Fire Protection Engineering Analysis Report

ACME Semiconductor Foundry – Fab Expansion
United States

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Keywords: SFRM, spray applied fire resistive materials, Performance Based Design, Fire Dynamics Simulator (FDS)

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1. Executive Summary

The ACME Semiconductor Foundry – Fab Expansion is a new four story addition to an existing four story foundry facility. The Fab Expansion is approximately 154,500 square feet in footprint area that is connected to an existing four-story Fab Building.

This report has been prepared to identify the building's fire protection and life safety features that must be provided in accordance with the applicable codes and standards. The ACME Semiconductor Fab Expansion will contain multiple separated uses and will be required to be constructed with Type I-B construction. Building Construction Documents are provided in Appendix A showing compliance with the requirements found herein. There are multiple occupancy classifications within the building. The predominant use of the building is semiconductor fabrication (H-5), with some storage of hazardous materials (H-2, H-3, and H-4).

The structural fire protection requirements are presented. The structure, being Type I-B, would normally require 1-hour fire resistance rated roof supports. Other prescriptive structural requirements are shown to be compliant. A performance based analysis is presented showing that the roof support does not reach critical temperatures for duration of one hour when exposed to a worst case credible fire scenario.

The sprinkler system design requirements for the ACME Semiconductor Fab Expansion are presented showing various sprinkler system design densities. The most demanding case occurs in the Solvent Storage Room with 0.30 gallons per minute per square foot over a design area of 3,000 square feet. A summary of the inspection, testing, and maintenance requirements related to the fire sprinkler systems has been provided.

This report presents the relevant fire detection, alarm and communication system design requirements for the ACME Semiconductor Fab Expansion. An excerpt of fire alarm design drawings has been provided in Appendix G showing the general code requirements, typical notification device layout and spacing, and a unique detection situation utilizing radiant-energy sensing detectors. Detection response analysis has been performed using DETACT, FDS, and manufacturer's data for the unique flame detector situation. A brief summary of the inspection, testing, and maintenance requirements related to the fire alarm systems has been provided.

This report presents the relevant egress requirements for the ACME Semiconductor Fab Expansion. Life Safety Plans are provided in Appendix K showing areas of non-compliance with the prescriptive requirements of the LSC. Use of the IBC would yield compliance acceptable to many authorities having jurisdiction. The egress calculations shown and simulated provide the basis for a performance based design of the egress systems in this building. This report can be used to establish the RSET value to be compared to an ASET value determined through the use of a CFD fire model.

Recommendations include conducting a fire study to evaluate the egress systems in accordance with the LSC for high hazard industrial occupancies. The performance based analysis provides the thermal exposure and demand to capacity ratios for the exposed structural steel. A structural engineer can utilize the thermal exposure criteria to determine whether a critical value is reached in the exposed structural steel.

2. Introduction

The ACME Seminconductor Foundry – Fab Expansion is a new four story addition to an existing four story foundry facility. The Fab Expansion is approximately 154,500 square feet in footprint area that is connected to an existing four-story Fab Building. The building will contain the following uses:

- Semiconductor Fabrication Support / 231,000 square feet
- Cleanroom / 145,000 square feet
- Hazardous Material Storage or Dispensing / 28,000 square feet
- Exterior Loading Docks / 3,600 square feet
- Pyrophoric Storage / 430 square feet

This report has been prepared to identify the building’s fire protection and life safety features that must be provided in conjunction with the new construction.

The building design has been compared to the applicable codes and standards in terms of structural fire protection, fire protection systems; including fire sprinkler and fire alarm, means of egress requirements, and how the building is designed to handle smoke management.

The foundry is arranged such that the long side of the building is oriented north/south.

