSTEM (feet)</th>
<th>WITH SPRINKLER SYSTEM (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, E, F-1, M, R, S-1</td>
<td>200</td>
<td>250&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>I-1</td>
<td>Not Permitted</td>
<td>250&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>B</td>
<td>200</td>
<td>300&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>F-2, S-2, U</td>
<td>300</td>
<td>400&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>H-1</td>
<td>Not Permitted</td>
<td>75&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>H-2</td>
<td>Not Permitted</td>
<td>100&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>H-3</td>
<td>Not Permitted</td>
<td>150&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>H-4</td>
<td>Not Permitted</td>
<td>175&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>H-5</td>
<td>Not Permitted</td>
<td>200&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>I-2, I-3, I-4</td>
<td>Not Permitted</td>
<td>200&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Visibility of Egress Components

Lighting requirements are found in IBC Section 1008. There are requirements for the walking surface illumination under both normal and emergency power conditions. Exit signs should be installed to provide the necessary illumination in case the building power fails. Exit signs must also to be visible during normal lighting conditions. IBC Section 1013.1 requires installation of exit signs to indicate exits and exit access doors. Section 1013 has further requirements for exit signs including the size of characters and the words that may be used on such signs. It should be verified that the contractor installing these signs complies with these provisions.

Summary

Thus far it has been established that the Student Center meets the prescriptive requirements with regards to egress systems. It should be evident at this point in the project that multiple building systems are required to function together in providing for occupant safety. The next step is to consider the egress of occupants from the building, along with the time available for such egress. This will be accomplished by using accepted methods for performance based design.
Taft Community College

New Student Center Fire and Life Safety Analysis

Section 8: Performance Based Design
Performance Based Design

Uncertainty marks the largest obstacle for fire protection engineering. Every level of a built environment can change: from structural framing exposed to corrosion, an increase in persons beyond the designed occupant load, to temporary storage of safety cones, or a faulty HVAC thermostat. All such changes can have a meaningful impact on the results of a fire event.

A second challenge is that the best tools available to fire protection engineers involve empirical models. Given the numerous possible configurations that even a single room can have, one can quickly understand that no amount of empirical data sets would cover all possible building designs, let alone deviations from such designs.

Despite these limitations, fire protection engineers can use judgment to design for fire scenarios. Such scenarios can be used to set boundaries on what can reasonably be expected from fire events, and make informed recommendations to improve life safety.

Goals and Expectations

The performance based design will be used to investigate the adequacy of prescriptive code requirements, as addressed earlier in this report, with regards to particular fire scenarios and performance criteria. No abnormal construction or design selections at the Student Center require a performance based design as a result of exceeding the bounds of prescriptive code requirements.

Multiple performance criteria will be considered.

Occupants shall not be exposed to “instantaneous or cumulative” untenable conditions per LSC Section 5.2.2.

At least one occupant shall be located at the most remote point from exits per LSC Appendix A5.4.5.3.

Performance Based Design Criteria

Recent fire incidents, such as the World Trade Center attack, have resulted in increased focus on the safety of occupants when designing fire and life safety systems. Occupant safety is a critical requirement in all design scenarios, and it is the primary consideration with regards to the Student Center. However, it is also important that fire protection engineers consider the integrity of the building even after occupants have been evacuated. Both considerations: occupant safety and structural integrity have been addressed.

Occupant safety has been addressed by considering the following tenability criteria:

1. Visibility.
   a. One measure of visibility conditions is that visibility shall be considered tenable so long as the visibility distance is not reduced below 10m within the means of egress.
In an evacuation study, *Fire Research Note 953*, author P.G. Wood provides evidence that nearly all occupants were able to continue in their chosen direction when visibility levels were above 10m. A 10m visibility limit is also reasonable since the longest egress component at the Student Center, the East Vestibule, is approximately 10m long.

b. A second measure of visibility conditions is that the smoke layer height shall not descend below 6 ft. This limit is in agreement with the recommendation in LSC Appendix A5.2.2 Method 2.

2. Exposure to carbon monoxide
   a. SFPE Handbook Table 63.9 provides that at approximately 35,000ppm-min, a human will be incapacitated from exposure to carbon monoxide. A worst case scenario would be to consider the highest CO concentration that occupants can be continuously exposed to during a ten minute evacuation time. The corresponding CO concentration is 3.5 x 10³ ppm, which will be the tenability threshold for CO exposure.
   b. Tenability evaluation based on CO concentration is in agreement with the recommendation in LSC Appendix A5.2.2 Method 1.

3. Exposure to temperature effects.
   a. SFPE Handbook Chapter 63 provides results of previous studies on temperature effects which showed that at 60 °C (140 °F) the air becomes unbreathable. Therefore, once the temperature of the exit path at a height of 1.8m (6ft) exceeds 60 °C, the exit is no longer considered tenable.

The goal is to ensure that Student Center occupants are able to leave the building during a fire event prior to the fire event creating untenable exposures with regards to the criteria above. NFPA Handbook Chapter 4, and the LSC Appendix A.4.8.2.1(3), provide a means for making this determination by detailing the need for the available safe egress time (ASET) to exceed the required safe egress time (RSET).

Structural integrity has been addressed by considering the following tenability criteria:

1. Onset of flashover conditions.
   a. Flashover criteria is taken from the SFPE Handbook Chapter 38 (Pg. 1273). Flashover can be considered to occur when either the hot gas layer under the ceiling reaches a temperature of 500 °C (932 °F), or when the heat flux at the floor reaches 20 kW/m².

A complete structural analysis to fire exposure is beyond the scope of this project. However, limiting a potential fire so that it does not spread beyond the area of origin is a first step to ensuring that the structure is not continuously exposed to fire, which in turn helps to ensure that structural integrity is not compromised by fire events.
Fire Model Scenario Selection

To guide the selection of an appropriate fire scenario, Chapter 5 of the LSC was consulted. From the eight design fire scenarios provided, two stood out as the most reasonable for the task. Excerpts from the LSC detailing these two scenarios are provided in Figures 8.1 and 8.2 below.

Scenario 1 was modeled because it represents a scenario that should be common to the occupancy considered. Selection of a fire event was guided by information from NFPA Handbook Section 3. In particular, data for confined fires presented in NFPA Handbook Table 3.4.11 showed that, with regards to structure fires, the largest percentage of confined fires reported involved trash/rubbish. Therefore, it seems reasonable to consider a fire involving trash/rubbish within a compartment of the Student Center. A likely place for trash to exist is within an office environment. The model for design fire scenario 1 will involve a paper product trash fire located in the ASB Office (Room 505), based on the evidence and reasoning provided above. This fire scenario will be referred to as Design Fire A.

Scenario 6 was also modeled. This model was based on a fire occurring in the Bookstore and involving substantial amounts of books/paper products. The scenario was chosen to provide a worst-case fire exposure and evaluate the adequacy of the fire and life safety systems. A fire in the Bookstore has the potential to threaten occupants using a major exit, the East Vestibule. It is also possible to imagine a scenario where ignition of the fire event occurs after operating hours when the Bookstore is not occupied. Therefore, occupant notification will depend on the fire systems
present. These three things: large fuel load, potential for the fire to affect areas beyond the area of
origin, and the potential for the fire to develop unnoticed by building occupants makes the
Bookstore fire scenario a good candidate to satisfy design fire scenario 6. This fire scenario will be
referred to as: Design Fire B.

Both models are discussed individually in more detail below.

One may refer to Figure 1.3 at the beginning of the report for a plan view of the areas under
consideration.

**Fire Modeling Tool Selection**

This report will utilize Fire Dynamics Simulator (FDS) supported by the National Institute of
Standards and Technology (NIST) to model a design fire scenario at the Student Center. FDS is
described in the SFPE Handbook as a computational fluid dynamics (CFD) model. This model is
based on conservation equations of mass, momentum, and energy with regards to the fire source
and modeled space. Although a CFD model is designed to apply the conservation equations to
every interaction within the modeled space, limitation on computational power require that such
models look at the conservation equations from levels above the molecular scale.

Many studies have been performed to validate the results of FDS. These studies have compared
both reconstructed fire scenarios and, more importantly, actual testing of the very model simulated
by FDS. Such testing has involved both bench-scale and full scale testing.

This report will take advantage of the efforts to validate FDS to build a model framed by two
validation studies. The first is outlined in Section 3.27.3 of the FDS Validation Guide and involves
the NIST Full-Scale Enclosure Experiments, 2008. These experiments were used to study how fuel
type and arrangement affected compartment fires. This study was chosen to provide information on
modeling the compartment properties, such as the gypsum wallboard. The second study chosen was
the NIST Smoke Alarm Experiments. These experiments involved testing the response of smoke
detectors in a residential compartment. It is the author of this report's opinion that these validation
studies shown FDS to be an appropriate fire model for the design fire scenarios selected.

Determining an estimate of the evacuation time (RSET) for occupants in the Student Center will be
Egress Prediction* (NFPA Handbook). The procedure is a simple hydraulic model of occupant
movement based upon empirical data. The egress system must be designed so that the available
safe egress time (ASET) does not exceed the required safe egress time (RSET).

**Design Fire A**

The following assumptions and determinations were made when designing the FDS simulation.

- The 159 sq. ft. area of the ASB Director office, Room 505, can be represented by a
rectangular compartment with an average ceiling height of 14 ft.
• The door leading from Room 505 is modeled as open, and is considered a vent due to the size of the connecting areas.
• The walls and ceiling can be represented by gypsum wallboard, and the floors by concrete.
• The fire itself is taken to involve a trash bags placed in the corner of Room 505. Data for the heat release rate is taken from “Heat Release Rates of Burning Items in Fires”, by Kim and Lilley. Figure 8.3 provides the heat release rate curve obtained from that study where a medium growth t-squared fire with a maximum heat release rate of 336 kW was reported for three paper-filled trash bags.

![Figure 8.3: Design Fire A HRR Reference](image)

• The simulation run time is to be 10 minutes. The fuel is modeled to grow to a maximum heat release rate and then burn at the maximum heat release rate until the heat content is reached, which occurs within 6 minutes after fire initiation.
• The effect of automatic sprinklers on the fire growth can be modeled in FDS. However, the effect of automatic sprinklers needs to be calibrated with actual test data corresponding to the conditions at hand. Given a lack of test data showing the effect of the particular fire sprinklers, fuel arrangement, and compartment conditions, this study cannot justify a particular extinguishing coefficient for use in the FDS model. What can be done is to use the most basic requirements of prescriptive fire sprinkler design: the fire sprinkler system is designed so that, once activated, it can limit the further spread of fire. For the FDS simulation, this means that when the fire sprinklers are activated, the heat release rate at the time of activation is held constant.
• The FDS mesh size is to be 0.2 m. This size is based on a sensitivity analysis of the mesh size on the calculation results, which started with a mesh size of 0.5 m.
It is assumed that the fuel can be modeled as cellulose when determining combustion products. SFPE Handbook Table A.39 is referenced in selecting a soot yield of 0.015 (g/g). SFPE Handbook Figure 62.20 is referenced in selecting a CO yield of 0.01 (g/g).

Figure 8.4 below shows the layout of the FDS model. The following legend will help to distinguish the elements of the model.

1. ASB Office (Room 505)
2. Game Area/TV Lounge Area
3. Trash modeled as fire source
Results

The FDS simulation results show a minimum tenability period of 1 minutes, 30 seconds for Design Fire A. Visibility tenability criteria is exceeded with regards to the smoke layer height at 1 minute, 30 seconds. An overview of all the findings is presented below.

- First sprinkler activation occurred at approximately 107s after fire initiation. This is shown in Figure 8.5, which presents a graph of the sprinkler temperatures for the time of interest. The sprinklers are Viking VK 352 with an activation temperature of 68 °C (155 °F).

![Figure 8.5: Design Fire A Sprinkler Activation](image)

Visibility reaches tenability limit at 90s (1 minute, 30 seconds). Figure 8.6 shows the smoke layer height reaching the tenability limit of 1.8 m (6 ft.) at approximately 90 seconds, prior to visibility being reduced to 10 m.
Visibility is reduced to 10 m at approximately 136s. Equations 16.5 and 16.6 from the FDS User Guide are used to convert FDS data on soot concentrations to a visibility distance based on a mass extinction coefficient of 8700 m$^2$/kg. It is also assumed that occupants will be guided by light emitting signs. Working backwards, a value of 10m for visibility is associated with a soot concentration of $9.20 \times 10^{-5}$ kg/m$^3$. Figure 8.7 below shows when this value is reached in the doorway at a height of 1.8m.
Figure 8.7: Design Fire A Soot Density at Tenability Limit

- **CO exposure does not exceed the tenability limit.** Figure 8.8 below shows a maximum $1.5 \times 10^{-4}$ ppm CO concentration being reached during the simulation, which is below the tenability limit criteria.
Figure 8.8: Design Fire A CO Concentration at Selected Time

- **Temperature criteria reached at 123s (2 minutes, 3 seconds).** The temperature in the doorway reaches 60 °C at approximately 123s. Figure 8.9 shows how the threshold temperature encroaches into the doorway at the time when tenability is reduced.
Flashover criteria are not reached. Figure 8.9 above shows a time when the largest ceiling temperature, 220 °C, is reached. The largest heat flux to the floor was 0.24 kW/m².

Design Fire B

The FDS model was built with the following assumptions and determinations:

- The 1282 sq. ft. area of the Bookstore can be represented by a square compartment with an average ceiling height of 20 ft.
- The door to the Room 504: Mail Room would be closed during a fire event.
- The door to the Room 511: Office would be closed during a fire event.
- The opening into the Delivery area requires that the Delivery area be represented. The exit door located in the Delivery area is assumed to be closed during a fire event.
- The East Entry Vestibule exit door is to remain closed, while the opening of this space into the Game Room can be considered a vent.
The exit door in the Northeast Corner can be modeled as closed.

The walls and ceiling can be represented by gypsum wall board, and the floors by concrete.

The fire itself is taken to involve two bookcases located on the East wall of the Bookstore. A quantity of two bookcases are assumed to be involved at a given time. Substantiation of the heat release rate of the bookcases is provided by a US Department of Commerce report titled “Quick Response Sprinklers in Office Configurations: Fire Test Results.” This study referenced a burn test of storage shelves containing paper products where the heat release rate was measured, Test 202 in the study. Heat release rate data is shown in Figure 8.10 below. The curve was simplified to a maximum heat release rate of 1400kW sustained for a period of 190s. Unfortunately, the effect of the sprinkler system was not considered as the shelves were allowed to burn freely. The shelf configuration is shown in Figure 8.11.

![Figure 8.10: Design Fire B HRR Reference](image-url)
The simulation run time is to be 20 minutes. The potential for fire to spread to adjacent cabinets means that it is reasonable to assume that two shelves are burning at any given time. Therefore, the fuel potential is not limited for the time under consideration.

The effect of automatic sprinklers on the fire growth can be modeled in FDS. However, the effect of automatic sprinklers needs to be calibrated with actual test data corresponding to the conditions at hand. Given a lack of test data showing the effect of the particular fire sprinklers, fuel arrangement, and compartment conditions present at the Student Center Bookstore, this study cannot justify a particular extinguishing coefficient for use in the FDS model. What can be done is to use the most basic requirements of prescriptive fire sprinkler design: the fire sprinkler system is designed so that, once activated, it can limit the further spread of fire. For the FDS simulation, this means that when the fire sprinklers are activated, the heat release rate at the time of activation is held constant.

The FDS mesh size is to be 0.2 m. This size is based on a sensitivity analysis of the mesh size on the calculation results, which started with a mesh size of 0.5 m.

It is assumed that the fuel can be modeled as cellulose when determining combustion products. SFPE Handbook Table A.39 is referenced in selecting a soot yield of 0.015 (g/g). SFPE Handbook Figure 62.20 is referenced in selecting a CO yield of 0.01 (g/g).
Figures 8.12 and 8.13 below show the layout of the FDS model. The following legend will help to distinguish the elements of the model.

1. Bookstore area
2. Deliver area
3. East Vestibule
4. Cabinets with books modeled as the fire source

Figure 8.12: Design Fire B FDS Model Layout
Results

The FDS simulation results show a minimum tenability period of 8 minutes, 27 seconds for Design Fire B. Visibility tenability criteria is exceeded with regards to the visibility distance at 8 minutes, 27 seconds. It is also important to note that the time to the first sprinkler activation is 120 seconds. An overview of all the findings is presented below.

- First sprinkler activation occurred at approximately 120s after fire initiation. This is shown in Figure 8.14, which presents a graph of the sprinkler temperatures for the time of interest. The sprinklers are Viking VK 352 with an activation temperature of 68 °C (155 °F).
Figure 8.14: Design Fire B Sprinkler Temperature vs. Time

- The heat release rate at the time of sprinkler activation was approximately 450 kW as shown in Figure 8.15 below. This heat release rate was then held steady for the remainder of the simulation in accordance with the discussion above.

Figure 8.15: Design Fire B Heat Release Rate vs. Time
Visibility is tenable until 507s (8 minutes, 27 seconds). Equations 16.5 and 16.6 from the FDS User Guide are used to convert FDS data on soot concentrations to a visibility distance based on a mass extinction coefficient of 8700 m²/kg. It is also assumed that occupants will be guided by light emitting signs. Working backwards, a value of 10m for visibility is associated with a soot concentration of 9.20x10⁻⁵ kg/m³. Figures 8.16 and 8.17 below show that this value is reached in the East Vestibule after 507s. Note that the black slider is placed on the density scale on the right of the figure at a value of 9.20x10⁻⁵ kg/m³. Then then black lines on the model space indicate where this value is present. One can see that the pathway in the East Vestibule and the surface leading into the Game Area begin to experience “fingering” of the soot density limit around 507s.

Figure 8.16: Design Fire B Soot Density at Visibility Limit
The smoke layer height does not reach 1.8 m in the East Vestibule at any time during the simulation as shown in Figure 8.18 below.

Figure 8.17: Design Fire B Soot Density at Visibility Limit
Figure 8.17: Design Fire B Smoke Layer Height vs Time

- **CO exposure tenability limit is not reached.** A maximum CO concentration of $1.5 \times 10^{-4}$ ppm was found in the East Vestibule. This value is below the tenability threshold of $3.0 \times 10^3$ ppm, which means that tenability regarding CO exposure is maintained. The state of the simulation at the highest CO concentration, at a time of 1060 s, in the East Vestibule is shown in Figure 8.18.
• **Temperature tenability limit is reached at 545s (9 minutes, 5 seconds).** The temperature at a height of 1.8 m in the East Vestibule doorway reaches 60 °C at approximately 545s. Figure 8.19 below shows the compartment and the regions at the limit temperature with a black bar.
Onset of flashover does not occur according to the FDS simulation. Figure 8.20 shows that the heat flux to the floor does not reach the defined condition for flashover, 20kW/m².
Figure 8.21 shows that during the 20 minute simulation, the maximum wall temperature at the ceiling level reached is approximately 220 °C, which is below the flashover criteria of 500 °C.

Figure 8.21: Design Fire B Maximum Temperature Profile

Performance Based Design for Occupant Egress

Thus far it has been established that the Student Center meets the prescriptive requirements with regards to egress systems per the 2015 IBC. It is now time consider a how fast the occupants can evacuate from the building. This step is considered performance-based design in that it goes beyond what is defined in and required by applicable building codes.

Occupant Characteristics

The Student Center will be occupied primarily by college students, faculty, and facilities personnel. It is also possible to have community members not associated with the campus visiting the Student Center. Factors that will have an impact on pre-evacuation times and egress travel times are discussed for each group below.

Students

- 18-32 years of age and generally in good health.
- Favorable reaction times to emergency notifications and conditions.
Capable of swift egress movement.
Will tend to remain with familiar cohorts, which may delay egress times and result in higher-than-expected population density.
Very familiar with the building layout.

Faculty
- Mature adults in good to fair health conditions
- Moderate to swift egress movement.
- Favorable reaction times to emergency notifications and conditions.
- Trained to act as facilitators for evacuation, making sure egress from their respective classrooms takes place.
- Very familiar with the building layout.

Facilities Staff
- Mature adults in good to fair health conditions
- Moderate to swift egress movement.
- Favorable reaction times to emergency notifications and conditions.
- Very familiar with the building layout.

Community Members
- Most characteristics will fall into one of the groups discussed above.
- Will not be familiar with the building layout.

For three of the groups familiarity of the building is enhanced by evacuation drills that are conducted periodically throughout the year. It is also noteworthy that there is a dedicated security force on campus that will help clarify the nature of emergencies and assist in the proper evacuation of the building, which is particularly important for visiting community members.

One factor that will slow the total building egress time is the presence of physically impaired individuals. It is possible that such individuals will be a part of the occupant population and will either require or receive help from others.

**Components of Travel Time**

As described in NFPA Handbook Chapter 4, there are four parts to determining RSET:
1. Time to notification
2. Reaction Time
3. Pre-evacuation activity time
4. Travel/Movement Time
**Delay Time Pre-Evacuation Activities**

Handbook Table 4.2.1 provides the results of the total delay times for various scenarios. For the Student Center there is a good match between two scenarios. The first involved a single story department store where an unannounced fire drill was conducted. The second involved another study on a single story department store.

For this building there is a mix of typical and unique activities that the building occupants are likely to engage in before beginning the evacuation process. The typical activities include:

- Gather backpacks, books, supplies.
- Put on outerwear when outside conditions are cold or rainy.
- Find and congregate with close friends.
- Unplug and pack laptop computers.

Unique pre-movement activities concern the laboratories located on each floor of the building.

- Shutdown lab equipment.
- Personnel cleanup/disinfection from lab activities.

Chapter 4 of the NFPA Handbook discusses how such studies have a hard time separating delay time and pre-movement times. Based on this, and the discussion of pre-movement activities below, the maximum delay time from the two studies will be taken, and this time is to represent both the reaction time and pre-movement activity time.

The delay plus pre-movement time for both Design Fire Scenario A and Design Fire Scenario B is to be 0.5 minutes, or 30 seconds.

**RSET for Design Fire A**

Determining an appropriate travel time will start with the assumption that the only egress component affected by the design fire in Room 505 will be the doorway for Room 505. For the office fire scenario the procedure for calculating the travel time is straightforward:

1. Calculate the time for the occupants in Room 505 to exit this area via the doorway.
   - Maximum travel distance: 15ft.
   - Travel speed (ft./min): 235  [Handbook Table 4.2.7]
   - Travel Time (seconds): 4

   It should take 4 seconds, or less, for the occupants to reach and egress from the doorway of Room 505.