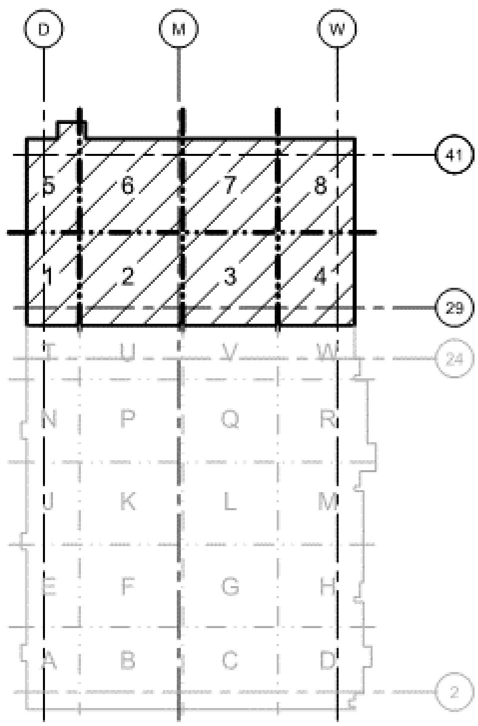

Figure 1. General Building Layout

The expansion portion of the building consists of zones 1 through 8 shown in Figure 1. The existing fabrication facility consists of Zones A through W. This report is concerned with the fire protection and life safety features of the expansion project.

3. Applicable Codes and Standards

The following codes and standards are applicable to this project:

- 2012 International Building Code (IBC).
- 2012 International Fire Code (IFC).
- Factory Mutual (FM) Datasheet 7-29, “Flammable Liquid Storage in Portable Containers.”
- FM Datasheet 7-50, “Compressed Gases in Cylinders.”
- FM Datasheet 7-82N, “Storage of Liquid/Solid Oxidizing Materials.”
- FM Datasheet 7-84, “Hydrogen Peroxide.”
- FM Datasheet 7-88, “Storage Tanks for Flammable Liquids.”
- NFPA 10: Standard for Portable Fire Extinguishers, 2010 Edition
- NFPA 13: Standard for the Installation of Sprinkler Systems, 2013 Edition
- NFPA 14: Standard for the Installation of Standpipes and Hose Systems, 2013 Edition
- NFPA 20: Standard for the Installation of Stationary Pumps for Fire Protection, 2013 Edition
- NFPA 22: Standard for Water Tanks for Private Fire Protection, 2011 Edition
- NFPA 24: Standard for the Installation of Private Fire Service Mains and Their Appurtenances, 2013 Edition
- NFPA 25: Standard for the Inspection, Testing, and Maintenance of Water‐Based Fire Protection Systems, 2015 Edition
- NFPA 30: Flammable and Combustible Liquids Code, 2012 Edition
- NFPA 55, “Standard for the Storage, Use and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationery Containers, Cylinders and Tanks,” 2005 Edition.
- NFPA 72: National Fire Alarm and Signaling Code, 2013 Edition
- NFPA 80: Standard for Fire Doors and Other Opening Protectives, 2010 Edition
- NFPA 92: Standard for Smoke Control Systems, 2012 Edition
- NFPA 110: Standard for Emergency and Standby Power Systems, 2010 Edition
- NFPA 251: Standard Methods of Tests of Fire Resistance of Building Construction and Materials, 2006 Edition
- NFPA 252: Standard Methods of Fire Tests of Door Assemblies, 2008 Edition
- NFPA 291: Recommended Practice for Fire Flow Testing and Marking of Hydrants, 2010 Edition
- NFPA 430, “Storage of Liquid and Solid Oxidizers,” 2004 Edition.
- NFPA 2001: Standard on Clean Agent Fire Extinguishing Systems, 2012 Edition
- Society of Fire Protection Engineers (SFPE) Handbook of Fire Protection Engineering, 4th Edition

4. Occupancy Classification

The ACME Semiconductor Fab Expansion will contain multiple separated uses. Table 1 provides the different occupancy classifications related to the various uses within the building:

Table 1. Building Occupancies

Description of Use	Occupancy Classification
Fabrication Areas	Semiconductor (Group H-5)
Flammable Liquid Storage	High Hazard (Group H-2)
Hazardous Material Storage	High Hazard (Group H-3)
Corrosive/Oxidizer Storage	High Hazard (Group H-4)
Mechanical & Electrical Rooms	Factory (Group F-1)

The building has been designed based on IBC requirements for mixed use occupancies. Occupancy separations are provided in accordance with IBC Section 508.4. Hourly ratings for separation between occupancies, as specified in IBC Table 508.4, are based on a fully sprinklered building.

5. Structural Fire Protection

The building has been designed in accordance with the prescriptive requirements of the IBC for primary structural framing and occupancy separation fire-resistance ratings. The exposed steel trusses supporting only the roof have been designed using a performance based approach, presented later in the report. The following sections present the passive fire protection throughout the building.

5.1. Construction Type

The construction type for the new Fab Expansion building is based on the building being four stories tall and 154,500 square feet in footprint area. The minimum construction permitted for the building is Type I-B. Table 2 contains the height and area requirements for a building of Type I-B construction in accordance with IBC Chapter 5.

Table 2. Height and Area Calculations

Requirements/Details	Values	Unit of Measure
Predominant Use Group (for story being considered)	Use Group H-5	
Construction Type (minimum within building)	Type I-B	
Tabular Area per Story (Table 503)	Unlimited	square feet
Frontage Increase (Section 506.2)	Not Applicable	square feet
Sprinkler Increase (Section 506.3)	Not Applicable	square feet

Requirements/Details	Values	Unit of Measure
Maximum Allowable Floor Area (for story being considered)	Unlimited	square feet
Actual Floor Area (footprint of 1st level)	154,500	square feet
Building Height		
Tabular Building Height (Table 503)	160	feet
Automatic Sprinkler System Increase (Section 504.2)	Not Permitted	feet
Total Building Height Allowed	160	feet
Actual Building Height	82	feet
Number of Stories		
Tabular Building Height (Table 503)	4	stories
Automatic Sprinkler System Increase (Section 504.2)	Not Permitted	stories
Total Building Height Allowed	4	stories
Actual Building Height	4	stories

5.2. Building Element Fire Resistance Ratings

Table 3 is a summary of the required fire resistance ratings and opening protection requirements for the building in accordance with IBC Tables 601 and 602.

Table 3. Building Elements - Based on Type I-B Construction

Building Element	IBC Required Fire Resistance Rating	Provided Fire Resistance Rating
Structural Frame	2 Hour	2 Hour
Bearing Walls (exterior)	2 Hour	2 Hour
Bearing Walls (interior)	2 Hour	2 Hour
Nonbearing Walls (exterior) (<30 feet)	1 Hour	1 Hour
Unprotected Openings (IBC Section 705.8)	Protection Required (footnote i), if less than 30 feet fire separation	None, fire separation distances > 30 feet
Nonbearing Walls (interior)	0 Hour	0 Hour
Floor Construction	2 Hour	2 Hour
Roof Construction*	1 Hour	**1 Hour***
Shaft Enclosures (IBC Section 713.4)	2-hour	2 Hour
Stairwell Enclosures (IBC Section 713.4)	2-hour	2 Hour
Exit Passageways - to extend travel distance	2 Hour	2 Hour
Separation between existing Fab Building and new Fab Expansion Building	Non-rated	Non-rated

***Roof construction with 1 hour of fire resistance will be shown through an alternative method complying with Section 104.11. The use of fire modeling will show a 1-hour fire resistance rating without the use of spray-applied fire resistive materials. The results of the modeling are presented later in this report.**

5.2.1. Building Element Construction Description

The building elements are described below. Structural drawings for the Northwest Quadrant of the building are provided in Appendix A for reference. The Northwest Quadrant is representative of the remainder of the building. Only this portion is provided due the building scale and ability to reproduce documents on a standard printer (11x17 quadrant drawings). A building section drawing is also provided for clarity.

Columns used throughout the building are steel wide-flange. On Level 1 and Level 2, columns are encased in concrete creating a total column dimension of 2-feet by 2-feet.

Primary structural framing used throughout the building consists of steel wide-flange girders, beams, and joists of various sizes. On Level 3, in the central portion of the building, the primary floor structure consists of poured-in-place, reinforced concrete beams and “waffle” slab. The Level 4 structural framing in the central portion of the building consists of a wide-flange truss approximately 14 feet between the top chord and bottom chord. The truss spans 232-feet between column supports. This truss is required to be of 1 hour fire-resistance rated construction which would require spray-applied fire resistive materials (SFRM). An alternative design method has been employed consisting of a performance based structural fire engineering approach. A fire model is presented later in this report to evaluate the roof truss to show achieving 1-hour of fire-resistance rating without the use of SFRM, under the worst credible fire scenario.