Notification of the fire should occur immediately for occupants in Room 505. The delay/pre-movement time is 30 seconds. Therefore, the RSET for Office fire scenario is found by taking the total of the RSET components, 34 seconds, and multiplying by a safety factor of 1.2. The total RSET is then 41 seconds.
RSET for Design Fire B

Determining an appropriate travel time will start with the assumption that the Bookstore fire will impact the East Vestibule. This in turn can possibly prevent use of this corridor and delay egress times for the building. It could also affect occupants coming from the bathrooms, which exit directly into the East Vestibule. Therefore, the approach taken is to consider the time it takes for all occupants to exit the Student Center. This approach will ensure that no occupants are trapped by untenable conditions in the East Vestibule. For the bookstore fire scenario the procedure for calculating the travel time is as follows:

1. Calculate the time for occupants to travel from the most remote point of the ASB Office and into the Student Commons.
2. Use the time calculated in step 1 to determine the number of persons that have exited from the Student Commons assuming a uniform distribution of occupants.
3. Use the time calculated in step 1 to determining the number of persons that have entered the Student Commons from other areas, to include the ASB Director Office and the Food Service area.
4. Combine the increase in occupants from steps 1 and 3 with the decrease of occupants from step 2 with regards to the Student Commons area. Then determine the time it takes of the occupants entering the Student Commons from the ASB Office to reach and pass through the nearest exit doorway.

These steps are presented in Table 8.1 below.

Table 8.1: Design Fire B Travel Time Calculation

<table>
<thead>
<tr>
<th>Step 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Travel Distance to Door (ft)</td>
<td>25</td>
</tr>
<tr>
<td>Max Travel Speed (ft/min)</td>
<td>235</td>
</tr>
<tr>
<td>Travel Time (minutes)</td>
<td>0.2</td>
</tr>
</tbody>
</table>

**Doorway Flow**

<p>| Clear Width (in)                      | 36    |
| Effective Width (in)                  | 24    |
| Max Specific Flow p/min/ft            | 24    |
| Max Flow through door (p/min)         | 48    |
| Occupants                            | 5     |
| Travel Time (minutes)                 | 0.2   |
| <strong>Total Time (minutes)</strong>              | 0.4   |</p>
<table>
<thead>
<tr>
<th>Step 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Doorway Flow</strong></td>
</tr>
<tr>
<td>Density (persons/sq.ft.)</td>
</tr>
<tr>
<td>Clear Width (in)</td>
</tr>
<tr>
<td>Effective Width (in)</td>
</tr>
<tr>
<td>Max Specific Flow p/min/ft</td>
</tr>
<tr>
<td>Max Flow through door (p/min)</td>
</tr>
<tr>
<td>Travel Time (minutes)</td>
</tr>
<tr>
<td><strong>Number of Occupants Egressed</strong></td>
</tr>
</tbody>
</table>

*Note: SFPE Handbook Figure 4.2.7 and Continue Use of Max Flows.*
### Step 3

**Doorway Flow - Food Service**

- Clear Width (in) 72
- Effective Width (in) 60
- Max Specific Flow p/min/ft 24
- Max Flow through door (p/min) 120
- Travel Time (minutes) 0.4
- Occupant Increase 48
  (Less than the total expected increase)

**Doorway Flow - ASB Director**

- Clear Width (in) 36
- Effective Width (in) 24
- Max Specific Flow p/min/ft 24
- Max Flow through door (p/min) 48
- Travel Time (minutes) 0.4
- Max Occupant Increase 19.2
  (More than the total expected increase)
- Actual Occupant Increase 2

**Doorway Flow - ASB Office**

- Clear Width (in) 36
- Effective Width (in) 24
- Max Specific Flow p/min/ft 24
- Max Flow through door (p/min) 48
- Travel Time (minutes) 0.4
- Max Occupant Increase 19.2
  (More than the total expected increase)
- Actual Occupant Increase 5

**Total Addition of Occupants To The Path of Egress** 55
From these steps the total travel time is approximately 3.5 minutes. With a notification time of 120s, and a delay time of 30s, the total egress time comes to 6 minutes. This time should be multiplied by a factor of 1.2 to give a satisfactory RSET value of 7 minutes, twelve seconds.

**RSET vs. ASET**

The analysis of Design Fire A found that ASET (1 minute, 30 seconds) exceeds RSET (34 seconds).

The analysis of Design Fire B found that ASET (8 minutes, 27 seconds) exceeds RSET (7 minutes, 12 seconds).

**Performance-Based Design for Fire Barrier Joints**

With a non-rated roof assembly, it would not be possible for head-of-wall joints to comply with Section 715. Fortunately, IBC Section 707.9 allows that joints between a fire barrier and non-rated roof or wall assemblies be protected with less stringent methods. It is only required that an approved system or material be installed that is secured in place, can retard the passage of flame and hot gases, and accommodate building movement. In practice, there are no readily available means to represent that these requirements have been met without referring to tested and listed assemblies. Therefore, it is recommended that listed firestop joint systems be used as a basis of design. There are a number of such systems involving concrete over metal deck assemblies, which

---

### Step 4

<table>
<thead>
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<th>Parameter</th>
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<tbody>
<tr>
<td>Density (persons/sq.ft.)</td>
<td>0.103854</td>
</tr>
<tr>
<td>Max Travel Distance to Door (ft)</td>
<td>120</td>
</tr>
<tr>
<td>Max Travel Speed (ft/min)</td>
<td>235</td>
</tr>
<tr>
<td>Travel Time (minutes)</td>
<td>0.6</td>
</tr>
</tbody>
</table>

**Doorway Flow**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear Width (in)</td>
<td>72</td>
</tr>
<tr>
<td>Effective Width (in)</td>
<td>60</td>
</tr>
<tr>
<td>Max Specific Flow p/min/ft</td>
<td>24</td>
</tr>
<tr>
<td>Max Flow through door (p/min)</td>
<td>120</td>
</tr>
<tr>
<td>Occupants</td>
<td>291</td>
</tr>
<tr>
<td>Travel Time (minutes)</td>
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</tr>
<tr>
<td><strong>Total Time (minutes)</strong></td>
<td><strong>3.1</strong></td>
</tr>
</tbody>
</table>

**Grand Total for Travel Time (min)** 3.5
is comparable to the metal deck assembly to be used at the Student Center. The listed firestop joint systems by default meet the requirements for preventing flame and temperature passage, but they also provide ratings for air leakage and movement capabilities. A common firestop system for joint applications that resembles the head-of-wall application at the Student Center is provided in Figure 8.22 below. Such a system should form the basis of design.
System No. HW-D-0042

<table>
<thead>
<tr>
<th>ANSI/UL 2079</th>
<th>CAN/ULC S115</th>
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<tbody>
<tr>
<td>Assembly Ratings — 1 and 2 hr (See Items 2 and 3A)</td>
<td>F Ratings — 1 and 2 hr (See Items 2 and 3A)</td>
</tr>
<tr>
<td>Nominal Joint Width — 1 in.</td>
<td>FT Ratings — 1 and 2 hr (See Items 2 and 3A)</td>
</tr>
<tr>
<td>Class II Movement Capabilities — 50% Compression or Extension</td>
<td>FH Ratings — 1 and 2 hr (See Items 2 and 3A)</td>
</tr>
<tr>
<td>L Rating at Ambient — Less Than 1 CFM/lin ft</td>
<td>FTH Ratings — 1 and 2 hr (See Items 2 and 3A)</td>
</tr>
<tr>
<td>L Rating at 400°F — Less Than 1 CFM/lin ft</td>
<td>Nominal Joint Width — 1 in.</td>
</tr>
<tr>
<td>Class II Movement Capabilities — 50% Compression or Extension</td>
<td>L Rating at Ambient — Less Than 1 CFM/lin ft</td>
</tr>
<tr>
<td>L Rating at 400°F — Less Than 1 CFM/lin ft</td>
<td></td>
</tr>
</tbody>
</table>

Figure 8.22: Common Head-of-Wall Firestop Joint (1 of 4)
System No. HW-D-0042

1. Floor Assembly — The fire-rated fluted steel deck/concrete floor assembly shall be constructed of the materials and in the manner described in the individual D700 or D900 Floor-Ceiling Design in the UL Fire Resistance Directory and shall include the following construction features:
   A. Steel Floor And Form Units — Max 3 in. (76 mm) deep galv steel fluted units.
   B. Concrete — Min 2-1/2 in. (64 mm) thick reinforced concrete, as measured from the top plane of the floor units.
   C. Spray-Applied Fire Resistant Materials — (Optional, Not Shown)—Prior to or after the installation of the steel ceiling runners, Forming Material and Fill, Void or Cavity Material (items 2A, 3A, 3B, respectively) the steel floor units may be sprayed with a min 5/16 in. (8 mm) to max 1-3/4 in. (45 mm) thickness of fire resistant material.
   ISOLATEK INTERNATIONAL — Type 300
   W R GRACE & CO - CONN — Types MK-6-HY or MK-10HB

1A. Roof Assembly — (Not Shown) — As an alternate to the floor assembly, a fire rated fluted steel deck roof assembly may be used. The roof assembly shall be constructed of the materials and in the manner described in the individual F700 Series Roof-Ceiling Design in the UL Fire Resistance Directory. The hourly rating of the roof assembly shall be equal to or greater than the hourly rating of the wall assembly. The roof assembly shall include the following construction features:
   A. Steel Roof Deck — Max 3 in. (76 mm) deep galv steel fluted roof deck.
   B. Roof Insulation — Min 2-1/4 in. (57 mm) thick poured insulating concrete, as measured from the top plane of the floor units.

1B. Roof Assembly — As an alternate to Items 1 and 1A, a fire rated protected fluted steel deck roof assembly may be used. The roof assembly shall be constructed of the materials and in the manner described in the individual F700 Series Roof-Ceiling Design in the UL Fire Resistance Directory. The hourly rating of the roof assembly shall be equal to or greater than the hourly rating of the wall assembly. The roof assembly shall include the following construction features:
   A. Steel Roof Deck — Max 3 in. (76 mm) deep galv steel fluted roof deck.
   B. Spray—Applied Fire Resistant Materials — (Not Shown)—Prior to or after the installation of the steel ceiling runners, Forming Material and Fill, Void or Cavity Material (items 2A, 3A, 3B, the roof assembly shall be sprayed with the type and thickness of fire resistive material indicated in the individual F700 Series design.
   ISOLATEK INTERNATIONAL — Type 300
   W R GRACE & CO - CONN — Types MK-6-HY or MK-10HB

2. Wall Assembly — The 1 1/2 hr fire rated gypsum board/stud wall assembly shall be constructed of the materials and in the manner described in the individual U400 or V400 Series Wall and Partition Design in the UL Fire Resistance Directory and shall include the following construction features:
   A. Steel Floor And Ceiling Runners — Floor and ceiling runners of wall assembly shall consist of galv steel channels sized to accommodate steel studs (item 2C). Flange height of ceiling runner shall be min 1/4 in. (6 mm) greater than max extended joint width. Ceiling runner installed perpendicular to direction of fluted steel deck and secured to valleys with steel masonry anchors, steel fasteners or welds spaced max 24 in. (610 mm) OC, before or after optional spray-applied fire resistive material is used. The use of welds to secure the ceiling runner may only be used prior to the installation of the optional spray-applied material.

A1. Light Gauge Framing — Slotted Ceiling Runner — As an alternate to the ceiling runner in item 2A, slotted ceiling runner to consist of galv steel channel with slotted flanges sized to accommodate steel studs (item 2C). Slotted ceiling runner installed perpendicular to direction of fluted steel deck and secured to valleys with steel fasteners or welds spaced max 24 in. (610 mm) OC before optional spray-applied fire resistive material is used. Ceiling runner installed perpendicular to direction of fluted steel deck and secured to valleys with steel masonry anchors, steel fasteners or welds spaced max 24 in. (610 mm) OC, before or after optional spray-applied fire resistive material is used. The use of welds to secure the ceiling runner may only be used prior to the installation of the optional spray-applied material.

BRADY CONSTRUCTION INNOVATIONS INC, DBA SLIPTRACK SYSTEMS — SLF-TRK
CALIFORNIA EXPANDED METAL PRODUCTS CO — CST
CLARKDIETRICH BUILDING SYSTEMS — Type SLT, SLT-H
CONSOLIDATED FABRICATORS CORP, BUILDING PRODUCTS DIV — SHT250, SHT300
MARINOWARE DIV OF WARE INDUSTRIES INC — Type SLT
METAL-LITE INC — The System
OMAR SUPPLY INC — STT250, STT300
R & P SUPPLY — SCT250, SCT300
SCAFCO STEEL STUD MANUFACTURING CO
TELLING INDUSTRIES LLC — True-Action Deflection Track

Hilti Firestop Systems

Reproduced by Hilti, Inc. Courtesy of Underwriters Laboratories, Inc.
December 08, 2015

Figure 8.22: Common Head-of-Wall Firestop Joint (2 of 4)
System No. HW-D-0042

A2. Light Gauge Framing* - Vertical Deflection Ceiling Runner — When the net joint width is less than or equal to 3/4 in. (19 mm), vertical deflection ceiling runner may be used as an alternate to the ceiling runners in Items 2A and 2A1. Vertical deflection ceiling runner to consist of galv steel channel with slotted vertical deflection clips mechanically fastened within runner. Slotted clips provided with stop bushings for permanent fastening of steel studs. Flanges sized to accommodate steel studs (item 2C). Vertical deflection ceiling runner installed perpendicular to direction of fluted steel deck and secured to valleys with steel masonry anchors, steel fasteners or welds spaced max 24 in. (610 mm) OC. before or after optional spray-applied fire resistive material is used. The use of welds to secure the ceiling runner may only be used prior to the installation of the optional spray-applied material.

THE STEEL NETWORK INC — VertiTrack VTD250, VTD362, VTD400, VTD600 and VTD800

A3. Light Gauge Framing* - Notched Ceiling Runner — As an alternate to the ceiling runners in items 2A through 2A3, notched ceiling runners to consist of C-shaped galv steel channel with notched return flanges sized to accommodate steel studs (item 2C). Notched ceiling runner installed perpendicular to direction of fluted steel deck and secured to valleys with steel masonry anchors, steel fasteners or welds spaced max 24 in. (610 mm) OC. before or after optional spray-applied fire resistive material is used. The use of welds to secure the ceiling runner may only be used prior to the installation of the optional spray-applied material.

OLMAR SUPPLY INC — Type SCR

B. Steel Attachment Clips — (Optional - Not Shown) - When spray applied fireproofing is used ceiling runner may be secured to deck with Z-shaped clips formed from min 1 in. (25 mm) long strips of min 20 ga galv steel. Length of clips should not exceed the width (thickness) of the wall. Clips to be sized to extend through the thickness of the spray-applied fire-resistive material on the bottom of the steel deck with 1-1/2 or 2 in. (38 or 51 mm) long upper and lower legs. Legs of clips fastened to valleys of steel deck (prior to application of spray-applied fire-resistive materials) and top of ceiling runner with steel masonry anchors, steel fasteners or welds. Clips spaced max 24 in. (610 mm) OC.

C. Studs — Steel studs to be min 2-1/2 in. (64 mm) wide. Studs cut 1/2 to 3/4 in. (13 to 19 mm) less in length than assembly height with bottom nesting in and resting on floor runner and with top nesting in ceiling runner without attachment. When slotted ceiling runner (item 2A1) is used, steel studs secured to slotted ceiling runner with No. 8 by 1/2 in. (13 mm) long wafer head steel screws at midheight of slot on each side of wall. When vertical deflection ceiling runner (item 2A2) is used, steel studs secured to slotted vertical deflection clips, through the bushings, with steel screws at midheight of each slot. Stud spacing not to exceed 24 in. (610 mm) OC.

D. Gypsum Board — Gypsum board installed to a min total thickness of 5/8 in. and 1-1/4 in. (16 and 32 mm) on each side of wall for 1 and 2 hr rated assemblies, respectively. Wall to be constructed as specified in the individual Wall and Partition Design in the UL Fire Resistance Directory, except that a max 1 in. (25 mm) gap shall be maintained between the top of the gypsum board and the bottom of the steel deck units and the top row of screws shall be installed into the studs 1-1/2 to 2 in. (38 to 51 mm) below the bottom of the ceiling runner. The hourly rating of the joint system is dependent on the hourly rating of the wall.

Figure 8.22: Common Head-of-Wall Firestop Joint (3 of 4)
System No. HW-D-0042

3. Joint System — Max separation between bottom of floor or roof and top of wall at time of installation of joint system is 1 in. (13 mm). The joint system is designed to accommodate a max 50 percent compression or extension from its installed width. The joint system consists of forming material and a fill material, as follows:

A. Forming Material* — Nom 4 pcf (64 kg/m³) density mineral wool batt insulation cut with a length approx equal to the overall thickness of the wall. Multiple pieces staked on top of each other, as needed, and then compressed 25 percent in thickness and inserted into the flutes of the steel deck above the top of the ceiling runner. The mineral wool batt insulation is to project beyond each side of the ceiling runner, flush with wall surfaces. Alternately, nom 4 pcf (64 kg/m³) forming material cut to shape of flute and nom 1 in. (25 mm) longer than thickness of wall, mineral wool compressed from ends and firmly packed into each flute to attain a min compression rate of 14.3 percent in the length (wall thickness) direction to be flush with both wall surfaces. Additional 5/8 in. and 1-1/4 in. (16 and 32 mm) wide strips for 1 and 2 hr rated assemblies, respectively, of nom 4 pcf (64 kg/m³) mineral wool batt insulation are to be cut to fill the gap between the top of the gypsum board and bottom of the steel deck. The strips of mineral wool are compressed 50 percent and tightly packed, cut edge first, into the gap between the top of the gypsum board and bottom of the steel deck on both sides of the wall.

HILTI CONSTRUCTION CHEMICALS, DIV OF HILTI INC — CP777 Speed Plugs

B. Fill, Void or Cavity Material* — 3/16 in. (1.6 mm) dry thickness (1/8 in. or 2.2 mm wet thickness) of fill material sprayed or troweled on each side of the wall to completely cover mineral wool forming material and to overlap a min of 1/2 in. (13 mm) onto gypsum board and steel deck on both sides of wall. When Spray-Applied Fire Resistant Material* is applied to the Steel Floor and Form Units*, the fill material is to overlap the gypsum board a min of 1/2 in. (13 mm) and the Spray-Applied Fire Resistant Material a min of 2 in. (51 mm) on both sides of wall. When spray-applied fire resistant materials are used, the firestop joint spray shall overlap the wall a min 1/2 in. (13 mm) and overlap the spray-applied fire resistant material a min of 2 in. (51 mm) on both sides of the wall.

HILTI CONSTRUCTION CHEMICALS, DIV OF HILTI INC — CFS-SP WB Firestop Joint Spray

* Indicates such products shall bear the UL or cUL Certification Mark for jurisdictions employing the UL or cUL Certification (such as Canada), respectively.
To further enhance the treatment of the head-of-wall joints, an Engineering Judgment showing the specific conditions encountered at the Student Center should be obtained. Engineering Judgments have been identified by the International Firestop Council as acceptable alternatives to using listed firestop systems where no listed firestop systems match the jobsite conditions. The basis for such Engineering Judgments is contained IBC Appendix K105: Alternative Engineered Design.

Section K105.2 refers to alternative designs for fire resistance ratings and requires that manufacturer instructions be followed. Even though a fire resistance rating is not required for the fire barrier head-of-wall joints at the Student Center, an Engineering Judgment issued by the firestop manufacturer will provide reassurance that the firestop products are being used in an acceptable manner.

It should be noted that the fire barriers are formed from gypsum wall assemblies. Gypsum-to-gypsum corner joints can be protected with mud and tape. This is supported by the UL Guide Info. (Category BXUV) for fire resistance rated assemblies.

Summary

The performance based design analysis presented above has affirmed that the prescriptive requirements for fire and life safety systems at the Student Center are adequate to meet the goals of maintaining the life safety of occupants and providing a first step in ensuring structural integrity. This conclusion was reached using an FDS simulation informed by data on common fires, data regarding fires involving items of interest present at the Student Center, and by the performance based design guidance provided in the LCS and SFPE Handbook. Two fire scenarios, Design Fire Scenario 1 (Design Fire A) and Design Fire Scenario 6 (Design Fire B), as detailed in LSC Section 5.5.3.1 were evaluated.

The analysis of Design Fire A found that ASET (1 minute, 30 seconds) exceeds RSET (41 seconds). The ASET was established by the tenability criteria for visibility whereby the smoke layer reached a height of 1.8 meters at 90 seconds. The temperature in the doorway reached 60 °C by 123 seconds. Carbon monoxide exposure did not reach untenable levels during the simulation run time. Flashover conditions were not met because the maximum ceiling temperature was 220 °C and because the maximum heat flux to the floor was 0.24 kW/m². The first sprinkler activated at 107 seconds. The RSET was found by using a hydraulic model for occupant movement to find the time it would take for occupants in Room 505 to exit the room and clear the doorway. RSET was composed of an instant time to notification due to occupants being in the room of fire origin, a delay/pre-movement time of 30 seconds, a travel time of 4 seconds, and a 20% safety factor.

The analysis of Design Fire B found that ASET (8 minutes, 27 seconds) exceeds RSET (7 minutes, 12 seconds). ASET was established by visibility falling below 10 meters at 507 seconds. The temperature threshold was reached by 545 seconds. Exposure to CO did not reach the tenability limit. Flashover conditions were not met because the maximum ceiling temperature was 220 °C
and because the maximum heat flux to the floor was 0.45 kW/m². The first sprinkler activated at 120 seconds. RSET was established by calculating the time for a complete evacuation of the Student Center based on a hydraulic model. RSET was composed of a 120s time to notification, a 30 second delay/pre-movement time, a 3.5 minute travel time, and a 20% safety factor.

An approach for providing documentation for meeting the prescriptive requirements regarding fire barrier joints by using engineered judgments was presented.
Summary of Report Findings

A summary of this fire and life safety report is provided below.

Section 1: Project Introduction

The new Student Center is intended to provide a place of recreation and activities for students, faculty, staff, and community members. It is located along two public ways: a county library to the north and a street to the east. The Student Center is also situated between dormitories to the South and a courtyard to the West. The Student Center is designed as a one-story building.

Section 2: Use and Occupancy Classification, Building Type, and Fire and Smoke Protection Features

The selection of Type II-B construction exceeds the IBC requirements given the size and layout of the Student Center. It also seems to have allowed the designers more flexibility in specifying an aesthetically pleasing and functional space. This analysis concludes that the requirements of the 2015 IBC in regards to structural fire protection features have been satisfied.