Floor assemblies are as shown in Table 4 below:

Table 4. Floor Assemblies

Building Level	Description
Grade (Level 1)	Reinforced concrete slab (varying thickness) over spread footings
Level 2 (east and west wings only)	Normal weight concrete poured over metal deck
Level 3	Poured-in-place concrete waffle slab
Level 4 (east and west wings only)	Normal weight concrete poured over metal deck

The roof deck assembly consists of lightweight concrete poured over metal decking, supported by wide-flange steel girders and joists.

Exterior walls consist of insulated metal panels affixed to secondary structural framing.

Interior walls and partitions are non-bearing and are composed of non-combustible construction. Studs are predominantly lightweight steel, installed 16-inches on-center with non-rated gypsum board. Where fire ratings are required, various UL listed wall assemblies are provided.

5.3. Occupancy Separation Ratings

Table 5 is a summary of the required occupancy separation fire resistance rating requirements between the different building areas in accordance with IBC Table 508.4, unless otherwise noted.

Table 5. Building Areas

Building Areas	IBC Required Fire Resistance Rating	Provided Fire Resistance Rating
Fabrication (H-5) to Mechanical/electrical Rooms (F-1)	1 Hour	1 Hour
Egress Passageways from other areas	2 Hour	2 Hour
Fabrication (H-5) and Hazardous Materials (H-3)	1-hour	1 Hour
Fabrication (H-5) and Flammable Storage (H-2)	1 Hour	1 Hour

5.4. Roof Ratings

Table 6 outlines the required roof rating requirements in accordance with IBC Table 1505.1. The minimum required classification listed in the Table below is based on Construction Type I-B.

Table 6. Roof Covering Classification for Construction Type I-B

Component	Minimum Required Classification	Provided Classification
Roof	B	B
Skylight	B	B

5.5. Protection of Openings

The following requirements apply to openings in and penetrations through fire rated walls. They also address exterior wall openings of a unique nature.

5.6. Penetration and Opening Protection

Fire-resistive floors and ceilings are required to be continuous and all openings for mechanical and electrical equipment are required to be enclosed in accordance with IBC Section 713 and 714. Additionally, opening protection in occupancy separation walls is required to be installed per IBC Section 716.

Fire Dampers complying with the requirements of IBC Section 717 are required to be installed, in a manner that makes them readily accessible for service, in the following locations:

- Duct penetrations of area or occupancy separation walls.
- Ducts passing through horizontal exit walls
- Duct penetrations of fire-rated shafts unless exhaust or return-air sub-ducts extend 22 inches vertically in a vented shaft.
- Duct penetrating the ceiling of fire-resistive floor ceiling or roof-ceiling assemblies

- Ducts penetrating fire-rated corridor walls having openings into the corridor.

Fire ratings for opening protection are required to comply with Table 7 below.

Table 7. Opening Protection

Wall type	All Openings in Walls
2- Hr Fire Resistive Separation	Fire assembly having 1-1/2 -hr fire protection rating.
1- Hr Fire Resistive Separation	Fire assembly having 3/4-hr fire protection rating.
0- Hr Fire Resistive Separation	Smoke seal.

5.7. Fire Resistive Joint Systems

All Joints installed between fire-resistance-rated walls, floor or floor/ceiling assemblies and roofs or roof/ceiling assemblies are required to be protected by an approved fire-resistive joint system designed to resist the passage of fire for a time period not less than the required fire-resistance rating of the wall, floor, or roof in or between which it is installed in accordance with IBC Section 715.

5.8. Interior Finish

Table 8 outlines the required interior wall and ceiling finish requirements in accordance with IBC Table 803.9 for a fully sprinklered building. The minimum required classifications listed are based on the most restrictive Use Group (H).