Section 3: Interior Finish and Flammability Assessment

Interior finishes will need to be monitored to ensure compliance with the basic prescriptive requirements, as discussed in Section 3, throughout the life of the Student Center. Moreover, if materials that can pose significant fire risk are used, the assessment of their impact on fire safety should go beyond the prescriptive requirements. It may be necessary to limit the use of materials that are otherwise acceptable to prescriptive requirements.

Section 4: Automatic Fire Sprinkler System

The fire sprinkler system designed for the Student Center is adequate based upon the system supply exceeding the expected demand. System supply is shown in Table 4.1 and Figure 4.3. Demand is calculated as being 535 gpm at a residual pressure of 46.1 psig. The supply was based upon fire hydrant flow testing that produced a static pressure of 62 psig, and residual pressure of 28 psig, and flow of 1540 gpm at the residual pressure. It will be necessary for the original designer to submit full calculations with regards to the fire sprinkler demand. It will also be necessary to re-verify the water supply requirements and include the results with the fire sprinkler design plan.

Significant figures and tables include:

- Figure 4.7: Fire Sprinkler System Components
- Table 4.3: Fire Sprinkler Hydraulic Calculations
- Figure 4.9: Fire Sprinkler Supply vs Demand
Section 5: Kitchen Fire Suppression System

The Ansul R-102 is a proprietary pre-engineered fire suppression system. Specific requirements for performing the installation and maintenance of such systems will be contained in the manufacturer’s instructions. Only personnel qualified by the manufacturer should perform work on this system. The kitchen fire suppression system is connected to the fire alarm system so that building occupants will be notified upon system discharge.

Section 6: Fire Alarm System

Smoke detectors are not the primary means of automatic fire detection, but photoelectric type smoke detectors are planned for locations involving sensitive fire alarm equipment. Fire sprinklers are the primary means of detection as these devices are located throughout the Student Center. The integration of the fire sprinklers in to the fire alarm system is via a water flow switch installed on the sprinkler system riser which is connected to a monitor module installed on the fire alarm system. There is a similar connection between the fire alarm system and the kitchen fire suppression system. Duct smoke detectors are installed as a means of smoke control and are intended to limit the spread of combustion products via the HVAC system. Duct smoke detectors are connected to the fire alarm system.

Notification appliances are installed in the correct orientation and with the correct spacing throughout the Student Center. Power requirements for the fire alarm control panel and the two notification appliance circuit extender panels, with regards to a secondary power source, are satisfied by batteries, which calculations show are properly sized. Similarly, the voltage drop of these three devices when servicing all connected devices does not exceed acceptable limits.

Significant figures and tables include:

- Figure 6.2: Smoke Detector Layout
- Figure 6.8: Pull Station Layout
- Figure 6.9: Duct Detector Layout
- Figure 6.10: Notification Appliance Layout

Section 7: Egress System and Components

The Student Center meets the prescriptive requirements with regards to egress systems. The use of each area has been clearly identified. The flow of occupants in an evacuation scenario is clearly indicated on the design documents.

Significant figures and tables include:

- Table 7.1: Occupant Load Breakdown by Area
- Figure 7.2: Exit Analysis Floor Plan
Section 8: Performance Based Design

The performance based design analysis presented above has affirmed that the prescriptive requirements for fire and life safety systems at the Student Center are adequate to meet the goals of maintaining the life safety of occupants and providing a first step in ensuring structural integrity. This conclusion was reached using an FDS simulation informed by data on common fires, data regarding fires involving items of interest present at the Student Center, and by the performance based design guidance provided in the LCS and SFPE Handbook. Two fire scenarios, Design Fire Scenario 1 (Design Fire A) and Design Fire Scenario 6 (Design Fire B), as detailed in LSC Section 5.5.3.1 were evaluated.

The analysis of Design Fire A found that ASET (1 minute, 30 seconds) exceeds RSET (41 seconds). The ASET was established by the tenability criteria for visibility whereby the smoke layer reached a height of 1.8 meters at 90 seconds. The temperature in the doorway reached 60 °C by 123 seconds. Carbon monoxide exposure did not reach untenable levels during the simulation run time. Flashover conditions were not met because the maximum ceiling temperature was 220 °C and because the maximum heat flux to the floor was 0.24 kW/m². The first sprinkler activated at 107 seconds. The RSET was found by using a hydraulic model for occupant movement to find the time it would take for occupants in Room 505 to exit the room and clear the doorway. RSET was composed of an instant time to notification due to occupants being in the room of fire origin, a delay/pre-movement time of 30 seconds, a travel time of 4 seconds, and a 20% safety factor.

The analysis of Design Fire B found that ASET (8 minutes, 27 seconds) exceeds RSET (7 minutes, 12 seconds). ASET was established by visibility falling below 10 meters at 507 seconds. The temperature threshold was reached by 545 seconds. Exposure to CO did not reach the tenability limit. Flashover conditions were not met because the maximum ceiling temperature was 220 °C and because the maximum heat flux to the floor was 0.45 kW/m². The first sprinkler activated at 120 seconds. RSET was established by calculating the time for a complete evacuation of the Student Center based on a hydraulic model. RSET was composed of a 120s time to notification, a 30 second delay/pre-movement time, a 3.5 minute travel time, and a 20% safety factor.

An approach for providing documentation for meeting the prescriptive requirements regarding fire barrier joints by using engineered judgments was presented.

Concluding Remarks and Recommendations

From a prescriptive requirement standpoint, the proposed fire and life safety features of the Student Center are adequate. There is room for improvement with regards to the information conveyed by project documents. This section will consider those deficiencies that have been identified, administrative controls, and recommendations to help provide a sense for what steps can be taken to enhance confidence of the fire and life safety systems.
Deficiencies

Section 2: Use and Occupancy Classification, Building Type, Fire and Smoke Protection Features

1. More information needs to be provided in regards to the areas in the Student Center shown to have fire resistance rated construction. The design documents should explicitly indicate the reasons for this departure from the rest of the Student Center. The Boiler Room clearly fits into the IBC definition of incidental use, but the Electrical Room and ASB Storage have no clear reasons to use fire rated construction.

2. The need for firestop systems for penetrations and joints at fire barriers should be identified on the project documents so that the relevant trades can be aware of this requirement and plan appropriately.

Section 4: Automatic Fire Sprinkler System

1. Hydraulic calculations must be properly documented and placed with the fire sprinkler design documents.

Recommendations and Proposed Administrative Controls

1. There are some sections of IBC Chapter 10 that should be reviewed based upon the potential uses of the Student Center. Section 1003.6 requires that the means of egress shall not be interrupted by building elements or by obstructions. In the case of events at the Student Center, such as food sales or game marathons, controls should be put in place to ensure that the furnishings used by such events do not diminish the capacity of hallways or doors. It is also important to ensure that decorations do not obstruct the view of exit signage.

2. Repurposing an area within the Student Center can affect the total number of occupants in such a way that the number of exits would not be adequate for the increased occupant load. The area most susceptible to this would be the delivery area, which has a design occupant load of 3, ample space for additional individuals, and only one exit. In the case that this area is repurposed, the number of exits available must be taken into account to comply with the provisions of IBC Section 1006.2.1 and Table 1006.2.1.

3. The Northeast exit from the Bookstore should be increased in size and designed to match the entry/exit from the East Vestibule. This will help ensure that occupants entering the Bookstore are immediately aware of this alternative exit.

4. Redundancy should be added to the fire sprinkler flow switch to fire alarm monitor module interface. This will ensure that a single failure cannot disrupt the automatic notification of fire events to Student Center occupants.


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

1. DESCRIPTION
The Viking Microfast® Quick Response Pendent Sprinkler VK352 is a small thermosensitive glass bulb spray sprinkler available with various finishes and temperature ratings to meet design requirements. The special Polyester, Polytetrafluoroethylene (PTFE), and Electroless Nickel PTFE (ENT) coatings can be used in decorative applications where colors are desired. In addition, these coatings have been investigated for installation in corrosive atmospheres and are listed/approved as corrosion resistant as indicated in the Approval Charts. (Note: FM Global approves ENT finish as corrosion resistant. FM Global has no approval classification for PTFE and Polyester coatings as corrosion resistant.)

2. LISTINGS AND APPROVALS
- cULus Listed: Category VNIV
- FM Approved: Class Series 2000
- VdS Approved: Certificates G414019 and G414020
- LPCB Approved
- CE Certified: Standard EN 12259-1, EC-certificate of conformity 0832-CPD-2001 and 0786-CPD-40279

Refer to Approval Chart 1 and Design Criteria cULus Listing requirements, and refer to Approval Chart 2 and Design Criteria for FM Approval requirements that must be followed.

3. TECHNICAL DATA
Specifications:
- Minimum Operating Pressure: 7 psi (0.5 bar)
- Rated to 175 psi (12 bar) water working pressure
- Factory tested hydrostatically to 500 psi (34.5 bar)
- Thread size: 3/4” NPT, 20 mm BSP
- Nominal K-Factor: 8.0 U.S. (115.2 metric**)
- Glass-bulb fluid temperature rated to -65 °F (-55 °C)
- Overall Length: 2-1/4” (58 mm)

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

Material Standards:
- Frame Casting: Brass UNS-C84400
- Deflector: Phosphor Bronze UNS-C51000 or Copper UNS-C19500
- Bulb: Glass, nominal 3 mm diameter
- Belleville Spring Sealing Assembly: Nickel Alloy, coated on both sides with PTFE Tape
- Screw: Brass UNS-C36000
- Pip Cap and Insert Assembly: Copper UNS-C11000 and Stainless Steel UNS-S30400
- For PTFE Coated Sprinklers: Belleville Spring-Exposed, Screw-Nickel Plated, Pip Cap-PTFE Coated
- For Polyester Coated Sprinklers: Belleville Spring-Exposed
- For ENT Coated Sprinklers: Belleville Spring-Exposed, Screw and Pip Cap - ENT plated.

Ordering Information:
Order Quick Response Upright and Pendent Sprinklers by first adding the appropriate suffix for the sprinkler finish and then the appropriate suffix for the temperature rating to the sprinkler base part number.

Finish Suffix: Brass = A, Chrome = F, White Polyester = M-W, Black Polyester = M-B, Black PTFE = N, and ENT = JN

Temperature Suffix: 135 °F (68 °C) = A, 155 °F (68 °C) = B, 175 °F (79 °C) = D, 200 °F (93 °C) = E, 286 °F (141 °C) = G

Available Finishes And Temperature Ratings: Refer to Table 1.

Accessories: (Also refer to the “Sprinkler Accessories” section of the Viking data book.)

Sprinkler Wrenches:

Viking Technical Data may be found on The Viking Corporation’s Web site at http://www.vikinggroupinc.com. The Web site may include a more recent edition of this Technical Data Page.
A. Standard Wrench: Part No. 10896W/B (available since 2000).
B. Wrench for Recessed Pendent Sprinklers: Part No. 16036W/B** (available since 2011)
C. Optional Protective Sprinkler Cap Remover/Escutcheon Installer Tool*** Part No. 15915 (available since 2010)

**A ½” ratchet is required (not available from Viking).

***Allows use from the floor by attaching a length of 1” diameter CPVC tubing to the tool. Ideal for sprinkler cabinets. Refer to Bulletin F_051808.

Sprinkler Cabinets:
A. Six-head capacity: Part No. 01724A (available since 1971)
B. Twelve-head capacity: Part No. 01725A (available since 1971)

4. INSTALLATION
Refer to appropriate NFPA Installation Standards.

5. OPERATION
During fire conditions, the heat-sensitive liquid in the glass bulb expands, causing the glass to shatter, releasing the pip cap and sealing spring assembly. Water flowing through the sprinkler orifice strikes the sprinkler deflector, forming a uniform spray pattern to extinguish or control the fire.

6. INSPECTIONS, TESTS AND MAINTENANCE
Refer to NFPA 25 for Inspection, Testing and Maintenance requirements.

7. AVAILABILITY
The Viking Microfast® Quick Response Pendent Sprinkler VK352 is available through a network of domestic and international distributors. See The Viking Corporation web site for the closest distributor or contact The Viking Corporation.

8. GUARANTEE
For details of warranty, refer to Viking’s current list price schedule or contact Viking directly.
TABLE 1: AVAILABLE SPRINKLER TEMPERATURE RATINGS AND FINISHES

<table>
<thead>
<tr>
<th>Sprinkler Temperature Classification</th>
<th>Sprinkler Nominal Temperature Rating¹</th>
<th>Maximum Ambient Ceiling Temperature²</th>
<th>Bulb Color</th>
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</thead>
<tbody>
<tr>
<td>Ordinary</td>
<td>135 °F (57 °C)</td>
<td>100 °F (38 °C)</td>
<td>Orange</td>
</tr>
<tr>
<td>Ordinary</td>
<td>155 °F (68 °C)</td>
<td>100 °F (38 °C)</td>
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<tr>
<td>Intermediate</td>
<td>175 °F (79 °C)</td>
<td>150 °F (65 °C)</td>
<td>Yellow</td>
</tr>
<tr>
<td>Intermediate</td>
<td>200 °F (93 °C)</td>
<td>150 °F (65 °C)</td>
<td>Green</td>
</tr>
<tr>
<td>High</td>
<td>286 °F (141 °C)</td>
<td>225 °F (107 °C)</td>
<td>Blue</td>
</tr>
</tbody>
</table>

Sprinkler Finishes: Brass, Chrome, White Polyester, Black Polyester, Black PTFE, and ENT

Corrosion-Resistant Coatings³: White Polyester, Black Polyester, and Black PTFE. ENT in all temperature ratings except 135 °F (57 °C)

**Footnotes**

¹ The sprinkler temperature rating is stamped on the deflector.
² Based on NFPA-13. Other limits may apply, depending on fire loading, sprinkler location, and other requirements of the Authority Having Jurisdiction. Refer to specific installation standards.
³ The corrosion-resistant coatings have passed the standard corrosion test required by the approving agencies indicated in the Approval Charts. These tests cannot and do not represent all possible corrosive environments. Prior to installation, verify through the end-user that the coatings are compatible with or suitable for the proposed environment. For automatic sprinklers, the coatings indicated are applied to the exposed exterior surfaces only. Note that the spring is exposed on sprinklers with Polyester, PTFE, and ENT coatings. For ENT coated automatic sprinklers, the waterway is coated.

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Sprinkler wrench 16036W/B**

** for recessed pendent sprinklers

** A 1/2" ratchet is required (not available from Viking)

Carefully slide the wrench sideways around the protective cap, ensuring engagement with the sprinkler wrench flats

Figure 2: Wrench 16036W/B for Recessed Pendent Sprinklers
**TECHNICAL DATA**

**MID-OCTB® QUICK RESPONSE PENDENT SPRINKLER VK352 (K8.0)**

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

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### Approval Chart 1 (UL)

The Viking Microfast® Quick Response Pendant Sprinkler VK352

Maximum 175 PSI (12 Bar) WWP

<table>
<thead>
<tr>
<th>Base Part Number</th>
<th>SIN</th>
<th>Sprinkler Style</th>
<th>Thread Size</th>
<th>Nominal K-Factor</th>
<th>Overall Length</th>
<th>Listings and Approvals</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>NPT</td>
<td>BSP</td>
<td>U.S.</td>
<td>metric</td>
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<tr>
<td>18258</td>
<td>VK352</td>
<td>Pendant</td>
<td>3/4&quot;</td>
<td>20 mm</td>
<td>8.0</td>
<td>115.2</td>
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<tr>
<td>18260</td>
<td>VK352</td>
<td>Pendant</td>
<td>1/2&quot;</td>
<td>15 mm</td>
<td>8.0</td>
<td>115.2</td>
</tr>
</tbody>
</table>

#### Approved Temperature Ratings

- **A**: 135 °F (57 °C), 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), 286 °F (141 °C)
- **B**: 135 °F (57 °C), 155 °F (68 °C), 175 °F (79 °C), and 200 °F (93 °C)
- **C**: 155 °F (68 °C), 175 °F (79 °C), and 200 °F (93 °C)
- **D**: 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), 286 °F (141 °C)

#### Approved Finishes

1. Brass, Chrome, White Polyester, Black Polyester, and Black PTFE
2. ENT
3. Brass, Chrome, White Polyester, and Black Polyester

#### Approved Escutcheons

- **X**: Standard surface-mounted escutcheon or the Viking Micromatic® Model E-1 Recessed Escutcheon
- **Y**: Standard surface-mounted escutcheon or the Viking Microfast® Model F-1 Adjustable Escutcheon, or recessed with the Viking Micromatic® Model E-1 or E-2 Recessed Escutcheon
- **Z**: Standard surface-mounted escutcheon or the Viking Microfast® Model F-1 Adjustable Escutcheon

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**Footnotes**

1. Base part number shown. For complete part number, refer to Viking’s current price schedule.
2. Metric K-factor measurement shown is when pressure is measured in Bar. When pressure is measured in kPa, divide the metric K-factor shown by 10.0.
3. This table shows the listings and approvals available at the time of printing. Other approvals may be in process.
4. Listed by Underwriters Laboratories Inc. for use in the U.S. and Canada.
5. cULus Listed as corrosion-resistant.
6. Other colors are available on request with the same Listings and Approvals as the standard colors.
7. The 1/2" NPT Large Orifice Sprinkler is listed and approved for retrofit only when installed in accordance with NFPA 13.

---

**DESIGN CRITERIA - UL**

(Also refer to Approval Chart 1 above.)

**cULus Listing Requirements:**

The Viking Microfast® Quick Response Pendant Sprinkler VK352 is cULus Listed as indicated in the Approval Chart for installation in accordance with the latest edition of NFPA 13 for standard spray sprinklers.

- Designed for use in Light, Ordinary, and Extra Hazard occupancies.
- The sprinkler installation rules contained in NFPA 13 for standard spray pendant sprinklers must be followed.

**IMPORTANT:** Always refer to Bulletin Form No. F_091699 - Care and Handling of Sprinklers. Also refer to page QR1-3 for general care, installation, and maintenance information. Viking sprinklers are to be installed in accordance with the latest edition of Viking technical data, the appropriate standards of NFPA, LPCB, APSAD, VdS or other similar organizations, and also with the provisions of governmental codes, ordinances, and standards, whenever applicable.

---

Form No. F_033414 Rev 14.1
The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

Approval Chart 2 (FM)
The Viking Microfast® Quick Response Pendent Sprinkler VK352
Maximum 175 PSI (12 Bar) WWP

<table>
<thead>
<tr>
<th>Base Part Number</th>
<th>SIN</th>
<th>Sprinkler Style</th>
<th>Thread Size</th>
<th>Nominal K-Factor</th>
<th>Overall Length</th>
<th>FM Approvals</th>
</tr>
</thead>
<tbody>
<tr>
<td>18258</td>
<td>VK352</td>
<td>Pendent</td>
<td>3/4&quot;</td>
<td>20 mm</td>
<td>8.0</td>
<td>A1Z, B1Y, D2X, C2</td>
</tr>
<tr>
<td>18260</td>
<td>VK352</td>
<td>Pendent</td>
<td>1/2&quot;</td>
<td>15 mm</td>
<td>8.0</td>
<td>A1Z, B1Y, D2X, C2</td>
</tr>
</tbody>
</table>

Approved Temperature Ratings
A - 135 °F (57 °C), 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), 286 °F (141 °C)
B - 135 °F (57 °C), 155 °F (68 °C), 175 °F (79 °C), and 200 °F (93 °C)
C - 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), 286 °F (141 °C)
D - 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C)

Approved Finishes
1 - Brass, Chrome, White Polyester, and Black Polyester
2 - ENT

Approved Escutcheons
X - Standard surface-mounted escutcheon or the Viking Micromatic® Model E-1 Recessed Escutcheon
Y - Standard surface-mounted escutcheon or the Viking Microfast® Model F-1 Adjustable Escutcheon, or recessed with the Viking Micromatic® Model E-1 or E-2 Recessed Escutcheon
Z - Standard surface-mounted escutcheon or the Viking Microfast® Model F-1 Adjustable Escutcheon

Footnotes
1 Base part number shown. For complete part number, refer to Viking's current price schedule.
2 Metric K-factor measurement shown is when pressure is measured in Bar. When pressure is measured in kPa, divide the metric K-factor shown by 10.0.
3 This table shows the FM Approvals available at the time of printing. Other approvals may be in process.
4 Other colors are available on request with the same Approvals as the standard colors.
5 FM approved as corrosion resistant.

FM Approval Requirements:
The Viking Microfast® Quick Response Pendent Sprinkler VK352 is FM Approved as quick response Non-storage upright and pendent sprinklers as indicated in the FM Approval Guide. For specific application and installation requirements, reference the latest applicable FM Loss Prevention Data Sheets (including Data Sheet 2-0). FM Global Loss Prevention Data Sheets contain guidelines relating to, but not limited to: minimum water supply requirements, hydraulic design, ceiling slope and obstructions, minimum and maximum allowable spacing, and deflector distance below the ceiling.

NOTE: The FM installation guidelines may differ from cULus and/or NFPA criteria.

IMPORTANT: Always refer to Bulletin Form No. F_091699 - Care and Handling of Sprinklers. Also refer to page QR1-3 for general care, installation, and maintenance information. Viking sprinklers are to be installed in accordance with the latest edition of Viking technical data, the appropriate standards of NFPA, FM Global, LPCB, APSAD, VdS or other similar organizations, and also with the provisions of governmental codes, ordinances, and standards, whenever applicable.
Figure 3: Sprinkler Dimensions with a Standard Escutcheon and the Model F-1 Adjustable Escutcheon

Figure 4: Sprinkler Dimensions with the Model E-1 and E-2 Recessed Escutcheons
PVC C900 High Pressure Water Pipe

Tough, Reliable and Perfect for Municipal Water Systems

www.pwpipe.com
Why more specifiers choose PWPipe C900 for potable water systems.

PWPipe is the largest producer of PVC pipe in western North America and our products are available from distributors throughout this geographic region. Our water works products are distributed primarily in the states West of the Rockies.

PWPipe products include PVC and polyethylene pipe and tubing for a variety of applications servicing the potable water, well casing, sewer, turf, agriculture, plumbing, communications, and electrical markets. Our manufacturing facilities in Oregon, Washington, California, Utah, and Nebraska assure on-time delivery.

PWPipe C900 high pressure water pipe combines superior materials with the latest manufacturing technology. PWPipe products meet or exceed industry standards because of our rigorous quality-control program.