Table 8. Wall and Ceiling Finish

Component	Minimum Required Classification	Provided Classification	Flame Spread Index	Smoke Development Index
Exit Enclosures/Passageways	B	B	0-25	0-450
Corridors	B	B	26-75	0-450
Rooms/Enclosed Spaces	C	C	76-200	0-450

The building has been designed based on IBC requirements for mixed use occupancies. Occupancy separations are provided in accordance with IBC Section 508.4. Hourly ratings for separation between occupancies, fire-resistive joints, and interior finish are all compliant and are based on a fully sprinklered building. The specific fire protection requirements are provided in the following section.

6. Fire Protection Systems

The building is equipped throughout with an automatic sprinkler system, fire alarm system, standpipes, and portable fire extinguishers. The following sections describe each of these fire protection features:

6.1. Water Supply

The water supply to the entire site is provided from a 5 million gallon tank via gravity. A 266,000 gallon fire protection storage tank is provided as a secondary water supply to the sprinkler system. A modular fire pump house with two (2) fire pumps boosts the pressure to the entire facility via the 12-inch underground main. A fire hydrant flow test was taken with readings at the hydrant nearest to but upstream of the site fire pumps, as shown in Table 9 below.

Table 9. Hydrant Flow Test

Flow Test Summary	
Static PSI	68 psi
Residual PSI	67 psi
Pitot PSI	12 psi
Orifice Diameter	4"
Coefficient of Discharge	0.9
GPM	1,500 gpm
Date	1/20/2016
Location	Hydrant upstream of fire pump inlet
By Who	ABC Fire Contractor, Inc.

An electric fire pump supplements the existing city water pressure and a diesel-engine driven fire pump boosts the pressure from the storage tank. A single centralized fire department connection (FDC) is provided at the fire pump house, downstream of the fire pump's discharge. The fire pump criteria for the electric fire pump is provided in Table 10 below. The diesel fire pump is provided for emergency backup only and is not discussed further in this analysis.