PWPipe supports the PVC pipe industry’s efforts to maintain the highest design and manufacturing standards. We are members of the Uni-Bell PVC Pipe Association and American Water Works Association (AWWA).
Corrosion Resistance
C900 is immune to nearly all types of internal and external corrosion. Since PVC is a non-conductor, it is not affected by electrolysis. Nor is it susceptible to alkaline or acid soil conditions. A correctly installed PWPipe system will provide long-term service at reduced operating costs.

Water Quality
Extractant water purity tests performed by independent test laboratories ensure that our pipe meets the requirements for water purity as specified by ANSI/NSF Standard 61.

Superior Flow Characteristics
An extremely smooth inner surface gives C900 a Hazen-Williams flow coefficient of C=150. This means less burden on pumps and reduced pumping costs, because there's less friction between moving water and pipe walls.

Exceptional Strength and Durability
Every piece of C900 is hydrostatically proof tested at four times its pressure class.
A 2.5-to-1 safety factor is applied to the long-term pressure capacity of the pipe. The resulting value is further reduced by a surge pressure value, which also incorporates a 2.5-to-1 safety factor. Burst test pressure capability of C900 Class 150 is at least 755 psi, with sustained pressure test capability of 500 psi.
Throughout the country, in all conditions and climates, C900 has served admirably in municipal water mains, fire lines, and sewage force mains.

Joint Integrity
PWPipe's integral bell gasketed joint meets the same strength requirements of the C900 pipe, as well as the demanding test criteria of ASTM D 3139. The ability of PVC to bend without breaking allows the joint and pipe assembly to compensate for minor earth movement, which can cause problems in more rigid, non-PVC assemblies.

Certification
C900 is periodically tested to maintain listings from Factory Mutual System* (FM) and Underwriters Laboratories (UL). C900 also conforms to applicable requirements of the Uniform Plumbing Code™.
*Factory Mutual is not applicable to Class 100, DR 25 products.

1. Clean all debris from the bell end of the pipe. Check the gasket position. Be sure it’s completely seated in the groove, with no raised areas.
2. Lubricate the spigot end, using only the PWPipe recommended lubricant supplied with the pipe.
3. Place the pipes in straight alignment. Assemble to the insertion line on the spigot—but no farther.
See the PWPipe installation guide for more detailed instructions.

Basic Assembly Instructions
Factors Affecting Design

Hydraulics
C900’s pipe wall is extremely smooth and energy-efficient. It has a Hazen-Williams coefficient of C=150.

Pressure Class
PWPipe offers a choice of three pressure classes (100, 150, and 200) which can be used where operating pressures do not exceed the pressure class plus surge allowances. When you have questions or encounter unusual circumstances, call a PWPipe representative.

Temperature
For operation at temperatures 80˚F or higher, multiply the pressure class by these derating factors:

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Derating Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>80˚</td>
<td>0.88</td>
</tr>
<tr>
<td>90˚</td>
<td>0.75</td>
</tr>
<tr>
<td>100˚</td>
<td>0.62</td>
</tr>
<tr>
<td>110˚</td>
<td>0.50</td>
</tr>
<tr>
<td>120˚</td>
<td>0.40</td>
</tr>
<tr>
<td>140˚</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Class 100 DR 25

<table>
<thead>
<tr>
<th>Nominal Pipe Size (inches)</th>
<th>Average Outside Diameter (inches)</th>
<th>Average Inside Diameter (inches)</th>
<th>Minimum Wall Thickness (inches)</th>
<th>Approximate Weight (lbs/100 ft)</th>
<th>Approximate Crate Weight (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4.80</td>
<td>4.39</td>
<td>0.192</td>
<td>190</td>
<td>1800</td>
</tr>
<tr>
<td>6</td>
<td>6.90</td>
<td>6.31</td>
<td>0.276</td>
<td>390</td>
<td>1400</td>
</tr>
<tr>
<td>8</td>
<td>9.05</td>
<td>8.28</td>
<td>0.362</td>
<td>670</td>
<td>2010</td>
</tr>
<tr>
<td>10</td>
<td>11.10</td>
<td>10.15</td>
<td>0.444</td>
<td>1020</td>
<td>1630</td>
</tr>
<tr>
<td>12</td>
<td>13.20</td>
<td>12.08</td>
<td>0.528</td>
<td>1440</td>
<td>1720/2300</td>
</tr>
</tbody>
</table>

Class 150 DR 18

<table>
<thead>
<tr>
<th>Nominal Pipe Size (inches)</th>
<th>Average Outside Diameter (inches)</th>
<th>Average Inside Diameter (inches)</th>
<th>Minimum Wall Thickness (inches)</th>
<th>Approximate Weight (lbs/100 ft)</th>
<th>Approximate Crate Weight (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4.80</td>
<td>4.23</td>
<td>0.267</td>
<td>260</td>
<td>2470</td>
</tr>
<tr>
<td>6</td>
<td>6.90</td>
<td>6.08</td>
<td>0.383</td>
<td>530</td>
<td>1920</td>
</tr>
<tr>
<td>8</td>
<td>9.05</td>
<td>7.98</td>
<td>0.503</td>
<td>920</td>
<td>2760</td>
</tr>
<tr>
<td>10</td>
<td>11.10</td>
<td>9.78</td>
<td>0.617</td>
<td>1390</td>
<td>2230</td>
</tr>
<tr>
<td>12</td>
<td>13.20</td>
<td>11.64</td>
<td>0.733</td>
<td>1970</td>
<td>2360/3150</td>
</tr>
</tbody>
</table>

Class 200 DR 14

<table>
<thead>
<tr>
<th>Nominal Pipe Size (inches)</th>
<th>Average Outside Diameter (inches)</th>
<th>Average Inside Diameter (inches)</th>
<th>Minimum Wall Thickness (inches)</th>
<th>Approximate Weight (lbs/100 ft)</th>
<th>Approximate Crate Weight (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4.80</td>
<td>4.07</td>
<td>0.343</td>
<td>330</td>
<td>3120</td>
</tr>
<tr>
<td>6</td>
<td>6.90</td>
<td>5.85</td>
<td>0.493</td>
<td>680</td>
<td>2430</td>
</tr>
<tr>
<td>8</td>
<td>9.05</td>
<td>7.67</td>
<td>0.646</td>
<td>1160</td>
<td>3490</td>
</tr>
<tr>
<td>10</td>
<td>11.10</td>
<td>9.41</td>
<td>0.793</td>
<td>1770</td>
<td>2830</td>
</tr>
<tr>
<td>12</td>
<td>13.20</td>
<td>11.19</td>
<td>0.943</td>
<td>2500</td>
<td>3000/4000</td>
</tr>
</tbody>
</table>

*These figures allow for manufacturing tolerances. **Gasket shown is for reference purposes only.
Product Description

Standard Specifications
Material
PVC compound meets ASTM D 1784, cell class 12454.

Pipe
Meets AWWA C900. Class 100 meets requirements of DR 25. Class 150 meets requirements of DR 18. Class 200 meets requirements of DR 14.

Elastromeric Seal
Integral bell pipe provided with factory-installed gaskets meeting requirements of ASTM F 477.

Gasketed Joint Assembly
Meets requirements of ASTM D 3139.

Installation
AWWA C605 and PWPipe’s Installation Guide for PVC Water Pipe.

Product
C900 is suitable for use as a pressure conduit. Expansion and contraction are accommodated by a properly assembled gasketed joint. Each bell section meets the same pressure capacity requirements as the pipe.

Standard laying lengths are 20 feet (plus or minus 1 inch).

<table>
<thead>
<tr>
<th>Pipe Stiffness</th>
<th>Pressure Class</th>
<th>DR</th>
<th>Pipe Stiffness (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>25</td>
<td>129</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>18</td>
<td>364</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>14</td>
<td>814</td>
<td></td>
</tr>
</tbody>
</table>

Quality Assurance

Hydrostatic Proof Testing
Each standard and random length of C900 is tested to four times the pressure class of the pipe, for a minimum of five seconds. The integral bell is tested with the pipe.

Falling Weight Impact Test
At 73°F, C900 withstands an impact energy of 150 ft-lbs, when tested in accordance with ASTM D 2444.

Quick Burst Test
Randomly selected C900 samples are tested in accordance with ASTM D 1599 to withstand pressures listed below. Class 100 has a minimum burst pressure of 535 psi; Class 150, a minimum burst pressure of 755 psi; Class 200, a minimum burst pressure of 985 psi.

Pipe Stiffness
C900 meets these minimum stiffness requirements:

<table>
<thead>
<tr>
<th>Pressure Class</th>
<th>DR</th>
<th>Pipe Stiffness (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>25</td>
<td>129</td>
</tr>
<tr>
<td>150</td>
<td>18</td>
<td>364</td>
</tr>
<tr>
<td>200</td>
<td>14</td>
<td>814</td>
</tr>
</tbody>
</table>
Installation

Pipe Embedment
All PVC pipe should be installed with bedding that provides uniform longitudinal support under the pipe. Use embedment material that is free of large stones, frozen matter, or other debris. Use proper compaction procedures to provide soil densities as specified by the design engineer.

Service Connections
Direct Tapping: Direct taps may be made in C900 Class 150 and Class 200 in nominal sizes 6 inch through 12 inch. Corporation stops should be in sizes 1⁄8, 1⁄4, or 1 inch. When sizes larger than 1 inch are required, tapping saddles or sleeves should be used.

Saddle Tapping: Saddle taps may be made in any size or class of C900 pipe. Maximum outlet size recommended for saddle taps is 2 inches. For sizes larger than 2 inches, a tapping sleeve should be used.

Tapping Sleeves: Tapping sleeves may be used on all sizes and classes of C900. Sleeves are available up to size-on-size.

Caution: Saddles and sleeves should not:
• Distort the pipe when tightened
• Have lugs that dig into the pipe when the bolts are tightened
• Have a clamping arrangement not fully contoured to the outside diameter of the pipe

For more information on tapping, see Uni-Bell's tapping video and publications Uni-B-8 and Uni-Pub-8.

Longitudinal Bending
Axial deflection at the pipe joints is not recommended, However, it is possible to curve C900 to allow for slight changes in direction.

Bending to these minimum radii will not jeopardize C900’s design capability. See PWPipe’s Technical Bulletin “Longitudinal Bending of PVC Pipe” for more details.

<table>
<thead>
<tr>
<th>Nominal Pipe Size (inches)</th>
<th>Fitting 90˚ Elbow (lbs force)</th>
<th>Fitting 45˚ Elbow (lbs force)</th>
<th>Valves, Tees, Dead Ends (lbs force)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2,160</td>
<td>1,180</td>
<td>1,530</td>
</tr>
<tr>
<td>6</td>
<td>4,460</td>
<td>2,420</td>
<td>3,160</td>
</tr>
<tr>
<td>8</td>
<td>7,700</td>
<td>4,160</td>
<td>5,440</td>
</tr>
<tr>
<td>10</td>
<td>11,600</td>
<td>6,260</td>
<td>8,190</td>
</tr>
<tr>
<td>12</td>
<td>16,400</td>
<td>8,880</td>
<td>11,600</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Allowable Bearing Pressure (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muck, Peat, Etc.</td>
<td>0</td>
</tr>
<tr>
<td>Soft Clay</td>
<td>500</td>
</tr>
<tr>
<td>Sand</td>
<td>1,000</td>
</tr>
<tr>
<td>Sand and Gravel</td>
<td>1,500</td>
</tr>
<tr>
<td>Sand and Gravel With Clay</td>
<td>2,000</td>
</tr>
<tr>
<td>Sand and Gravel Cemented With Clay</td>
<td>4,000</td>
</tr>
<tr>
<td>Hard Pan</td>
<td>5,000</td>
</tr>
</tbody>
</table>

Note: Values are estimated for horizontal thrusts at depths of burial which exceed 2 feet.
Note: These values should be used only for estimating purposes. Values for design should be determined by an engineer familiar with site soil conditions.
Adequate thrust restraint is necessary for all gasketed joint systems. The “push on” features of our joints provide many installation advantages, but without adequate thrust restraint they can become “push off” problems. The large thrust forces present in water-distribution systems (see Table 1) require thrust restraints designed to handle test and peak operating pressures.

Concrete Thrust Blocks
If concrete thrust blocks are used, the size and type of thrust blocking must be based on the load-bearing capacity of the soil, pressure in the pipe, and diameter of the pipe. Table 2 provides conservative estimates of load-bearing values for various soil types. When soil conditions are not known, samples should be tested to determine soil properties.

Mechanical Restraints
If mechanical thrust restraint devices are used, they should be a type designed for use with PVC pipe. The devices should meet the test requirements of Uni-Bell’s Specification Uni-B-13 “Joint Restraint Devices for Use with PVC Pipe.” Design manuals and computer software are available from the restraint manufacturers.

For typical thrust blocking and mechanical thrust restraint examples, see Figures 1 through 6.

**THRUST BLOCKS**

- FIGURE 1: Through line connection, tee
- FIGURE 2: Direction change, elbow
- FIGURE 3: Change line size, reducer

**MECHANICAL THRUST RESTRAINT DEVICES**

- FIGURE 4: Through line connection, cross used as tee
- FIGURE 5: Direction change, elbow
- FIGURE 6: Direction change, tee used as elbow
Testing of Installed Systems

Place sufficient backfill before pipe filling and field testing. Under conditions requiring immediate backfilling of trenches, test after backfilling but prior to placement of permanent surface. Testing short lengths of pipe first will verify proper installation and joint assembly. If concrete thrust blocks are required, allow sufficient curing before testing.

Separate tests for pressure and leakage may be performed. If separate tests are done, the pressure test should be done first. See Table 4.

Procedure
While the line is under pressure, check for leaks in all exposed pipe, fittings, valves, and hydrants. Repair or replace all defective elements. Repeat the test until all visible leaks stop and the allowable leakage requirements are met, per Table 5. For detailed pressure-testing requirements, consult your engineer or the PWPipe installation guide.

<table>
<thead>
<tr>
<th>Table 3. Volume of Water Required for Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nominal Pipe Size</strong></td>
</tr>
<tr>
<td>(inches)</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 4. System Test Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Procedure</strong></td>
</tr>
<tr>
<td>Simultaneous pressure and leakage tests</td>
</tr>
<tr>
<td>Separate pressure test</td>
</tr>
<tr>
<td>Separate leakage test</td>
</tr>
</tbody>
</table>

Source: Underground Installation of PVC Pressure Pipe and Fittings for Water, AWWA C605.

*Under no circumstances should test pressures exceed 305 psi for DR 14, 235 psi for DR 18, and 165 psi for DR 25 C900 PVC pipe.

<table>
<thead>
<tr>
<th>Table 5. Allowable Leakage per 50 Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nominal Pipe Size</strong></td>
</tr>
<tr>
<td>(inches)</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>12</td>
</tr>
</tbody>
</table>

WARNING: Do not use PVC pipe for pressurized air systems. Injury or death may result due to the catastrophic nature of pipe failure should failure occur. Rapid expansion of compressed air could propel shards of plastic throughout the area.

WARNING: Expel all air from the pipeline during filling and again before testing for pressure or leaks. Automatic air-release valves are recommended. Compressed entrapped air can greatly amplify surges or pumping pressures. Also, compressed air might leak through a joint that will not leak water.
The System Sensor OSY2 is used to monitor the open position of an Outside Screw and Yoke (OS&Y) type gate valve.

**Features**
- NEMA 3R-rated enclosure
- User-friendly mounting bracket fits newer valve yokes
- Single side conduit entry does not require right angle fittings
- Adjustable length actuator eliminates the need for cutting the shaft
- Accommodates up to 12 AWG wire
- Three position switch monitors vandal and valve close signals
- Two SPDT contacts are enclosed in a durable terminal block for added strength
- 100 percent synchronization activates both alarm panel and local bell simultaneously

**Robust Construction.** The OSY2 consists of a rugged housing, intended for indoor and outdoor use. When installed with the actuator in the vertical position, the OSY2 is NEMA 3R rated per UL.

**Application Flexibility.** The OSY2 features a user-friendly mounting bracket and adjustable shaft to permit mounting to most OS&Y valves, ranging in size from 1” to 12”. Its right angle design and wide bracket span provides maximum clearance for valve components, to accommodate troublesome valves. Removing the OSY2's gate valve bracket allows the unit to monitor side-bracket-style pressure reducing valves.

**Simplified Operation.** Installation is made easier with the OSY2's single side conduit entrance. By providing a direct conduit pathway to the electrical source, right angle fittings are not required. Installation is further simplified by the OSY2's adjustable length actuator, which eliminates the need for cutting the shaft.

**Reliable Performance.** The OSY2 is equipped with tamper-resistant cover screws to prevent unauthorized entry. Inside, two sets of SPDT (Form C) synchronized switches are enclosed in a durable terminal block to assure reliable performance.
**OSY2 Specifications**

**Architectural/Engineering Specifications**

Model shall be model number OSY2 supervisory switch as manufactured by System Sensor. OSY2 shall be installed on each valve as designated on the drawings and/or as specified herein. Switches shall be mounted so as not to interfere with the normal operation of the valve and shall be adjusted to operate within two revolutions of the valve control or when the stem has moved no more than one-fifth of the distance from its normal position. The mechanism shall be contained in a weatherproof die cast metal housing that provides a side entrance for ½” conduit and incorporates the necessary facilities for attachment to the valve. A grounding provision is provided. The switch assembly shall include two switches each with a rated capacity of 10 Amp @ 125/250VAC and 2.5 Amp @ 24VDC. The cover shall contain tamper-resistant screws for which a security wrench will be provided with each switch. The OSY2 shall be Underwriters Laboratories listed for indoor or outdoor use. The OSY2 shall be Factory Mutual, CSFM, and MEA approved.

**Physical Specifications**

<table>
<thead>
<tr>
<th>Overall Switch Dimensions</th>
<th>Contact Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 ¾” H x 3 ½” W x 3 ¼” D</td>
<td>Two sets of SPDT (Form C)</td>
</tr>
<tr>
<td>(14.6cm x 8.9cm x 8.2cm)</td>
<td>10.0 A @ 125/250VAC, 2.5 @ 6/12/24VDC</td>
</tr>
</tbody>
</table>

**Shipping Weight**

2.8 lbs. (1.3 kg)

**Operating Temperature Range**

32°F to 120°F (0°C to 49°C)

**Cover Tamper Switch**

Standard with ULC model
Optional for UL model, part no. 546-7000

**Maximum Stem Extension**

2 5/8” (6.7cm)

**Bracket Span**

1 ¼” H x 6 ½” W x 1” D (5.7cm x 17.1cm x 2.5cm)

**Conduit Entrances**

One single side open for ½” conduit

**Warranty**

3 years

**Enclosure Rating**

UL indoor/outdoor
NEMA 3R when mounted with the actuator vertical

**Service Use**

Automatic Sprinkler: NFPA 13
One or Two Family Dwelling: NFPA 13D
Residential Occupancies up to 4 stories: NFPA 13R
National Fire Alarm code: NFPA 72

**OSY2 Mounting**

The following are examples of acceptable mounting positions:

- **Actuator Vertical (Down)**
- **Actuator Horizontal**
- **Actuator Vertical (Pointing Up)**

---

**Electrical Connections for OSY2**

**TYPICAL FACP CONNECTION**

- TO NONSILENCABLE INITIATING ZONE OF LISTED FACP
- END-OF-LINE RESISTOR
- BREAK WIRE AS SHOWN FOR SUPERVISION OF CONNECTION. DO NOT ALLOW STRIPPED WIRE LEADS TO EXTEND BEYOND SWITCH HOUSING. DO NOT LOOP WIRES.

**TYPICAL LOCAL BELL CONNECTION**

- TO POWER SOURCE COMPATIBLE WITH BELL

**CONTACT RATINGS**

- 125/250 VAC: 10 AMPS
- 24 VDC: 2.5 AMPS

**NOTE:** COMMON AND B CONNECTIONS WILL CLOSE WHEN VALVE MOVES 1/5 OF ITS TOTAL TRAVEL DISTANCE.

**Ordering Information**

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSY2</td>
<td>Outside Screw and Yoke valve supervisory switch</td>
</tr>
<tr>
<td>OSY2A</td>
<td>Outside Screw and Yoke valve supervisory switch (ULC model)</td>
</tr>
</tbody>
</table>

**Accessories**

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSYRK</td>
<td>Replacement hardware kit (wrenches, screw pack and J-hooks)</td>
</tr>
<tr>
<td>546-7000</td>
<td>Cover tamper switch kit</td>
</tr>
<tr>
<td>507-66-XX</td>
<td>Tamper screws for cover</td>
</tr>
<tr>
<td>WFDW</td>
<td>Replacement tamper-proof wrench for cover</td>
</tr>
<tr>
<td>HEXW</td>
<td>Replacement hex wrench</td>
</tr>
</tbody>
</table>

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Product specifications subject to change without notice. Visit systemsensor.com for current product information, including the latest version of this data sheet.
Specifications subject to change without notice.

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Model</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot;</td>
<td>DN50</td>
<td>VSR-2</td>
</tr>
<tr>
<td>2 1/2&quot;</td>
<td>DN65</td>
<td>VSR-2 1/2</td>
</tr>
<tr>
<td>3&quot;</td>
<td>DN80</td>
<td>VSR-3</td>
</tr>
<tr>
<td>3 1/2&quot;</td>
<td>-</td>
<td>VSR-3 1/2</td>
</tr>
<tr>
<td>4&quot;</td>
<td>DN100</td>
<td>VSR-4</td>
</tr>
<tr>
<td>5&quot;</td>
<td>-</td>
<td>VSR-5</td>
</tr>
<tr>
<td>6&quot;</td>
<td>DN150</td>
<td>VSR-6</td>
</tr>
<tr>
<td>8&quot;</td>
<td>DN200</td>
<td>VSR-8</td>
</tr>
</tbody>
</table>

Optional: Cover Tamper Switch Kit, stock no. 0090148
Replaceable Components: Retard/Switch Assembly, stock no. 1029030

Important: This document contains important information on the installation and operation of the VSR waterflow switches. Please read all instructions carefully before beginning installation. A copy of this document is required by NFPA 72 to be maintained on site.

General Information
The Model VSR is a vane type waterflow switch for use on wet sprinkler systems. It is UL Listed for use on a steel pipe; schedules 5 through 40, sizes 2" - 6" and is UL Listed and FM Approved for use on steel pipe; schedules 10 through 40, sizes 2" thru 8" (50 mm thru 200 mm). LPC approved sizes are 2" thru 8" (50 mm thru 200 mm). See Ordering Information chart.