Table 10. Fire Pump Criteria

```
FIRE PUMP SPECIFICATIONS
   DRIVER:  ELECTRIC   Test Date:  N/A  Test By:
   Location:  FIRE PUMP HOUSE
   CHURN: 144.8  psi   83
   100%: 70  psi Flow: 1,500  GPM
   150%: 45.5  psi Flow: 2,250  GPM
   Source Elevation Level: 316  ft.
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Please see Appendix B for the site plan showing sprinkler riser points of connection and underground main routing back to the water source.

6.2. Hazard Analysis

The IFC, Chapters 50, 53, 55, and 57-67, provide the requirements for the storage, use and handling of hazardous production materials (HPM). This analysis assumes that all incompatible chemicals are segregated or separated in accordance with IFC, Section 5004.4.

Bulk Aqueous Chemical Room (F111121)

The Bulk Aqueous Chemical Room is used to store and dispense the following chemicals at concentrations shown:

- Hydrofluoric Acid (HF) – 49%
- Hydrofluoric Acid (HF) – 5.1%
- Hydrochloric Acid (HCl) – 36%
- Ammonium Hydroxide (NH4OH) – 29%
- Hydrogen Peroxide (H2O2) – 31%

The Hazardous Materials Inventory Statement (HMIS) lists hydrogen peroxide with a 31% concentration as a Class 1 Oxidizer. The indoor storage of oxidizers is governed by IFC, Section 6304.1. The sprinkler system requirements shall be in accordance with NFPA 430. The chemicals are going to be stored in bulk storage vessels, either 25,000 liter tanks or smaller 2,000 liter day tanks. The tallest tanks are 24-feet in height and are potentially made from stainless steel, plastic, or fiberglass. NFPA 430, Section 5.3.2 (3), requires that Class 1 oxidizers contained in plastic containers be designated as a Class III commodity.

NFPA 13, Figure 14.2.4.2 and Figure 14.2.4.3 can be utilized to determine the design density for a 24-foot tall Class III commodity. This criteria is 0.20 gpm/sq. ft. over a design area of 3,000 square feet. This design density satisfies the IFC requirement for the protection of the other corrosive and toxic materials stored in the same room.

Hazardous Specialty Gas Dispensing Room (F111122)

The Hazardous Specialty Gas Dispensing Room contains bulk gaseous storage containers and/or rated gas cabinets for the following gaseous chemicals:

- Fluorine (1.0%), Krypton (1.2%), Neon (97.8%)
- Hexfluoro-1,3-Butadiene
- Ethylene
- Difluoromethane (CH2F2)
- F-41
- Methane
- Carbon Monoxide
- Nitrous Oxide
- Fluorine (1%), Argon (3.7%), Neon
- Fluorine (20%), Nitrogen
- Hydrogen Bromide
- Sulfur Dioxide
- Chlorine
- Diborane (1%), Hydrogen (99%)
- Dichlorsilane
- Hydrogen Chloride
- Nitrogen Trifluoride
- Ammonia (NH3)
- Silicon tetrafluoride
- Carbonyl sulfide
- TMS
- Octafluorocyclopentene
- F-14
- Hydrogen Fluoride
- Chlorosilane
- Phosphine (4.5%), Helium (95.5%)

The sprinkler density in this gas dispensing room is required to be 0.25 gpm per square foot over 3,000 square feet in accordance with NFPA 55, Section 6.9.2.2. Sprinklers are also required within each of the gas cabinets.

NFPA 55, Table 7.1.10.2, outlines the separation requirements for containers of incompatible materials. The 20-foot separation requirement is permitted to be reduced where the cylinders or containers are separated by a barrier with a fire resistance rating of at least 30 minutes (NFPA 55, Section 7.1.10.2.1). No separation distance is required for incompatible materials where both are enclosed in approved gas cabinets.

Bulk Gas Purifier Room (F11821)

The Bulk Gas Purifier Room houses equipment used to purify inert gases used throughout the facility. The gas purifiers utilize a getter material comprised of pyrophoric solids. These getter materials are contained in sealed vessels within the purifier equipment. Previous agreements with the AHJ result in a sprinkler system design density of 0.30 gpm per square foot over an area of 2,500 square feet. The room is required to be contained in 2-hour fire-resistive construction. The sprinklers within the room are required to be high-temperature rated at 286°F. The sprinklers outside the room, but immediately adjacent to the 2-hour rated wall, are also required to be capable of providing the 0.30 gpm/sq. ft. design density.

Aqueous Chemical Room (F111021)

The Aqueous Chemical Room is used to store and dispense the following chemicals:

- Tetramethyl Ammonium Hydroxide (TMAH) – 25%
- Tetramethyl Ammonium Hydroxide (TMAH) – 2.38%
- Nitric Acid (HNO3) – 69%
- Citric Acid – 25%

The chemicals are stored in Intermediate Bulk Container (IBC) cabinets and 500 liter or 2,000 liter day tanks. Nitric acid is a Class 2 oxidizer and a corrosive liquid. NFPA 430, Table 6.4.1, requires a design density of 0.20 gpm/sq. ft. over a design area of 3,750 square feet for the bulk storage of a Class II oxidizer up to 8-feet.

TMAH is a Class II combustible liquid and presents a different hazard. NFPA 30, Table 16.4.1(a), requires sprinkler protection criteria in accordance with NFPA 13 for the storage of a Class III commodity. The ceiling sprinkler protection required is therefore 0.20 gpm/sq. ft. over an area of 1,500 square feet.