The VSR may also be used as a sectional waterflow detector on large systems. The VSR contains two single pole, double throw, snap action switches and an adjustable, instantly recycling pneumatic retard. The switches are actuated when a flow of 10 GPM (38 LPM) or more occurs downstream of the device. The flow condition must exist for a period of time necessary to overcome the selected retard period.

Enclosure
The VSR switches and retard device are enclosed in a general purpose, die-cast housing. The cover is held in place with two tamper resistant screws which require a special key for removal. A field installable cover tamper switch is available as an option which may be used to indicate unauthorized removal of the cover. See bulletin number 5401103 for installation instructions of this switch.
Installation (see Fig. 1)

These devices may be mounted on horizontal or vertical pipe. On horizontal pipe they shall be installed on the top side of the pipe where they will be accessible. The device should not be installed within 6" (15 cm) of a fitting which changes the direction of the waterflow or within 24" (60 cm) of a valve or drain.

**NOTE:** Do not leave cover off for an extended period of time.

Drain the system and drill a hole in the pipe using a hole saw in a slow speed drill (see Fig. 1). Clean the inside pipe of all growth or other material for a distance equal to the pipe diameter on either side of the hole. Roll the vane so that it may be inserted into the hole; do not bend or crease it. Insert the vane so that the arrow on the saddle points in the direction of the waterflow. Take care not to damage the non-corrosive bushing in the saddle. The bushing should fit inside the hole in the pipe. Install the saddle strap and tighten nuts alternately to required torque (see the chart in Fig. 1). The vane must not rub the inside of the pipe or bind in any way.

---

<table>
<thead>
<tr>
<th>Model</th>
<th>Nominal Pipe O.D.</th>
<th>Pipe Wall Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSR-2</td>
<td>2 DN50</td>
<td>0.109</td>
</tr>
<tr>
<td>VSR-2 1/2</td>
<td>2.575</td>
<td>0.154</td>
</tr>
<tr>
<td>VSR-2 1/2</td>
<td>3.000</td>
<td>0.120</td>
</tr>
<tr>
<td>VSR-3</td>
<td>3 DN80</td>
<td>0.109</td>
</tr>
<tr>
<td>VSR-3 1/2</td>
<td>3.500</td>
<td>0.120</td>
</tr>
<tr>
<td>VSR-4</td>
<td>4 DN100</td>
<td>0.120</td>
</tr>
<tr>
<td>VSR-5</td>
<td>5 DN150</td>
<td>0.134</td>
</tr>
<tr>
<td>VSR-6</td>
<td>6 DN200</td>
<td>0.148</td>
</tr>
<tr>
<td>VSR-8</td>
<td>8 DN200</td>
<td>0.148</td>
</tr>
</tbody>
</table>

**CAUTION**

Do not trim the paddle. Failure to follow these instructions may prevent the device from operating and will void the warranty. Do not obstruct or otherwise prevent the trip stem of the flow switch from moving when water flows as this could damage the flow switch and prevent an alarm. If an alarm is not desired, a qualified technician should disable the alarm system.

---

**Retard Adjustment**

The delay can be adjusted by rotating the retard adjustment knob from 0 to the max setting (60-90 seconds). The time delay should be set at the minimum required to prevent false alarms.

---

**NOTE:** For copper or plastic pipe use Model VSR-CF.
Fig. 2
To remove knockouts: Place screwdriver at inside edge of knockouts, not in the center.

**NOTICE**
Do not drill into the base as this creates metal shavings which can create electrical hazards and damage the device. Drilling voids the warranty.

Fig. 3
Break out thin section of cover when wiring both switches from one conduit entrance.

**WARNING**
An uninsulated section of a single conductor should not be looped around the terminal and serve as two separate connections. The wire must be severed, thereby providing supervision of the connection in the event that the wire become dislodged from under the terminal. Failure to sever the wire may render the device inoperable risking severe property damage and loss of life. Do not strip wire beyond 3/8” of length or expose an uninsulated conductor beyond the edge of the terminal block. When using stranded wire, capture all strands under the clamping plate.

Fig. 5
**Typical Electrical Connections**

**Notes:**
1. The Model VSR has two switches, one can be used to operate a central station, proprietary or remote signaling unit, while the other contact is used to operate a local audible or visual annunciator.
2. For supervised circuits, see “Switch Terminal Connections” drawing and warning note (Fig. 4).

**Testing**
The frequency of inspection and testing for the Model VSR and its associated protective monitoring system shall be in accordance with applicable NFPA Codes and Standards and/or the authority having jurisdiction (manufacturer recommends quarterly or more frequently).

If provided, the inspector’s test valve shall always be used for test purposes. If there are no provisions for testing the operation of the flow detection device on the system, application of the VSR is not recommended or advisable.

A minimum flow of 10 GPM (38 LPM) is required to activate this device.

**NOTE**
Advise the person responsible for testing of the fire protection system that this system must be tested in accordance with the testing instructions.

Fig. 6
**Mounting Dimensions**

Fig. 7
**LOAD TO BELL**
**NEUTRAL FROM BELL**
**CONNECTOR**
**BELL**
**BREAKER**
**LINE FROM BREAKER**
**EOL (End Of Line Resistor)**

**NOTE:** When connecting to a UL Listed control panel, use the panel’s resistor value for circuit supervision.
Maintenance
Inspect detectors monthly. If leaks are found, replace the detector. The VSR waterflow switch should provide years of trouble-free service. The retard and switch assembly are easily field replaceable. In the unlikely event that either component does not perform properly, please order replacement retard switch assembly stock #1029030 (see Fig. 8). There is no maintenance required, only periodic testing and inspection.

Retard/Switch Assembly Replacement (See Fig. 8)

NOTICE The Retard/Switch Assembly is field-replaceable without draining the system or removing the waterflow switch from the pipe

1. Make sure the fire alarm zone or circuit connected to the waterflow switch is bypassed or otherwise taken out of service.
2. Disconnect the power source for local bell (if applicable).
3. Identify and remove all wires from the waterflow switch.
4. Remove the (2) mounting screws holding retard/switch assembly to the base. Do not remove the (2) retard housing screws.
5. Remove the retard assembly by lifting it straight up over the tripstem.
6. Install the new retard assembly. Make sure the locating pins on the retard/switch assembly fit into the locating pin bosses on the base.
7. Re-install the (2) original mounting screws.
8. Reconnect all wires. Perform a flow test and place the system back in service.

Removal of Waterflow Switch
- To prevent accidental water damage, all control valves should be shut tight and the system completely drained before waterflow detectors are removed or replaced.
- Turn off electrical power to the detector, then disconnect wiring.
- Loosen nuts and remove U-bolts.
- Gently lift the saddle far enough to get your fingers under it. With your fingers, roll the vane so it will fit through the hole while continuing to lift the waterflow detector saddle.
- Lift detector clear of pipe.
Appendix B: Fire Alarm System Component Details
NFS2-640(E)
Intelligent Addressable
Fire Alarm System

General
The NFS2-640 intelligent Fire Alarm Control Panel is part of the ONYX® Series of Fire Alarm Controls from NOTIFIER.

In stand-alone or network configurations, ONYX Series products meet virtually every application requirement.

The NFS2-640’s modular design makes system planning easier. The panel can be configured with just a few devices for small building applications, or networked with many devices to protect a large campus or a high-rise office block. Simply add additional peripheral equipment to suit the application.

A host of other options are available, including single- or multi-channel voice; firefighter’s telephone; LED, LCD, or PC-based graphic annunciators; networking; advanced detection products for challenging environments; wireless fire protection; and many additional options.

NOTE: Unless called out with a version-specific “E” at the end of the part number, “NFS2-640” refers to models NFS2-640 and NFS2-640E; similarly, “CPU2-640” refers to models CPU2-640 and CPU2-640E.

Features
• Certified for seismic applications when used with the appropriate seismic mounting kit.
• Approved for Marine applications when used with listed compatible equipment. See DN-60688.
• One, expandable to two, isolated intelligent Signaling Line Circuit (SLC) Style 4, 6 or 7.
• Wireless fire protection using SWIFT Smart Wireless Integrated Fire Technology. See DN-60820.
• Up to 159 detectors and 159 modules per SLC; 318 devices per loop/636 per FACP or network node.
  – Detectors can be any mix of ion, photo, thermal, or multi-sensor; wireless detectors are available for use with the FWSG.
  – Modules include addressable pull stations, normally open contact devices, two-wire smoke detectors, notification, or relay; wireless modules are available for use with the FWSG.
• Standard 80-character display, 640-character large display (NCA-2), or display-less (a node on a network).
• Network options:
  – High-speed network for up to 200 nodes (NFS2-3030, NFS2-640, NFS-320(C), NFS-320SYS, NCA-2, DVC-EM, ONYXWorks, NFS-3030, NFS-640, and NCA).
  – Standard network for up to 103 nodes (NFS2-3030, NFS2-640, NFS-320(C), NFS-320SYS, NCA-2, DVC-EM, ONYXWorks, NCS, NFS-3030, NFS-640, NCA, AFP-200, AFP-300/400, AFP-1010, and AM2020). Up to 54 nodes when DVC-EM is used in network paging.
• 6.0 A switch mode power supply with four Class A/B built-in Notification Appliance Circuits (NAC). Selectable System Sensor, Wheelock, or Gentex strobe synchronization.
• Built-in Alarm, Trouble, Security, and Supervisory relays.
• VeriFire® Tools online or offline programming utility. Upload/Download, save, store, check, compare, and simulate panel databases. Upgrade panel firmware.
• Autoprogramming and Walk Test reports.
• Multiple central station communication options:
  – Standard UDACT
  – Internet
  – Internet/GSM
• 80-character remote annunciators (up to 32).
• EIA-485 annunciators, including custom graphics.
• Printer interface (80-column and 40-column printers).
• History file with 800-event capacity in nonvolatile memory, plus separate 200-event alarm-only file.
• Alarm Verification selection per point, with automatic counter.
• Presignal/Positive Alarm Sequence (PAS).
• Silence inhibit and Auto Silence timer options.
• March time/temporal/California two-stage coding/strobe synchronization.
• Field-programmable on panel or on PC, with VeriFire Tools program check, compare, simulate.
• Full QWERTY keypad.
• Battery charger supports 18 – 200 AH batteries.
• Non-alarm points for lower priority functions.
• Remote ACK/Signal Silence/System Reset/Drill via monitor modules.
• Automatic time control functions, with holiday exceptions.
• Surface Mount Technology (SMT) electronics.
• Extensive, built-in transient protection.
• Powerful Boolean logic equations.
• Support for SCS Series smoke control system in HVAC mode.
**NCA-2 as Primary Display**
- Backlit, 640-character display.
- Supports SCS Series smoke control system in FSCS mode when SCS is connected to the NCA-2 used as primary display.
- Supports DVC digital audio loop.
- Printer and CRT EIA-232 ports.
- EIA-485 annunciator and terminal mode ports.

**FLASHScan® Intelligent Features**
- Polls up to 318 devices in less than two seconds.
- Activates up to 159 outputs in less than five seconds.
- Multicolor LEDs blink device address during Walk Test.
- Fully digital, high-precision protocol (U.S. Patent 5,539,389).
- Manual sensitivity adjustment — up to nine levels.
- Pre-alarm ONYX intelligent sensing — up to nine levels.
- Day/Night automatic sensitivity adjustment.
- Sensitivity windows:
  - Ion — 0.5 to 2.5%/foot obscuration.
  - Photo — 0.5 to 2.35%/foot obscuration.
  - Laser (VIEW™) — 0.02 to 2.0%/foot obscuration.
  - Acclimate Plus™ — 0.5 to 4.0%/foot obscuration.
  - IntelliQuad™ — 1.0 to 4.0%/foot obscuration.
  - IntelliQuad™ PLUS — 1.0 to 4.0%/foot obscuration
- Drift compensation (U.S. Patent 5,764,142).
- Degraded mode — in the unlikely event that the CPU2-640 microprocessor fails, FlashScan detectors revert to degraded operation and can activate the CPU2-640 NAC circuits and alarm relay. Each of the four built-in panel circuits includes a Disable/Enable switch for this feature.
- Multi-detector algorithm involves nearby detectors in alarm decision (U.S. Patent 5,627,515).
- Automatic detector sensitivity testing (NFPA-72 compliant).
- Maintenance alert (two levels).
- Self-optimizing pre-alarm.

**FSL-751 (Very Intelligent Early Warning) Smoke Detection Technology**
- Advanced ONYX intelligent sensing algorithms differentiate between smoke and non-smoke signals (U.S. Patent 5,831,524).
- Addressable operation pinpoints the fire location.
- Early warning performance comparable to the best aspiration systems at a fraction of the lifetime cost.

**FAPT-851 Acclimate Plus Low-Profile Intelligent Multi-Sensor**
- Detector automatically adjusts sensitivity levels without operator intervention or programming. Sensitivity increases with heat.
- Microprocessor-based technology; combination photo and thermal technology.
- Low-temperature warning signal at 40°F ± 5°F (4.44°C ± 2.77°C).

**FSC-851 IntelliQuad Advanced Multi-Criteria Detector**
- Detects all four major elements of a fire (smoke, heat, CO, and flame).
- Automatic drift compensation of smoke sensor and CO cell.
- High nuisance-alarm immunity.

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Sample System Options

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**SLC Intelligent Loop 1**
- EIA-485
- NBG-12LX
- FSP-851 Photo
- FST-851 Thermal
- FSA-8000
- etc.

**SLC Intelligent Loop 2**
- EIA-485
- ACM-8R
- ACM/ÆM-24AT
- LED Annunciator

**Optional 636-point UDACT**
- Dual phone lines to Central Station

---

**NFS2-640 “C” cabinet size shown**
- KDM-R2 display
- OR
- NCA-2 OR with no display
- Up to 32 remote displays

---

**PRN Series Printer**
Intelligent Sensing

Intelligent sensing is a set of software algorithms that provides the NFS2-640 with industry-leading smoke detection capability. These complex algorithms require many calculations on each reading of each detector, and are made possible by the high-speed microcomputer used by the NFS2-640.

Drift Compensation and Smoothing: Drift compensation allows the detector to retain its original ability to detect actual smoke, and resist false alarms, even as dirt accumulates. It reduces maintenance requirements by allowing the system to automatically perform the periodic sensitivity measurements required by NFPA 72. Smoothing filters are also provided by software to remove transient noise signals, such as those caused by electrical interference.

Maintenance Warnings: When the drift compensation performed for a detector reaches a certain level, the performance of the detector may be compromised, and special warnings are given. There are three warning levels: (1) Low Chamber value; (2) Maintenance Alert, indicative of dust accumulation that is near but below the allowed limit; (3) Maintenance Urgent, indicative of dust accumulation above the allowed limit.

Sensitivity Adjust: Nine sensitivity levels are provided for alarm detection. These levels can be set manually, or can change automatically between day and night. Nine levels of pre-alarm sensitivity can also be selected, based on predetermined levels of alarm. Pre-alarm operation can be latching or self-restoring, and can be used to activate special control functions.

Self-Optimizing Pre-Alarm: Each detector may be set for “Self-Optimizing” pre-alarm. In this special mode, the detector “learns” its normal environment, measuring the peak analog readings over a long period of time, and setting the pre-alarm sensitivity to actual smoke by a factor of almost two to one.

Field Programming Options

Autoprogram is a timesaving feature. The FACP “learns” what devices are physically connected and automatically loads them in the program with default values for all parameters. Requiring less than one minute to run, this routine allows the user to have almost immediate fire protection in a new installation, even if only a portion of the detectors are installed.

Keypad Program Edit (with KDM-R2) The NFS2-640, like all NOTIFIER intelligent panels, has the exclusive feature of program creation and editing capability from the front panel keypad, while continuing to provide fire protection. The architecture of the NFS2-640 software is such that each point entry carries its own program, including control-by-event links to other points. This allows the program to be entered with independent per-point segments, while the NFS2-640 simultaneously monitors other (already installed) points for alarm conditions.

VeriFire® Tools is an offline programming and test utility that can greatly reduce installation programming time, and increase confidence in the site-specific software. It is Windows®-based and provides technologically advanced capabili-
ties to aid the installer. The installer may create the entire program for the NFS2-640 in the comfort of the office, test it, store a backup file, then bring it to the site and download from a laptop into the panel.

**Placement of Equipment in Chassis and Cabinet**

The following guidelines outline the NFS2-640's flexible system design.

**Rows:** The first row of equipment in the cabinet mounts in the chassis shipped with the FACP. Mount the second, third, or fourth rows of equipment in a CHS-4 series chassis or, for Digital Voice Command products, in CA-1 or CA-2. (For DVC-EM and DAA2/DAX components see DVC Manual; for DS series components see DS-AMP Manual; for DVC-AO applications, see AA Series Installation Manual). Other options are available; see your panel's installation manual.

**Wiring:** When designing the cabinet layout, consider separation of power-limited and non-power-limited wiring as discussed in the NFS2-640 Installation Manual.

**Positions:** A chassis offers four basic side-by-side positions for components; the number of modules that can be mounted in each position depends on the chassis model and the size of the individual module. There are a variety of standoffs and hardware items available for different combinations and configurations of components.

It is critical that all mounting holes of the NFS2-640 are secured with a screw or standoff to ensure continuity of Earth Ground.

**Layers:** The control panel's chassis accepts four layers of equipment, including the control panel. The CPU2-640 fills three positions (left to right) in the first-installed layer (the back of the chassis); its integral power supply occupies the center two positions in the next two layers; the optional display occupies (the left) two positions at the front, flush with the door. Some equipment, such as the NCA-2, may be mounted in the dress panel directly in front of the control panel. The NCA-2 can be used as a primary display for the NFS2-640 (use NCA/640-2-KIT) by directly connecting their network ports (required in Canadian stand-alone applications); see NCA-2 data sheet for mounting options (DN-7047).

**Expansion:** Installing an LEM-320 Loop Expander Module adds a second SLC loop to the control panel. The LEM-320 is mounted onto the CPU2-640, occupying the middle-right, second (back) slot on the chassis.

**Networking:** If networking two or more control panels, each unit requires a Network Communication Module or High-Speed Network Communication Module. (HS-NCM can support two nodes; see “Networking Options” on page 5). These modules can be installed in any option board position (see manual), and additional option boards can be mounted in front of the network communication modules.

**KDM-R2 Controls and Indicators**

**Program Keypad:** QWERTY type (keyboard layout, see figure).

**12 LED Indicators:** Power; Fire Alarm; Pre-Alarm; Security; Supervisory; System Trouble; Signals Silenced; Points Disabled; Control Active; Abort; Pre-Discharge; Discharge.

**Keypad Switch Controls:** Acknowledge/Scroll Display; Signal Silence; Drill; System Reset; Lamp Test.

**LCD Display:** 80 characters (2 x 40) with long-life LED backlight.

**Product Line Information**

- “Configuration Guidelines” on page 4
- “Networking Options” on page 5
- “Auxiliary Power Supplies and Batteries” on page 5
- “Audio Options” on page 5
- “Compatible Devices, EIA-232 Ports” on page 5
- “Compatible Devices, EIA-485 Ports” on page 5
- “Compatible Intelligent Devices” on page 6
- “Enclosures, Chassis, and Dress Plates” on page 7
- “Other Options” on page 7

**Configuration Guidelines**

Stand-alone and network systems require a main display. On systems with one FACP (one CPU2-640/640E), display options are the KDM-R2 or the NCA-2. On network systems (two or more networked fire panel nodes), at least one NCA-2, NCS, or ONYXWorks annunciation device is required. Other options listed as follows;

**KDM-R2:** 80-character backlit LCD display with QWERTY programming and control keypad. Order two BMP-1 blank modules and DP-DISP2 mounting plate separately. Requires top row of a cabinet. Required for each stand-alone 80-character display system. The KDM-R2 may mount in network nodes to display "local" node information as long as at least one NCA-2 or NCS/ONYXWorks network display is on the system to display network information. (Non-English versions also available: KDM-R2-SP.)

**NCA-2:** Network Control Annunciator, 640 characters. On single CPU2-640/640E systems, the optional NCA-2 can be used as the Primary Display for the panel and connects directly to the CPU2-640/640E. On network systems (two or more networked fire panel nodes), one network display (either NCA-2 or NCS/ONYXWorks) is required for every system. On network systems, the NCA-2 connects to (and requires) a standard Network Communication Module or High-Speed Network Communication Module. Mounts in a row of FACP node or in two annunciator positions. Mounting options include the DP-DISP2, ADP-4B, or in an annunciator box, such as the ABS-2D. In CAB-4 top-row applications, a DP-DISP2 and two BMP-1 blank modules are required for mounting. Required for NFS2-640 applications employing the DVC-EM with DAL devices. Non-English versions are available. For marine applications, order NCA-2-M; for non-English Marine applications, order NCA-2-M and the appropriate KP-KIT-XX. See DN-7047.

**CPU2-640:** Central processing unit (CPU) with integral 3.0 A (6.0 A in alarm) power supply for an NFS2-640 system. Includes control panel factory-mounted on a chassis; one Signaling Line Circuit expandable to two; documentation kit. Order one per system or as necessary (up to 103 network nodes) on a network system. (Non-English versions also available: CPU2-640-FR, CPU2-640-PO, CPU2-640-SP.)

**CPU2-640E:** Same as CPU2-640 but requires 240 VAC, 1.5 A, (3.0 A in alarm). (Non-English versions also available: CPU2-640E-PO, CPU2-640E-SP)

**NCA/640-2-KIT:** Bracket installation kit required to mount NCA-2 to the CPU2-640/640E’s standard chassis.

**DP-DISP2:** Dress panel for top row in cabinet with CPU2-640/640E installed.

**ADP2-640:** Dress panel for middle rows with CPU2-640/640E installed.

**BMP-1:** Blank module for unused module positions.

**BP2-4:** Battery plate, required.

**LEM-320:** Loop Expander Module. Expands each NFS2-640 to two Signaling Line Circuits. See DN-6881.
**Networking Options**

**NCM-W, NCM-F:** Standard Network Communications Modules. Wire and multi-mode fiber versions available. See DN-6681.

**HS-NCM-W/WMF/SWF/WSF/MFSF:** High-speed Network Communications Modules that can connect to two nodes. Wire, single-mode fiber, multi-mode fiber, and media conversion models are available. See DN-60454.

**RPT-W, RPT-F, RPT-WF:** Standard-network repeater board with wire connection (RPT-W), multi-mode fiber connection (RPT-F), or allowing a change in media type between wire and fiber (RPT-WF). Not used with high-speed networks. See DN-6971.

**ONXYWorks:** UL-listed graphics PC workstation, software, and computer hardware. See DN-7048 for specific part numbers.

**NFS-GW-EM-3:** NFS Gateway, embedded. (Replaces NFS-GW-EM.) See DN-60494.

**NWS-3:** NOT•FIRE•NET™ Web Server. See DN-6928.

**CAP-GW:** Common Alerting Protocol Gateway. See DN-60756.

**VESDA-HLI-GW:** VESDAnet high-level interface gateway. See DN-60753.

**LEDSIGN-GW:** UL-listed sign gateway. Interfaces with classic and high-speed NOT•FIRE•NET networks through the NFN Gateway. See DN-60679.

**OAX2-24V:** UL-listed LED sign, used with LEDSIGN-GW. See DN-60679.

**Auxiliary Power Supplies and Batteries**

**ACPS-610:** 6.0 A or 10.0 A addressable charging power supply. See DN-60244.

**APS2-6R:** Auxiliary Power Supply. Provides up to 6.0 amperes of power for peripheral devices. Includes battery input and transfer relay, and overcurrent protection. Mounts on two of four positions on a CHS-4L or CHS-4 chassis. See DN-5952.

**FCPS-24S6/S8:** Remote 6 A and 8 A power supplies with battery charger. See DN-6927.

**BAT Series:** Batteries. NFS2-640 uses two 12 volt, 18 to 200 AH batteries. See DN-6933.

**Audio Options**

**NOTE:** For mounting hardware, see “Enclosures, Chassis, and Dress Plates” on page 7 and peripheral data sheets.

**DVC-EM:** Digital Voice Command, digital audio processor with message storage for up to 32 minutes of standard quality (4 minutes at high quality) digital audio. Capable of playing up to eight simultaneous messages when used with Digital Audio Loop (DAL) devices. See DN-7045.

**DVC-RPU:** Digital Voice Command Remote Paging Unit for use with DVC-EM. Includes the keypad/display. See DN-60726.

**DS-DB:** Digital Series Distribution Board, provides bulk amplification capabilities to the DVC-EM while retaining digital audio distribution capabilities. Can be configured with up to four DS-AMPS, supplying high-level risers spread throughout an installation. See DN-60565.

**DVC-KD:** DVC-EM keypad for local announcement and controls; status LEDs and 24 user-programmable buttons. See DN-7045.

**DS-AMP/E:** 125W, 25 VRMS, or 100W, 70VRMS. 70VRMS requires DS-XF70V step-up transformer. Digital Series Amplifier, part of the DS-DB system. See DN-60663.

**DS-RFM, DS-FM, DS-SFM:** Fiber conversion modules for DVC-EM, DS-DB distribution board, and DAX and DAA2 Series amplifiers. See DN-60633.

**DVC-AO:** DVC Analog Output board provides four analog output circuits for use with AA Series amplifiers. Four-channel operation supported. See DN-7045.

**DAA2-5025(E):** 50W, 25 VRms Digital Audio Amplifier assembly with power supply; includes chassis. See DN-60556.

**DAA2-5070(E):** 50W, 70.7 VRms Digital Audio Amplifier assembly with power supply; includes chassis. See DN-60556.

**DAA2-7525(E):** 75W, 25 VRms digital audio amplifier assembly with power supply; includes chassis. See DN-60556.

**DAX-3525(E):** 35W, 25 VRms Digital Audio Amplifier assembly with power supply, includes chassis. See DN-60561.

**DAX-3570(E):** 35W, 70.7 VRms Digital Audio Amplifier assembly with power supply, includes chassis. See DN-60561.

**DAX-5025(E):** 50W, 25 VRms Digital Audio Amplifier assembly with power supply, includes chassis. See DN-60561.

**DAX-5070(E):** 50W, 70.7 VRms Digital Audio Amplifier assembly with power supply, includes chassis. See DN-60561.

**TELH-1:** Firefighter’s Telephone Handset for use with the DVC-EM when mounted in the CA-2 chassis. See DN-7045.

**CMIC-1:** Optional microphone and microphone well assembly used with the CA-1 chassis.

**RM-1/1RM-1SA:** Remote microphone assemblies, mount on ADP-4 (RM-1) dress panel or CAB-RM/RMR (RM-1SA) stand-alone cabinets. See DN-6728.

**AA-30:** Audio Amplifier, 30 watts, 25 VRms. Includes amplifier and audio input supervision, backup input, and automatic switchover, power supply, cables. See DN-3224.

**AA-120/AA-100:** Audio Amplifier provides up to 120 watts of 25 VRms audio power for the NFS-640. The amplifier contains an integral chassis for mounting to a CAB-B4, -C4, or -D4 backbox (consumes one row). Switch-mode power. Includes audio input and amplified output supervision, backup input, and automatic switchover to backup tone. Order the AA-100 for 70.7 VRms systems and 100 watts of power. See DN-3224.

**DAA Series Digital Audio Amplifiers:** Legacy DAA Series amplifiers are compatible with DVC-EM systems running SR4.0. For specific information on DAA-50 series amplifiers, refer to DN-7046. For information on DAA-7525 Series, refer to DN-60257.

**NFC-25/50:** 25 watt, 25 VRMS, emergency Voice Evacuation Control Panel (VECP) with integral commercial microphone, digital message generator, and single-channel Class A or Class B speaker circuits. See DN-60772.

**Compatible Devices, EIA-232 Ports**

**PRN-6:** 80-column printer. See DN-6956.

**PRN-7:** 80-column printer. See DN-60897.

**VS4095/5:** Printer, 40-column, 24V. Mounted in external backbox. See DN-3260.

**DPI-232:** Direct Panel Interface, specialized modem for extending serial data links to remotely located FACPs and peripherals. See DN-6870.

**Compatible Devices, EIA-485 Ports**

**ACM-24AT:** ONXY Series ACS annunciator – up to 96 points of annunciation with Alarm or Active LED, Trouble LED, and switch per circuit. Active/Alarm LEDs can be programmed (by powered-up switch selection) by point to be red, green, or yellow; the Trouble LED is always yellow. See DN-6862.
AEM-24AT: Same LED and switch capabilities as ACM-24AT, expands the ACM-24AT to 48, 72, or 96 points. See DN-6862.

ACM-48A: ONYX Series ACS annunciator – up to 96 points of annunciation with Alarm or Active LED per circuit. Active/Alarm LEDs can be programmed (by powered-up switch selection) in groups of 24 to be red, green, or yellow. Expandable to 96 points with one ACM-48A. See DN-6862.


ACM-8R: Remote Relay Module with eight Form-C contacts. Can be located up to 6,000 ft. (1828.8 m) from panel on four wires. See DN-3558.


DNR: Onyx Series ACS annunciator – up to 96 points of annunciation with Alarm or Active LED per circuit. Active/Alarm LEDs can be programmed (by powered-up switch selection) in groups of 24 to be red, green, or yellow. Expandable to 96 points with one ACM-48A. See DN-6862.

Compatible Intelligent Devices


FSA-5000: Intelligent FAAST® XS Fire Alarm Aspiration Sensing Technology. Intelligent aspirating smoke detector for applications up to 5,000 sq.ft. For Canadian applications, order FSA-5000A.

FSA-8000: Intelligent FAAST® XM Fire Alarm Aspiration Sensing Technology. Intelligent aspirating smoke detector for applications up to 8,000 sq.ft. For Canadian applications, order FSA-8000A. See DN-60792.

FSA-20000: Intelligent FAAST® XT Fire Alarm Aspiration Sensing Technology. Intelligent aspirating smoke detector for applications up to 28,800 sq.ft. For Canadian applications, order FSA-20000A. See DN-60849.

FUX-200: Intelligent beam smoke detector. See DN-6985.

FUX-200S: Intelligent beam smoke detector with integral sensitivity test. See DN-6985.

FSC-851: FlashScan IntelligQuad Advanced Multi-Criteria Detector. See DN-60412.

FCO-851: FlashScan IntelligQuad PLUS Advanced Multi-Criteria Fire/CO Detector. See DN-60899.

FSL-751: FlashScan VIEW laser photo detector. See DN-6886.

FSP-851T: FSP-851 plus dual electronic thermistors that add 135°F (57°C) fixed-temperature thermal sensing. See DN-6935.

FSP-851R: FSP-851, remote-test capable. For use with DNR(W). See DN-6935.


FST-851R: FlashScan thermal detector 135°F (57°C) with rate-of-rise. See DN-6936.

FST-851H: FlashScan 190°F (88°C) high-temperature thermal detector. See DN-6936.


**ENCLOSURES, CHASSIS, AND DRESS PLATES**

**CAB-4 Series Enclosure:** NFS2-640 mounts in a standard CAB-4 Series enclosure (available in four sizes, "A" through "D"). Backbox and door ordered seperately; requires BPZ-4 battery plate. A trim ring option is available for semi-flush mounting. See DN-6857.

**EQ Series Cabinets:** EQ series cabinets will house amplifiers, power supplies, battery chargers and control modules. EQ cabinets are available in three sizes, "B" through "D". See DN-60229.

**CAB-BM Marine System:** Protects equipment in shipboard and waterfront applications. Also order BB-MB for systems using 100 AH batteries. For a full list of required and optional equipment, see DN-60688.

**CHS-4:** Chassis for mounting up to four APS-6Rs. See DN-60688.

**CHS-4L:** Low-profile four-position Chassis. Mounts two AA-30 amplifiers or one AMG-E and one AA-30.

**DP-1B:** Blank dress panel. Provides dead-front panel for unused tiers; covers DAA2/DAX series or AA-series amplifier.

**NFS-LBB:** Battery Box (required for batteries larger than 26 AH).

**NFS-LBBR:** Same as above but red.

**CHS-BH1:** Battery chassis; holds two 12.0 AH batteries. Mounts one the left side of DAA2 chassis. See DN-7046.

**CA-1:** Chassis, occupies one tier of a CAB-4 Series enclosure. The left side accomodates one DVC-EM and a DVC-KD (optional); and the right side houses a CMIC-1 microphone and its well (optional). See DN-7045.

**CA-2:** Chassis assembly, occupies two tiers of a CAB-4 Series enclosure. The left side accomodates one DVC-EM mounted on a half-chassis and one NCA-2 mounted on a half-chassis. The right side houses a microphone/handset well. The CA-2 assembly includes CMIC-1 microphone. ADDR Series doors with two-tier visibility are available for use with the CA-2 configuration: ADDR-B4, ADDR-C4, ADDR-D4 (below).

**CFFT-1:** Chassis to mount firefighter’s telephone and one ACS annunciator in a CAB-4 row. Includes TELH-1 firefighter’s handset for the DVC-EM, chassis, phone well and mounting hardware. Order DP-CFFT dress panel separately.

**DP-CFFT:** CFFT-1 dress panel. Requires BMP-1 if no ACS annunciator is installed.

**ADDR-B4**: Two-tier-sized door designed for use with the CA-2 chassis configuration. ADDR Series doors are similar to CAB-4 Series “DR” doors, but a clear window space exposes the top two tiers of the CAB-4 enclosure. Use an SBB-D4 backbox with the ADDR-D4. See DN-7045, DN-6857.

**ADDR-C4**: Three-tier-sized door, designed for use with the CA-2 chassis configuration. ADDR Series doors are similar to CAB-4 Series “DR” doors, but a clear window space exposes the top two tiers of the CAB-4 enclosure. Use an SBB-C4 backbox with the ADDR-C4. See DN-7045, DN-6857.

**ADDR-D4**: Four-tier-sized door designed for use with the CA-2 chassis configuration. ADDR Series doors are similar to CAB-4 Series “DR” doors, but a clear window space exposes the top two rows with NCA-2 or BP-CA2. Use standard door when CA-2 is not installed in top two rows. For additional configuration information, see the DVC application guide on [http://esd.notifier.com](http://esd.notifier.com).

**DPA-1:** Dress panel, used with the CA-1 chassis when configured with a DVC-EM, DVC-KD, and CMIC-1. See DN-7045. **DPA-2B:** Dress panel used with CA-2 chassis assembly.

**VP-2B:** Dress panel, required when CA-2 chassis is installed in the top two cabinet rows.

**DPA-1A4:** Dress panel, used with the CA-1 chassis when the CMIC-1 is not used. Provides mounting options on right two bays for two ACS annunciators, or for blank plates. See DN-7045.

**BP-CA2:** Blank plate for CA-2 chassis.

**BB-UZC:** Backbox for housing the UZC-256 in applications where the UZC-256 will not fit in panel enclosure. Black, for red, order BB-UZC-R.

**SEISKIT-CAB:** Seismic mounting kit. Required for seismic-certified applications with NFS2-640 and other equipment mounted in CAB-4 Series Enclosures. Includes battery bracket for two 26 AH batteries.

**SEISKIT-LBB:** Seismic kit for the NFS-LBB. Includes battery bracket for two 55 AH batteries.

**OTHER OPTIONS**

**411:** Slave digital alarm communicator. See DN-6619.

**411UDAC:** Digital alarm communicator. See DN-6746.

**IPDACT-2/2UD, IPDACT Internet Monitoring Module:** Connects to primary and secondary DACT telephone output ports for internet communications over customer-provided Ethernet connection. Requires compatible Teldat VisorALARM Central Station Receiver. Can use DHCP or static IP. See DN-60408.

**IPCHSKIT:** IP Communicator Chassis Mounting Kit. For mounting an IPDACT-2/2UD onto the panel chassis or CHS-4 series chassis. Use IPENC for external mounting applications.

**IPSPLT:** Y-adapter option allow connection of both panel dialer outputs to one IPDACT-2/2UD cable input.

**IPENC:** External enclosure for IPDACT, includes IPBRKT mounting bracket, Red. For Black order IPENC-B.

**IPGSM-4G:** Internet and Digital Cellular Fire Alarm Communicator. Provides selectable configurable paths: cellular only, IP only, or IP primary with cellular backup. Connects to the primary and secondary ports of a DACT. For Canadian applications order IPGSM-4GC. See DH-60769.

**NOTE:** For other options including compatibility with retrofit equipment, refer to the panel's installation manual, the SLC manual, and the Device Compatibility Document.

**System Specifications**

**SYSTEM CAPACITY**

- Intelligent Signaling Line Circuits ............1 expandable to 2
- Intelligent detectors ...................................................... 159 per loop
- Addressable monitor/control modules............. 159 per loop
- Programmable software zones...................... 99
- Special programming zones............................ 14
- LCD annunciators per CPUIU-640/640E and NCA-2 (observe power)............... 32
- ACS annunciators per CPUIU-640/640E ............ 32 addresses x 64 points
The listings and approvals below apply to the basic NFS2-640 control panel. In some cases, certain modules may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- **UL Listed**: S635.
- **ULC Listed**: S635.
- **FM Approved**.
- **MEA**: 128-07-E.
- **Fire Dept. of New York**: #6121.
- **CSFM**: 7165-0028:0243.
- **City of Chicago**.
- **City and County of Denver**.
- **CCCF listed**.

**Marine Applications**: Marine approved systems must be configured using components itemized in this document. (See Main System Components, in “Product Line Information.” Specific connections and requirements for those components are described in the installation document, PN 54756. When these requirements are followed, systems are approved by the following agencies:

- **US Coast Guard** 161.002/50/0, 161.002/55/0 (Standard 46 CFR and 161.002).
- **Lloyd's Register** 11/600013 (ENV 3 category).
- **American Bureau of Shipping (ABS) Type Approval**.

**Agency Listings and Approvals**

This document is not intended to be used for installation purposes. We try to keep our product information up-to-date and accurate. We cannot cover all specific applications or anticipate all requirements. All specifications are subject to change without notice.

For more information, contact Notifier. Phone: (203) 484-7161, FAX: (203) 484-7118.

www.notifier.com
The Notifier NBG-12LX is a state-of-the-art, dual-action (i.e., requires two motions to activate the station) pull station that includes an addressable interface for any Notifier intelligent control panel except FireWarden series panels, and the NSP-25 panel. Because the NBG-12LX is addressable, the control panel can display the exact location of the activated manual station. This leads fire personnel quickly to the location of the alarm.

**Features**
- Maintenance personnel can open station for inspection and address setting without causing an alarm condition.
- Built-in bicolor LED, which is visible through the handle of the station, flashes in normal operation and latches steady red when in alarm.
- Handle latches in down position and the word “ACTIVATED” appears to clearly indicate the station has been operated.
- Captive screw terminals wire-ready for easy connection to SLC loop (accepts up to 12 AWG/3.25 mm² wire).
- Can be surface mounted (with SB-10 or SB-I/O) or semi-flush mounted. Semi-flush mount to a standard single-gang, double-gang, or 4” (10.16 cm) square electrical box.
- Smooth dual-action design.
- Meets ADAAG controls and operating mechanisms guidelines (Section 4.1.3[13]); meets ADA requirement for 5 lb. maximum activation force.
- Highly visible.
- Attractive shape and textured finish.
- Key reset.
- Includes Braille text on station handle.
- Optional trim ring (BG12TR).
- Meets UL 38, Standard for Manually Actuated Signaling Boxes.
- Up to 99 NBG-12LX stations per loop on CLIP protocol loops.
- Up to 159 NBG-12LX stations per loop on FlashScan® protocol loops.
- Dual-color LED blinks green to indicate normal on FlashScan® systems.

**Construction**
Shell, door, and handle are molded of durable polycarbonate material with a textured finish.

**Specifications**
- **Shipping Weight:** 9.6 oz. (272.15 g)
- **Normal operating voltage:** 24 VDC.
- **Maximum SLC loop voltage:** 28.0 VDC.
- **Maximum SLC standby current:** 375 μA.
- **Maximum SLC alarm current:** 5 mA.
- **Temperature Range:** 32°F to 120°F (0°C to 49°C)
- **Relative Humidity:** 10% to 93% (noncondensing)
- **For use indoors in a dry location**
4" (10.16 cm) square electrical box, and shall be installed within the limits defined by the Americans with Disabilities Act (ADA) or per national/local requirements. Manual Stations shall be Underwriters Laboratories listed.

Manual stations shall connect with two wires to one of the control panel SLC loops. The manual station shall, on command from the control panel, send data to the panel representing the state of the manual switch. Manual stations shall provide address setting by use of rotary decimal switches.

The loop poll LED shall be clearly visible through the front of the station. The LED shall flash while in the normal condition, and stay steadily illuminated when in alarm.

**Product Line Information**

**NBG-12LX:** Dual-action addressable pull station. Includes key locking feature. (Listed for Canadian and non-Canadian applications.)

**NBG-12LXSP:** Spanish/English labelled version.

**NBG-12LXP:** Portuguese labelled version.

**SB-10:** Surface backbox; metal.

**SB-I/O:** Surface backbox; plastic.

**BG12TR:** Optional trim ring.

**17021:** Keys, set of two.

**NY-Plate:** New York City trim plate.

**Agency Listings and Approvals**

In some cases, certain modules or applications may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- **UL/ULC Listed:** S692 (listed for Canadian and non-Canadian applications).
- **MEA:** 67-02-E.
- **CSFM:** 7150-0028:0199.
- **FDNY:** COA #6085 (NFS2-640), COA #6098 (NFS2-3030).
- **BSMI:** CI313066760047.
- **U.S. Coast Guard.**
- **Lloyd’s Register.**
- **FM Approved.**

**Patented:** U.S. Patent No. D428,351; 6,380,846; 6,314,772; 6,632,108.
LCD-80
Liquid Crystal Display

General
The LCD-80 is an 80-character, backlit LCD display annunciator for the NOTIFIER NFS2-640, NFS2-3030, NFS-320 fire alarm control panels, or the NCA-2 network control annunciator. Up to 32 LCD-80s may be connected onto the two-wire EIA-485 port. The LCD-80 has two basic modes of operation, “Terminal” and “ACS” mode.

NOTE: The LCD-80 can also be used with Legacy panels. Please refer to the LCD-80 manual for more information.

Common Features
• Listed to UL Standard 864, Ninth Edition
• 80-character backlit Liquid Crystal Display (20 characters x 4 lines).
• Control switches for System Acknowledge, Signal Silence and System Reset.
• Time and date display field.
• Enable Key switch option.
• Can be remotely located up to 6,000 ft. (1828.8 m) from the control panel.
• Local piezo sounder with alarm/trouble resound.
• Flush/surface/panel mount option.

ACS Mode
When operated in “ACS” mode, the LCD-80 provides vectored annunciation capability. Individual devices/zones can be installer-defined to only display at specific locations

EXAMPLE: A maintenance office receives only non-alarm point activations. These inputs could be sump pump on, high water, backup AHU on, low temperature in freezer, etc.
• Alarm/trouble count.
• Custom “normal” message.
• European option: first alarm/last alarm/alarm count.
• Field-programmable messages from CRT or PC-compatible computer (PK-LCD80 Programming Kit required).
• EIA-485 interface: up to 32 per system.
• Printer output port: EIA-232, compatible with PRN Series printers.
• Field-programmable messages in nonvolatile memory in two options: 128 points, 40 character labels; or 256 points, 20 character labels.
• Internal nonvolatile clock for time and date in ACS mode.

Terminal Mode
In “Terminal” mode, the LCD-80 mimics the NFS2-640, NFS2-3030, NFS-320, and NCA-2 displays. Up to 32 LCD-80s can annunciate and provide remote reset, acknowledge, and silence of the control panel from remote locations.
• Displays device type identifiers.
• Device and zone custom alpha labels.
• Time/date and Device address.
• May operate in addition to CRT.
• No programming necessary. LCD-80 displays time, date, and custom messages received from the panel or network annunciator.

The ABF-1DB Backbox
The ABF-1DB is a semi-flush-mount backbox for the NOTIFIER LCD-80 Series Annunciator. The ABF-1DB mounts one LCD-80. It includes an attractive smoked-glass door with NOTIFIER keylock.

Dimensions, BOX only: 9.938” (25.24 cm) high, 4.625” (11.75 cm) wide, 2.5” (6.35 cm) deep.

Dimensions, DOOR only: 10.713” (27.21 cm) high, 6.0” (15.24 cm) wide, 0.75” (1.9 cm) deep.

Related Options
PK-LCD80 (only available for download): Off-Line Programming Kit for LCD-80. Allows PC programming messages when LCD-80 is used in the ACS mode.

ABF-1DB: Semi-flush box with alternative smoked-glass door, any keylock.

ADP-4B: Annunciator Dress Plate, black. Allows panel mounting of up to four LCD-80 modules in a CAB-4 Series cabinet.
ABF-1B: Annunciator Flush Box, 9.938" (25.24 cm) high, 4.625" (11.75 cm) wide, and 2.5" (6.35 cm) deep. Order AKS-1B key switch if desired. Can also be mounted in ABF-2B or ABF-4B annunciator backboxes.

ABS-1TB: Deep Surface Backbox (mounts one LCD-80).

AKS-1B: Key Switch (black) to enable/disable controls when mounted in ABF or ABS-1TB.

PRN-6: 80-Column Serial Printer (see PRN data sheet).

**Agency Listings and Approvals**

These listings and approvals apply to the modules specified in this document. In some cases, certain modules or applications may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- **UL Listed:** S635
- **ULC Listed:** S635
- **MEA:** 345-02-E; 317-01-E (NFS-640); 128-07-E
- **FDNY:** COA#6026, 6038
- **CSFM:** 7120-0028:156
- **FM Approved**

**The LCD-80 in ACS Mode**

The LCD-80 in ACS Mode can be connected to the following devices:
- NFS-320, NFS2-640, NFS2-3030, or NCA-2 connecting to LCD-80

**The LCD-80 in Terminal Mode**

The LCD-80 in Terminal Mode can be connected to the following devices:
- NFS-320, NFS2-640, NFS2-3030, or NCA-2 connecting to LCD-80
FSP-851(A) Series
Intelligent Plug-In Photoelectric Smoke Detectors with FlashScan®

General
Notifier FSP-851(A) Series intelligent plug-in smoke detectors with integral communication provide features that surpass conventional detectors. Detector sensitivity can be programmed in the control panel software. Sensitivity is continuously monitored and reported to the panel. Point ID capability allows each detector's address to be set with rotary, decimal address switches, providing exact detector location for selective maintenance when chamber contamination reaches an unacceptable level. The FSP-851(A) photoelectric detector's unique optical sensing chamber is engineered to sense smoke produced by a wide range of combustion sources. Dual electronic thermistors add 135°F (57°C) fixed-temperature thermal sensing on the FSP-851T(A). The FSP-851R(A) is a remote test capable detector for use with DNR(A)/DNRW duct detector housings. FSP-851(A) series detectors are compatible with Notifier Onyx and CLIP series Fire Alarm Control Panels (FACPs).

FlashScan® (U.S. Patent 5,539,389) is a communication protocol developed by Notifier that greatly increases the speed of communication between analog intelligent devices. Intelligent devices communicate in a grouped fashion. If one of the devices in the group has new information, the panel's CPU stops the group poll and concentrates on single points. The net effect is response speed greater than five times that of earlier designs.

Features
- Sleek, low-profile design.
- Addressable-analog communication.
- Stable communication technique with noise immunity.
- Low standby current.
- Two-wire SLC connection.
- Compatible with FlashScan® and CLIP protocol systems.
- Rotary, decimal addressing (1-99 on CLIP systems, 1-159 on FlashScan systems).
- Optional remote, single-gang LED accessory.
- Dual LED design provides 360° viewing angle.
- Visible bi-color LEDs blink green every time the detector is addressed, and illuminate steady red on alarm (FlashScan systems only).
- Remote test feature from the panel.
- Walk test with address display (an address on 121 will blink the detector LED: 12-[pause]-1 (FlashScan systems only).
- Built-in functional test switch activated by external magnet.
- Built-in tamper-resistant feature.
- Sealed against back pressure.
- Constructed of off-white fire-resistant plastic, designed to commercial standards, and offers an attractive appearance.
- 94-5V plastic flammability rating.
- SEMS screws for wiring of the separate base.
- Optional relay, isolator, and sounder bases.

Specifications
Sensitivity: 0.5% to 2.35% per foot obscuration
Size: 2.1" (5.3 cm) high; base determines diameter.
  - B210LP(A): 6.1" (15.5 cm) diameter.
  - B501(A): 4.1" (10.4 cm) diameter.
  - B200S(A): 6.875" (17.46 cm) diameter.
  - B200SR(A): 6.875" (17.46 cm) diameter.
  - B224RB(A): 6.2" (15.748 cm) diameter.
  - B224BI(A): 6.2" (15.748 cm) diameter.
Shipping Weight: 5.2oz. (147g).
Operating Temperature range: FSP-851(A), 0°C to 49°C (32°F to 120°F). FSP-851T(A), 0°C to 38°C (32°F to 100°F). Low temperature signal for FSP-851T(A) at 45°F +/- 10°F (7.22°C +/- 5.54°C). FSP-851R(A) installed in a DNR(A)/DNRW, -20°C to 70°C (-4°F to 158°F).
UL/ULC Listed Velocity Range: 0-4000 ft/min. (1219.2 m/min.), suitable for installation in ducts.
Relative Humidity: 10%-93% noncondensing.

DETECTOR SPACING AND APPLICATIONS
Notifier recommends spacing detectors in compliance with NFPA 72. In low airflow applications with smooth ceiling, space detectors 30 feet (9.144m) for ceiling heights 10 feet (3.148m) and higher. For specific information regarding detector spacing, placement, and special applications refer to NFPA 72. System Smoke Detector Application Guide, document A05-1003, is available at systemsensor.com

ELECTRICAL SPECIFICATIONS
Voltage Range: 15-32 volts DC peak.
Standby Current (max. avg.): 300µA @ 24VDC (one communication every five seconds with LED enabled).
LED Current (max.): 6.5mA @ 24 VDC (“ON”).
Installation

FSP-851(A) plug-in detectors use a separate base to simplify installation, service, and maintenance. A special tool allows maintenance personnel to plug in and remove detectors without using a ladder.

Mount base (all base types) on an electrical backbox which is at least 1.5" (3.81 cm) deep. For a chart of compatible junction boxes, see DN-60054.

NOTE: 1) Because of inherent supervision provided by the SLC loop, end-of-line resistors are not required. Wiring “T-taps” or branches are permitted for Style 4 (Class “B”) wiring. 2) When using relay or sounder bases, consult the ISO-X(A) installation sheet 156-1380 for device limitations between isolator modules and isolator bases.

Agency Listings and Approvals

These listings and approvals apply to the modules specified in this document. In some cases, certain modules or applications may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- **UL Listed:** S1115.
- **ULC Listed:** S1115 (FSP-851A, FSP-851RA, FSP-851TA).
- **MEA Listed:** 225-02-E.
- **FM Approved.**
- **CSFM:** 7272-0028:0206.
- **Maryland State Fire Marshal:** Permit # 2122.
- **BSMI:** CI31066760036.
- **CCCC:** Certif. # 2004081801000017 (FSP-851T) Certif. # 2004081801000016 (FSP-851).
- **U.S. Coast Guard:** 161.002/42/1 (NFS-640); 161.002/50/0 (NFS2-640/NFS-320/NFS-320C, excluding B210LP(A)).
- **Lloyd’s Register:** 11/600013 (NFS2-640/NFS-320/NFS-320C, excluding B210LP(A)).

Product Line Information

**NOTE:** “A” suffix indicates ULC Listed model.

**FSP-851:** Low-profile intelligent photoelectric sensor. Must be mounted to one of the bases listed below.

**FSP-851A:** Same as FSP-851 but with ULC listing.

**FSP-851T:** Same as FSP-851 but includes a built-in 135°F (57°C) fixed-temperature thermal device.

**FSP-851TA:** Same as FSP-851T but with ULC listing.

**FSP-851R:** Low-profile intelligent photoelectric sensor, remote test capable. For use with DNRA/DNRW.

**FSP-851RA:** Same as FSP-851R but with ULC listing. For use with DNRA.

**INTELLIGENT BASES**

**NOTE:** “A” suffix indicates ULC Listed model.

**NOTE:** For details on intelligent bases, see DN-60054.

**B210LP(A):** Standard U.S. flanged low-profile mounting base.

**B210LPBP:** Bulk pack of B210LP; package contains 10.

**B501(A):** Standard European flangeless mounting base.

**B501BP:** Bulk pack of B501; package contains 10.

**B200S(A):** Intelligent, programmable sounder base capable of producing sound output in high or low volume with ANSI Temporal 3, ANSI Temporal 4, continuous tone, marching tone, and custom tone.

**B200SR(A):** Intelligent sounder base capable of producing sound output with ANSI Temporal 3 or continuous tone. Replaces B501BH series bases in retrofit applications.

**B224RB(A):** Plug-in System Sensor relay base. Screw terminals: up to 14 AWG (2.0 mm²). Relay type: Form-C. Rating: 2.0 A @ 30 VDC resistive; 0.3 A @ 110 VDC inductive; 1.0 A @ 30 VDC inductive.


**ACCESSORIES**

**F110:** Retrofit flange to convert B210LP(A) to match the B710LP(A) profile, or to convert older high-profile bases to low-profile.

**F110BP:** Bulk pack of F110; package contains 15.

**F210:** Replacement flange for B210LP(A) base.

**RA100Z(A):** Remote LED annunciator. 3 – 32 VDC. Mounts to a U.S. single-gang electrical box. For use with B501(A) and B210LP(A) bases only.

**SMB600:** Surface mounting kit

**M02-04-00:** Test magnet.

**M02-09-00:** Test magnet with telescoping handle.

**XR2B:** Detector removal tool. Allows installation and/or removal of detector heads from bases in high ceiling applications.

**XP-4:** Extension pole for XR2B. Comes in three 5-foot (1.524 m) sections.

**T55-127-010:** Detector removal tool without pole.

**BCK-200B:** Black detector covers for use with FSP-851(A) only; box of 10.

**WCK-200B:** White detector covers for use with FSP-851(A) only; box of 10.

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This document is not intended to be used for installation purposes. We try to keep our product information up-to-date and accurate. We cannot cover all specific applications or anticipate all requirements. All specifications are subject to change without notice.

For more information, contact Notifier. Phone: (203) 484-7161, FAX: (203) 484-7118. www.notifier.com
General

Four different monitor modules are available for Notifier’s intelligent control panels for a variety of applications. Monitor modules supervise a circuit of dry-contact input devices, such as conventional heat detectors and pull stations, or monitor and power a circuit of two-wire smoke detectors (FZM-1(A)).

FMM-1(A) is a standard-sized module (typically mounts to a 4” [10.16 cm] square box) that supervises either a Style D (Class A) or Style B (Class B) circuit of dry-contact input devices.

FMM-101(A) is a miniature monitor module a mere 1.3” (3.302 cm) H x 2.75” (6.985 cm) W x 0.5” (1.270 cm) D that supervises a Style B (Class B) circuit of dry-contact input devices. Its compact design allows the FMM-101(A) to be mounted in a single-gang box behind the device it monitors.

FZM-1(A) is a standard-sized module that monitors and supervises compatible two-wire, 24 volt, smoke detectors on a Style D (Class A) or Style B (Class B) circuit.

FDM-1(A) is a standard-sized dual monitor module that monitors and supervises two independent two-wire Style B (Class B) dry-contact initiating device circuits (IDCs) at two separate, consecutive addresses in intelligent, two-wire systems.

FlashScan® (U.S. Patent 5,539,389) is a communication protocol developed by NOTIFIER that greatly increases the speed of communication between analog intelligent devices. Intelligent devices communicate in a grouped fashion. If one of the devices within the group has new information, the panel CPU stops the group poll and concentrates on single points. The net effect is response speed greater than five times that of other designs.

FMM-1(A) Monitor Module

- Built-in type identification automatically identifies this device as a monitor module to the control panel.
- Powered directly by two-wire SLC loop. No additional power required.
- High noise (EMF/RFI) immunity.
- SEMS screws with clamping plates for ease of wiring.
- Direct-dial entry of address: 01 – 159 on FlashScan loops; 01 – 99 on CLIP loops.
- LED flashes green during normal operation (this is a programmable option) and latches on steady red to indicate alarm.

The FMM-1(A) Monitor Module is intended for use in intelligent, two-wire systems, where the individual address of each module is selected using the built-in rotary switches. It provides either a two-wire or four-wire fault-tolerant Initiating Device Circuit (IDC) for normally-open-contact fire alarm and supervisory devices. The module has a panel-controlled LED indicator. The FMM-1(A) can be used to replace MMX-1(A) modules in existing systems.

FMM-1(A) APPLICATIONS

Use to monitor a zone of four-wire smoke detectors, manual fire alarm pull stations, waterflow devices, or other normally-open dry-contact alarm activation devices. May also be used to monitor normally-open supervisory devices with special supervisory indication at the control panel. Monitored circuit may be wired as an NFPA Style B (Class B) or Style D (Class A) Initiating Device Circuit. A 47K ohm End-of-Line Resistor (provided) terminates the Style B circuit. No resistor is required for supervision of the Style D circuit.

FMM-1(A) OPERATION

Each FMM-1(A) uses one of the available module addresses on an SLC loop. It responds to regular polls from the control panel and reports its type and the status (open/normal/short) of its Initiating Device Circuit (IDC). A flashing LED indicates that the module is in communication with the control panel. The LED latches steady on alarm (subject to current limitations on the loop).

FMM-1(A) SPECIFICATIONS

Nominal operating voltage: 15 to 32 VDC.
Maximum current draw: 5.0 mA (LED on).
Average operating current: 350 μA ((LED flashing), 1 communication every 5 seconds, 47k EOL.
Maximum IDC wiring resistance: 40 ohms.
EOL resistance: 47K ohms.
Temperature range: 32°F to 120°F (0°C to 49°C).
Humidity range: 10% to 93% noncondensing.
Dimensions: 4.5” (11.43 cm) high x 4” (10.16 cm) wide x 1.25” (3.175 cm) deep. Mounts to a 4” (10.16 cm) square x 2.125” (5.398 cm) deep box.
FMM-101(A) Mini Monitor Module

- Built-in type identification automatically identifies this device as a monitor module to the panel.
- Powered directly by two-wire SLC loop. No additional power required.
- High noise (EMF/RFI) immunity.
- Tinned, stripped leads for ease of wiring.
- Direct-dial entry of address: 01 – 159 on FlashScan loops; 01 – 99 on CLIP loops.

The FMM-101(A) Mini Monitor Module can be installed in a single-gang junction directly behind the monitored unit. Its small size and light weight allow it to be installed without rigid mounting. The FMM-101(A) is intended for use in intelligent, two-wire systems where the individual address of each module is selected using rotary switches. It provides a two-wire initiating device circuit for normally-open-contact fire alarm and security devices. The FMM-101(A) can be used to replace MMX-101(A) modules in existing systems.

**FMM-101(A) APPLICATIONS**

Use to monitor a single device or a zone of four-wire smoke detectors, manual fire alarm pull stations, waterflow devices, or other normally-open dry-contact devices. May also be used to monitor normally-open supervisory devices with special supervisory indication at the control panel. Monitored circuit/device is wired as an NFPA Style B (Class B) Initiating Device Circuit. A 47K ohm End-of-Line Resistor (provided) terminates the circuit.

**FMM-101(A) SPECIFICATIONS**

- Nominal operating voltage: 15 to 32 VDC.
- Average operating current: 350 μA, 1 communication every 5 seconds, 47K EOL; 600 μA Max. (Communicating, IDC Shorted).
- Maximum IDC wiring resistance: 40 ohms.
- Maximum IDC Voltage: 11 Volts.
- Maximum IDC Current: 400 μA.
- EOL resistance: 47K ohms.
- Temperature range: 32°F to 120°F (0°C to 49°C).
- Humidity range: 10% to 93% noncondensing.

Dimensions: 1.3” (3.302 cm) high x 2.75” (6.985 cm) wide x 0.65” (1.651 cm) deep.

Wire length: 6” (15.24 cm) minimum.

FZM-1(A) Interface Module

- Supports compatible two-wire smoke detectors.
- Supervises IDC wiring and connection of external power source.
- High noise (EMF/RFI) immunity.
- SEMS screws with clamping plates for ease of wiring.
- Direct-dial entry of address: 01 – 159 on FlashScan loops, 01 – 99 on CLIP loops.
- LED flashes during normal operation; this is a programmable option.
- LED latches steady to indicate alarm on command from control panel.

The FZM-1(A) Interface Module is intended for use in intelligent, addressable systems, where the individual address of each module is selected using built-in rotary switches. This module allows intelligent panels to interface and monitor two-wire conventional smoke detectors. It transmits the status (normal, open, or alarm) of one full zone of conventional detectors back to the control panel. All two-wire detectors being monitored must be UL compatible with the module. The FZM-1(A) can be used to replace MMX-2(A) modules in existing systems.

**FZM-1(A) APPLICATIONS**

Use the FZM-1(A) to monitor a zone of two-wire smoke detectors. The monitored circuit may be wired as an NFPA Style B (Class B) or Style D (Class A) Initiating Device Circuit. A 3.9 K ohm End-of-Line Resistor (provided) terminates the end of the Style B or D (class B or A) circuit (maximum IDC loop resistance is 25 ohms). Install ELR across terminals 8 and 9 for Style D application.

**FZM-1(A) SPECIFICATIONS**

- Nominal operating voltage: 15 to 32 VDC.
- Maximum current draw: 5.1 mA (LED on).
- Average operating current: 300 μA, 1 communication and 1 LED flash every 5 seconds, 3.9k eol.
- EOL resistance: 3.9K ohms.
- External supply voltage (between Terminals T3 and T4): DC voltage: 24 volts power limited. Ripple voltage: 0.1 Vrms maximum. Current: 90 mA per module maximum.
- Temperature range: 32°F to 120°F (0°C to 49°C).
- Humidity range: 10% to 93% noncondensing.
- Dimensions: 4.5” (11.43 cm) high x 4” (10.16 cm) wide x 1.25” (3.175 cm) deep. Mounts to a 4” (10.16 cm) square x 2.125” (5.398 cm) deep box.
FDM1(A) Dual Monitor Module

The FDM-1(A) Dual Monitor Module is intended for use in intelligent, two-wire systems. It provides two independent two-wire initiating device circuits (IDCs) at two separate, consecutive addresses. It is capable of monitoring normally open contact fire alarm and supervisory devices; or either normally open or normally closed security devices. The module has a single panel-controlled LED.

NOTE: The FDM-1(A) provides two Style B (Class B) IDC circuits ONLY. Style D (Class A) IDC circuits are NOT supported in any application.

FDM-1(A) SPECIFICATIONS

Normal operating voltage range: 15 to 32 VDC.
Maximum current draw: 6.4 mA (LED on).
Average operating current: 750 μA (LED flashing).
Maximum IDC wiring resistance: 1,500 ohms.
Maximum IDC Voltage: 11 Volts.
Maximum IDC Current: 240 μA
EOL resistance: 47K ohms.
Maximum SLC Wiring resistance: 40 Ohms.
Temperature range: 32° to 120°F (0° to 49°C).
Humidity range: 10% to 93% (non-condensing).
Dimensions: 4.5" (11.43 cm) high x 4" (10.16 cm) wide x 2.125" (5.398 cm) deep.

FDM-1(A) AUTOMATIC ADDRESSING

The FDM-1(A) automatically assigns itself to two addressable points, starting with the original address. For example, if the FDM-1(A) is set to address “26”, then it will automatically assign itself to addresses “26” and “27”.

NOTE: “Ones” addresses on the FDM-1(A) are 0, 2, 4, 6, or 8 only. Terminals 6 and 7 use the first address, and terminals 8 and 9 use the second address.

CAUTION: Avoid duplicating addresses on the system.

Installation

FMM-1(A), FZM-1(A), and FDM-1(A) modules mount directly to a standard 4" (10.16 cm) square, 2.125" (5.398 cm) deep, electrical box. They may also be mounted to the SMB500 surface-mount box. Mounting hardware and installation instructions are provided with each module. All wiring must conform to applicable local codes, ordinances, and regulations. These modules are intended for power-limited wiring only.

The FMM-101(A) module is intended to be wired and mounted without rigid connections inside a standard electrical box. All wiring must conform to applicable local codes, ordinances, and regulations.

Agency Listings and Approvals

In some cases, certain modules may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

• UL: S635
• ULC: S635
• FM Approved
• CSFM: 7300-0028:0219
• MEA: 457-99-E
• U.S. Coast Guard:

Product Line Information

NOTE: “A” suffix indicates ULC-listed model.

FDM-1(A): Monitor module, dual, two independent Class B circuits.
SMB500: Optional surface-mount backbox.

NOTE: See installation instructions and refer to the SLC Wiring Manual, PN 51253.
General
The FCPS-24S6E (6-amp) and FCPS-24S8E (8-amp) are remote power supplies with battery charger. The FCPS-24S6/-24S8 may be connected to any 12 or 24 volt fire alarm control panel (FACP) or may be used as stand-alone supplies. Primary applications include notification appliance (bell) circuit (NAC) expansion (to support ADA requirements and NAC synchronization) or auxiliary power to support 24 volt system accessories. The FCPS-24S6/-24S8 provides regulated and filtered 24 VDC power to four notification appliance circuits configured as either four Class B (Style Y) or Class A (Style Z, with ZNAC-4 option module). Alternate, the four outputs may be configured as all non-resettable, all resettable or two non-resettable and two resettable. The FCPS-24S6/-24S8 also contains a battery charger capable of charging up to 18 AH batteries. FCPS-24S6C & FCPS-24S8C are UL-listed.

NOTE: Unless otherwise specified, the terms FCPS-24S6 and FCPS-24S8 used in this document refers to the standard FCPS-24S6 and FCPS-24S8, FCPS-24S6C and FCPS-24S8C, the FCPS-24S6E and FCPS-24S8E.

Features
- UL-Listed NAC synchronization using System Sensor, Wheelock, or Gentex “Commander” appliances.
- Operates as a “sync-follower” or a “sync-generator” (default). See note on page 2.
- Contains two fully-isolated input/control circuits - triggered from FACP NAC (NAC expander mode) or jumped permanently “ON” (stand-alone mode).
- Four Class B (Style Y) or four Class A (Style Z, with ZNAC-4 module) NACs.
- 6-amp (FCPS-24S6) or 8-amp (FCPS-24S8) full load output, with 3 amps maximum/circuit, in NAC expander mode (UL 864).
- 4-amp (FCPS-24S6) or 6-amp (FCPS-24S8) continuous output in stand-alone mode (UL 1481).
- Compatible with coded inputs; signals passed through.
- Optional power-supervision relay (EOLR-1).
- In stand-alone mode, output power circuits may be configured as: resettable, (reset line from FACP required), non-resettable, or a mix of two and two.
- Fully regulated and filtered power output - optimal for powering four-wire smoke detectors, annunciators, and other system peripherals requiring regulated/filtered power.
- Power-limiting technology meets UL power-limiting requirements.
- Form-C normally-closed trouble relay.
- Fully supervised power supply, battery, and NACs.
- Selectable earth fault detection.
- AC trouble report selectable for immediate 2-hour delay.
- Works with virtually any UL 864 fire alarm control which utilizes an industry-standard reverse-polarity notification circuit (including unfiltered and unregulated bell power).
- Requires input trigger voltage of 9 - 32 VDC.
- Self-contained in compact, locking cabinet - 15”H x 14.5”W x 2.75”D (cm: 38.1H x 36.83W x 6.985D).

- Includes integral battery charger capable of charging up to 18 AH batteries. Cabinet capable of housing 7.0 AH batteries.
- Battery charger may be disabled via DIP switch for applications requiring larger batteries.
- Fixed, clamp-type terminal blocks accommodate up to 12 AWG (3.1mm²) wire.

Specifications
Primary (AC) Power:
- FCPS-24S6C/-24S8C: 120 VAC, 60 Hz, 3.2A maximum.
- FCPS-24S6E/-24S8E: 240 VAC, 50 Hz, 1.6A maximum.
- Wire Size: minimum #14 AWG (2.0mm²) with 600 V insulation.

Control Input Circuit:
- Trigger Input Voltage: 9 to 32 VDC.
- Trigger Current: 2.0 mA (16 - 32 V); Per Input: 1.0 mA (9 - 16 V).

Trouble Contact Rating: 5 A at 24 VDC.

Auxiliary Power Output: Specific application power 500 mA maximum.

Output Circuits:
- +24 VDC filtered, regulated.
- 3.0 A maximum for any one circuit.
- Total continuous current for all outputs (stand-alone mode):
  - FCPS-24S6: 4.0 A maximum.
  - FCPS-24S8: 6.0 A maximum.
- Total short-term current for all outputs (NAC expander mode):
  - FCPS-24S8: 8.0 A maximum.

Secondary Power (Battery) Charging Circuit:
- Supports lead-acid batteries only.
- Float-charge voltage: 27.6 VDC.
Applications

Example 1: Expand notification appliance power an additional 6.0 A (FCPS-24S6) or 8.0 A (FCPS-24S8). Use up to four Class B (Style Y) outputs or four Class A (Style Z) outputs (using ZNAC-4). For example, the FACP notification appliance circuits will activate the FCPS when reverse-polarity activation occurs. Trouble conditions on the FCPS are sensed by the FACP through the notification appliance circuit.

Example 2: Use the FCPS to expand auxiliary regulated 24-volt system power up to 4.0 A (FCPS-24S6) or up to 6.0 A (FCPS-24S8). Both resettable and non-resettable power options are available. Resettable outputs are created by connecting the resettable output from the FACP to one or both of the FCPS inputs.

Example 3: Use addressable control modules to activate the FCPS instead of activating it through the FACP notification appliance circuits. This typically allows for mounting the FCPS at greater distances* away from the FACP while expanding system architecture in various applications.

For example, an addressable control module is used to activate the FCPS, and an addressable monitor module is used to sense FCPS trouble conditions. Local auxiliary power output from the FCPS provides power to the addressable control module.

*NOTE: Addressable FACPs are capable of locating control and monitor modules at distances of up to 12,500 feet (3,810 meters).

Sync Follower/Generator Note

In some installations, it is necessary to synchronize the flash timing of all strobes in the system for ADA compliance. Strobes accomplish this by monitoring very short timing pulses on the NAC power which are created by the FACP. When installed at the end of a NAC wire run, the FCPS-24S6/-24S8 can track (i.e. “follow”) the strobe synchronization timing pulses on the existing NAC wire run. This maintains the overall system flash timing of the additional strobes attached to the FCPS.

When the FCPS-24S6/-24S8 is configured (via DIP switch settings) as a “sync follower,” the FCPS’s NAC outputs track the strobe synchronization pulses present at the FCPS’s sync input terminal. The pulses originate from an upstream FACP or other power supply.

When the FCPS-24S6/-24S8 are configured (via DIP switch settings) as a “sync generator,” the FCPS’s sync input terminals are not used. Rather, the FCPS is the originator of the strobe synchronization pulses on the FCPS’s NAC outputs. In “sync generator” mode, the sync type (System Sensor, Wheelock, or Gentex) is selectable via DIP switch settings.

Standards and Codes

The FCPS-24S6 and FCPS-24S8 comply with the following standards:

- UL 1481 Power Supplies for Fire Alarm Systems.

Agency Listings and Approvals

These listings and approvals apply to the modules specified in this document. In some cases, certain modules or applications may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- UL Listed: S635, S674
- ULC Listed: S635 (FCPS-24S6C & FCPS-24S8C)
- CSFM Approved: 7315-0028:225
- MEA: 299-02-E
- FM Approved

Ordering Information

FCPS-24S6: 6.0 A, 120 VAC remote charger power supply. Includes main printed circuit board, transformers, enclosure (15"H x 14.5"W x 2.75"D [cm: 38.1H x 36.83W x 6.985D]), and installation instructions.

FCPS-24S6C: Same as above, ULC-listed.

FCPS-24S6R: Same as FCPS-24S6 with red enclosure.

FCPS-24S6E: 6.0 A, 240 VAC remote charger power supply. Includes main printed circuit board, transformers, enclosure (15"H x 14.5"W x 2.75"D [cm: 38.1H x 36.83W x 6.985D]), and installation instructions.

FCPS-24S8: 8.0 A, 120 VAC remote charger power supply. Includes main printed circuit board, transformers, enclosure (15"H x 14.5"W x 2.75"D [cm: 38.1H x 36.83W x 6.985D]), and installation instructions.

FCPS-24S8C Same as above, ULC-listed.

FCPS-24S8R: Same as FCPS-24S8 with red enclosure.

FCPS-24S8E: 8.0 A, 240 VAC remote charger power supply. Includes main printed circuit board, transformers, enclosure (15"H x 14.5"W x 2.75"D [cm: 38.1H x 36.83W x 6.985D]), and installation instructions.

ZNAC-4: Class A (Style Y) NAC option module.

EOLR-1: 12/24 VDC end-of-line relay for monitoring four-wire smoke detector power.

BATTERY: Battery, 12-volt, 7.0 AH (two required, see BATTERY data sheet DN-593).

PS-1270: Battery, 12-volt, 7.0 AH (two required, see PS-1270 data sheet DN-1109)
DNR(A)/DNRW InnovairFlex
Intelligent Non-Relay Photoelectric Duct Smoke Detector

General
The Notifier InnovairFlex® DNR(A) intelligent non-relay photoelectric duct smoke detector and DNRW watertight non-relay photoelectric duct smoke detector feature a pivoting housing that fits both square and rectangular footprints capable of mounting to a round or rectangular duct.

DNRW duct smoke detector, with its NEMA-4 rating, is listed as a watertight, UV resistant enclosure providing protection against falling dirt, rain, and windblown dust, splashing and hose directed water, allowing operators to use the detector in the most extreme environments.

These units sense smoke in the most challenging conditions, operating in airflow speeds of 100 to 4,000 feet per minute (0.5 to 20.32 m/s), temperatures of -4°F to 158°F (-20°C to 70°C), and a humidity range of 0 to 95 percent (non-condensing.)

An improved cover design isolates the sensor head, which allows for ease of maintenance. A cover tamper feature indicates a trouble signal for a removed or improperly installed sensor cover. The Notifier InnovairFlex housing provides a 3/4-inch conduit knockout and ample space to facilitate easy wiring and mounting of a relay module.

The Notifier InnovairFlex duct smoke detector can be customized to meet local codes and specifications without additional wiring. The new InnovairFlex product line is compatible with all previous Innovair models, including remote test accessories.

Features
• Photoelectric, integrated low-flow technology.
• Air velocity rating from 100 ft/min to 4,000 ft/min (0.5 m/s to 20.32 m/s).
• Versatile mounting options: square or rectangular configuration.
• Broad ranges for operating temperature (-4°F to 158°F, -20°C to 70°C) and humidity (0% to 95% non-condensing).
• Patented sampling tube installs from front or back of the detector with no tools required.
• Cover tamper signal.
• Increased wiring space with a newly added 3/4" conduit knockout.
• Available space within housing to accommodate mounting of a relay module.
• Easily accessible code wheels on sensor head (sold separately).
• Clear cover for convenient visual inspection.
• Remote testing capability.
• Requires com line power only.
• Accommodates the installation of an addressable relay module, sold separately. (FRM-1 or NC-100R) for applications requiring a Form-C relay.

Specifications
Size: (Rectangle) 14.38 in (37 cm) Length; 5 in (12.7 cm) Width, 2.5 in (6.6 cm) Depth.
Size: (Square) 7.75 in (19.7 cm) Length; 9 in (22.9 cm) Width; 2.5 in (6.35 cm) Depth.
Weight: 1.6 lb (0.73 kg).
Operating Temperature Range: -4°F to 158°F (-20°C to 70°C).
Storage Temperature Range: -22°F to 158°F (-30°C to 70°C).
Operating Humidity Range: 0% to 95% relative humidity (non-condensing).
Air Duct Velocity: 100 to 4,000 ft/min (0.5 to 20.32 m/s).

Accessories
Notifier provides system flexibility with a variety of accessories, including two remote test stations and different means of visible and audible system annunciation. As with our duct smoke detectors, all duct smoke detectors accessories are UL listed. DNR(W)s with a date code of 0013 or higher do not require external 24VDC for remote test applications when used with a remote-test-capable detector.

ACCESSORY CURRENT LOADS AT 24 VDC

<table>
<thead>
<tr>
<th>Device</th>
<th>Standby</th>
<th>Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA100Z</td>
<td>0mA</td>
<td>12 mA Max</td>
</tr>
<tr>
<td>RTS151/RTS151KEY</td>
<td>0mA</td>
<td>12mA Max</td>
</tr>
</tbody>
</table>

Agency Listings and Approvals
Consult product manual for lists of compatible UL-Listed devices. In some cases, certain modules may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.
• UL: S911, S3705.
• ULC: S635.
Product Line Information

NOTE: "A suffix indicates ULC listed model.

DNR(A): Intelligent non-relay photoelectric low flow smoke detector housing. Requires photoelectric smoke detector (sold separately).

DNRW: Watertight intelligent non-relay photoelectric low flow duct smoke detector housing. Requires photoelectric smoke detector (sold separately).


NP-100: Addressable low-profile photoelectric smoke detector for FireWarden series panels.

NP-100R(A): Remote test capable addressable low-profile photoelectric smoke detector for FireWarden series panels.

DCOIL: Remote test coil. Required for older DNR(W) duct detector housing.

DST1(A): Metal sampling tube duct width up to 1 ft (0.3m).

DST1.5(A): Metal sampling tube duct widths up to 1 ft to 2 ft (0.3 to 0.6 m).

DST3(A): Metal sampling tube duct widths up to 2 ft to 4 ft (0.6 to 1.2 m).

DST5(A): Metal sampling tube duct widths up to 4 ft to 8 ft (1.2 to 2.4 m).

DST10(A): Metal sampling tube duct widths up to 8 ft to 12 ft (2.4 to 3.7 m).

DH400OE-1: Weatherproof enclosure.

ETX: Metal exhaust tube duct, width 1 ft (0.3 m).

M02-04-00: Test magnet.

P48-21-00: End cap for metal sampling tubes.

RA100Z(A): Remote annunciator alarm LED.

RTS151(A): Remote test station.

RTS151KEY(A): Remote test station with key lock.

Important Note

- DNRW duct detector housings with a date code of 0013 or higher do not require a DCOIL or auxiliary 24 VDC for remote test applications when used with a remote test capable detector.

- DNRW duct detector housings with a date code of 0012 or earlier require a DCOIL and auxiliary 24 VDC power for remote test applications.
Appendix C: Fire Alarm Project Sheets
Appendix D: Architectural Sheets
### ACCESSORY SCHEDULE

<table>
<thead>
<tr>
<th>No</th>
<th>Material</th>
<th>Description</th>
<th>Mg/Ft</th>
<th>Qty</th>
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<td>&quot;STUDENT CENTER&quot;</td>
<td>REBAR</td>
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<tr>
<td>02</td>
<td>&quot;ARCHITECT&quot;</td>
<td>Piping</td>
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<tr>
<td>03</td>
<td>&quot;CONSULTANT&quot;</td>
<td>Piping</td>
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<tr>
<td>04</td>
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<td>Piping</td>
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<tr>
<td>05</td>
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### JOINT SEALANT SCHEDULE

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<td>&quot;POLYURETHANE&quot;</td>
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### ACCESSORY SCHEDULE

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</thead>
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<td>3'-0&quot; x 6'-0&quot;</td>
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<td>2</td>
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<td>3'-0&quot; x 6'-0&quot;</td>
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<tr>
<td>3</td>
<td>3'-0&quot; x 6'-0&quot;</td>
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### Door Schedule

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<th>Material</th>
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### Access Door Schedule

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<th>Door Type</th>
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### Reducer Strip Schedule

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<td>Solid Core Masonite Door</td>
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<tr>
<td>2</td>
<td>Hollow Metal Door</td>
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</table>

### Typical Details

- **General Door Typical Notes**
  1. Doors shall be solid core Masonite, with 3'-0" x 6'-0" height and finish as specified.
  2. Materials shall be selected by the Architect and shall be in accordance with the Contract Documents.
  3. All doors shall be pre-assembled and ready for installation. Special tools shall be provided by the Contractor.

### Door Type Schedule

- **Solid Core Masonite Door**
  - Size: 3'-0" x 6'-0"
  - Material: Solid Core Masonite
  - Finish: As Specified

- **Hollow Metal Door**
  - Size: 3'-0" x 6'-0"
  - Material: Hollow Metal
  - Finish: As Specified

### Diagrams

- **Diagram of Solid Core Masonite Door**
- **Diagram of Hollow Metal Door**
E. Building Section

F. Building Section
A. Elevation - Bookstore Desk

B. Elevation - Bookstore Desk

A. Partial Plan - Bookstore Desk
Appendix E: FDS File for Design Fire A
&HEAD CHID='PROJECT MODEL Simulation 1', TITLE='OFFICE FIRE SIMULATION' /

=====Compartment Configuration=====

*Book Store*
&MESH XB= -2.0, 4.6, 0.0, 3.6, 0.0, 4.0, IJK = 33,18,20 /

*West Wall*
&OBST XB= 0.0, 0.0, 0.0, 3.6, 0.0, 4.0, SURF_ID='WALL'/

*Door*
&HOLE XB= -0.1, 0.1, 2.6, 3.5, 0.0, 2.4 /

*Opening to Lounge/Game Area*
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&VENT XB= -2.0, 0.0, 3.6, 3.6, 0.0, 4.0 , SURF_ID='OPEN'/
&VENT XB= -2.0, -2.0, 0.0, 3.6, 0.0, 4.0 , SURF_ID='OPEN'/
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======Model Misc Details======

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&MISC TMPA=21. /

&DUMP DT_CTRL=0.5, DT_HRR=1., DT_DEVC=1., SIG_FIGS=3 /

=========Products of Combustion======

***Reference SFPE Handbook Table A.39 and SFPE Handbook Figure 62.20 for soot & CO yield***

&REAC ID='CELLULOSE',
   FYI='C_6 H_10 N O_25',
   FUEL='REAC_FUEL',
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   SOOT_YIELD=0.015 /
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QUANTITY = 'SPRINKLER LINK TEMPERATURE'
ACTIVATION_TEMPERATURE= 68.3
RTI = 50.0
C_FACTOR = 0.0
FLOW_RATE = 0.0 /

========
= Fire =
========

***Reference for HRR: "Heat Release Rates of Burning Items in Fires" by Kim and Lilley***

Wastebasket
*OBST XB= 3.9,4.5, 0.2, 0.8, 0.0,0.6 ,COLOR ='GREEN' /
*VENT XB= 3.9,4.5, 0.2, 0.8, 0.6,0.6, SURF_ID='fire', IOR=3 /
*SURF ID='fire', HRRPUA=933, RAMP_Q='fireramp', COLOR='RED' /

*Growth*
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    FYI            = 'Quintiere, Fire Behavior'
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    DENSITY       = 7600.
    CONDUCTIVITY  = 45. /
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DENSITY = 2100.
CONDUCTIVITY = 1.0 /

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FYI = 'INSWOOL HTZ for k and WEBBOOK for c'
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DENSITY = 128.
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Appendix F: FDS File for Design Fire B
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=====Compartment Configuration=====

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&MESH XB= 0.0,11.0, -2.0, 11.0, 0.0, 6.0, IJK = 55,65,30 /

*Delivery*
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*Delivery Area Wall*
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*East Entry Vestibule Wall*
&OBST XB=0.0, 11.0, 0.0, 0.0, 0.0, 6.0, SURF_ID='WALL'/

*East Entry Vestible Doorway in Bookstore*
&HOLE XB= 3.0, 4.83, -0.2, 0.1, 0.0, 2.4 /

*East Entry Vestibule Vent Into Game Area*
&VENT XB = 0.0,0.0, -2.0, 0.0, 0.0, 6.0, SURF_ID = 'OPEN' /

=====Model Misc Details=====

&TIME T_END= 1100. /
&MISC TMPA=21. /
&DUMP DT_CTRL=0.5, DT_HRR=1., DT_DEVF=1., SIG_FIGS=3 /

=========Products of Combustion=========*

***Reference SFPE Handbook Table A.39 and SFPE Handbook Figure 62.20 for soot & CO yield***

&REAC ID='CELLULOSE',
   FYI='C_6 H_10 N O_25',
   FUEL='REAC_FUEL',
   C=6.0,
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   O=5.0,
   CO_YIELD=0.01,
   SOOT_YIELD=0.015 /
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&PROP ID = 'SPK'
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ACTIVATION_TEMPERATURE = 68.3
RTI = 50.0
C_FACTOR = 0.0
FLOW_RATE = 0.0 /

======

= Fire =

======

***Reference for HRR: "Quick Response Sprinklers in Office Configurations: Fire Test Results" by US DEPT of Commerce***

Book Cases

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*Growth*

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  DENSITY = 790. /

&MATL ID = 'STEEL'
  FYI = 'Quintiere, Fire Behavior'
  SPECIFIC_HEAT = 0.77
  EMISSIVITY = 0.8
  DENSITY = 7800.
  CONDUCTIVITY = 45. /

&MATL ID = 'CONCRETE'
  FYI = 'Quintiere, Fire Behavior'
  SPECIFIC_HEAT = 0.88
  DENSITY = 2100.
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&MATL ID = 'K-LITE HTZ'
  FYI = 'INSWOOL HTZ for k and WEBBOOK for c'
  EMISSIVITY = 0.95
  DENSITY = 128.
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&DEVC XYZ = 4.0, 3.0, 6.0, PROP_ID = 'SPK', ID = '4,3' /
&DEVC XYZ = 6.0, 3.0, 6.0, PROP_ID = 'SPK', ID = '6,3' /
&DEVC XYZ = 8.0, 3.0, 6.0, PROP_ID = 'SPK', ID = '8,3' /
&DEVC XYZ = 10.0, 3.0, 6.0, PROP_ID = 'SPK', ID = '10,3' /
&DEVC XYZ = 2.0, 6.0, 6.0, PROP_ID = 'SPK', ID = '2,6' /
&DEVC XYZ = 4.0, 6.0, 6.0, PROP_ID = 'SPK', ID = '4,6' /
&DEVC XYZ = 6.0, 6.0, 6.0, PROP_ID = 'SPK', ID = '6,6' /
&DEVC XYZ = 8.0, 6.0, 6.0, PROP_ID = 'SPK', ID = '8,6' /
&DEVC XYZ = 10.0, 6.0, 6.0, PROP_ID = 'SPK', ID = '10,6' /
&DEVC XYZ = 2.0, 9.0, 6.0, PROP_ID = 'SPK', ID = '2,9' /
&DEVC XYZ = 4.0, 9.0, 6.0, PROP_ID = 'SPK', ID = '4,9' /
&DEVC XYZ = 6.0, 9.0, 6.0, PROP_ID = 'SPK', ID = '6,9' /
&DEVC XYZ = 8.0, 9.0, 6.0, PROP_ID = 'SPK', ID = '8,9' /
&DEVC XYZ = 10.0, 9.0, 6.0, PROP_ID = 'SPK', ID = '10,9' /

=======Measurements======

&DEVC XB=6.0,0.0,6.0,6.0,0.0,0.0, QUANTITY='LAYER HEIGHT', ID = 'Smoke Layer Height Center of Bookstore' /
&DEVC XB=6.0,0.0,-1.0,-1.0,0.0,6.0, QUANTITY='LAYER HEIGHT', ID = 'Smoke Layer Height Center of East Vestibule' /
&DEVC XYZ = 3.9, -1.0, 1.8, QUANTITY = 'DENSITY', SPEC_ID='SOOT', ID = 'Soot Density 1m Into EastVest' /
&DEVC XYZ = 3.9, -1.0, 1.8, QUANTITY = 'MASS FRACTION', SPEC_ID='CARBON MONOXIDE', ID = 'CO 1m Into EastVest' /
&SLCF PBX=1.0, QUANTITY='DENSITY',SPEC_ID='SOOT' /
&SLCF PBY=-1.0, QUANTITY='DENSITY',SPEC_ID='SOOT' /
&SLCF PBZ=1.8, QUANTITY='DENSITY',SPEC_ID='SOOT' /
&SLCF QUANTITY='MASS FRACTION', SPEC_ID='CARBON MONOXIDE', PBZ= 1.8, ID = 'CO AT 1.8 METERS' /
&SLCF QUANTITY='MASS FRACTION', SPEC_ID='CARBON MONOXIDE', PBY= -0.5, ID = 'CO 0.5 METERS INTO VESTIBULE' /
&SLCF QUANTITY='TEMPERATURE', PBZ= 1.8/
&SLCF QUANTITY='TEMPERATURE', PBX=6.0/
&SLCF QUANTITY='TEMPERATURE', PBY=6.0/
&SLCF QUANTITY='TEMPERATURE', PBZ= 1.8/
&SLCF QUANTITY='TEMPERATURE', PBX=6.0/
&SLCF QUANTITY='TEMPERATURE', PBY=6.0/
&SLCF QUANTITY='TEMPERATURE', PBZ= 6.0/
&SLCF QUANTITY='TEMPERATURE', PBY=6.0/
&DEVC ID='heat flux center of room 1.8 m high', QUANTITY='RADIATIVE HEAT FLUX GAS', XYZ=6.0,6.0,1.8, ORIENTATION=-1,0,0 /

&DEVC ID='heat flux center of room 0.1 m high', QUANTITY='RADIATIVE HEAT FLUX GAS', XYZ=6.0,6.0,0.1, ORIENTATION=-1,0,0 /

&SLCF PBX=1.2, QUANTITY='HRRPUV' /

&BNDF QUANTITY='WALL TEMPERATURE' /

&TAIL /