The protection criteria required by NFPA 430 yields a more conservative approach. The aqueous chemical room is approximately 2,400 square feet.

Solvent Room (F141211)

The Solvent Room is used for the storage and dispensing of the following flammable and combustible liquids:

- Isopropyl Alcohol (IPA) – 98%
- Tetraethylorthosilicate (TEOS)
- Ethyl Lactate (PGMEA) – 30%
- Ultrapure RER
- Developer

The IPA is stored in a 25,000 liter bulk storage tank. The other chemicals are stored in 2,000 liter day tanks. FM Datasheet 7-88 provides the criteria for the protection of an indoor storage tank room. The design criterion is 0.30 gpm/sq. ft. over the entire area of storage.

Outside the solvent room is a canopy for truck offloading of solvents. This canopy will be protected with a deluge sprinkler system providing a density of 0.30 gpm/sq. ft. over the entire canopy area.

Cold Storage Room (F141214)

Within the solvent room is a cold storage area for refrigerated storage of flammable and combustible liquids. The liquids are stored in bottles on shelving to a height of approximately 8 feet. The worst case design criteria will be 0.60 gpm/sq. ft. over the entire room, which is approximately 693 square feet. The room will be provided with dry pendent sprinklers being supplied from the overhead wet pipe sprinkler system.

Bottle Staging (F141212 / F141213)

Bottle Staging is used to store glass carboys of solvents on shelves. The protection requirement for glass bottle storage of flammable liquids is governed by IFC, Chapter 57 and FM DS 7-29. The worst case design criteria will be 0.60 gpm/sq. ft. over the entire room, which is approximately 492 square feet.

Acid/Base Small Pack (F111025)

The Acid and Base Small Pack room contains carboys and bottles of various chemicals including Class IB flammable liquids, corrosives, water reactives, and oxidizers. The storage shelves are required to be less than 6-feet in height and made of metal, in accordance with IFC, Section 5704.3.6.3. The Class IB flammable liquids present the most severe fire hazard present. Protection requirements for these chemicals will be in accordance with FM DS 7-29, Table 15, for water miscible liquids in non-metallic containers. The ceiling sprinkler protection criterion is 0.60 gpm/sq. ft. over the entire room.

Solvent Waste Room (F111402)

The Solvent Waste Room is used for the storage of chemicals that have gone through processing. The waste will be contained in rigid non-metallic IBCs and larger non-metallic storage vessels. The following chemicals will be present in the room:

- Isopropyl Alcohol (IPA) – 98%
- Ethyl Lactate (PGMEA) – 30%
- Acetone
- Sodium Hydroxide (NaOH) – 50%
- Sulfuric Acid (H_2SO_4) – 50%

The acetone and IPA present the most severe hazard. Storage of Class IB flammable liquids in containers greater than 5 gallons, when limited to a storage height equivalent to the height of one container, requires a sprinkler system with a density of 0.25 gpm per square foot over an area of 5,000 square feet (IFC, Table 5704.3.6.3(4)). NFPA 30 requires a density of 0.30 gpm per square foot for a design area of 3,000 square feet for the protection of relieving-style IBCs containing Class IB liquids (Table 16.5.2.2). Because the room is less than 3,000 square feet, the design density in accordance with NFPA 30 yields the more conservative protection criteria.

Waste Pit & Industrial Waste Treatment Room (F13019)

The Waste Pit and IWD Treatment area is used for the treatment and storage of industrial wastes. The chemicals are predominantly corrosives and toxics. IFC, Section 5004.5 requires an Ordinary Hazard Group 2 density over a 3,000 square foot area.

Hazardous Material Delivery Area (F13020)

The Hazardous Material Delivery Area, located at the northwest corner of the Fab, is a covered dock used to off-load the following chemicals from tanker trucks:

- Hydrofluoric Acid (HF) – 49%
- Hydrochloric Acid (HCl) – 36%
- Ammonium Hydroxide (NH4OH) – 29%
- Hydrogen Peroxide (H2O2) – 31%

Hydrogen peroxide presents the worst case and is classified as a Class 2 Oxidizer. NFPA 430, Table 6.4.1 recommends a design density based on indoor storage. The annex of NFPA 430 clarifies the hazard associated with storage of oxidizers. Oxidizers can increase the burning rate and cause spontaneous ignition of combustible materials. The offload dock is entirely of non-combustible construction and the storage of chemicals is transient in nature. Once the bulk transfer operation from the truck is completed, the chemicals are contained in bulk storage vessels within the building. The provisions of IFC, Section 5005.1.8 shall govern for the fire protection requirements. This outdoor canopy sprinkler system will have a design density of 0.20 gpm per square foot over the entire canopy (where it is less than 3,900 square feet).

Northeast Offload Dock (outside F111402)

The Northeast Offload Dock will be used for delivery of sodium hydroxide and sulfuric acid. The canopy over this truck station will be protected by an Ordinary Hazard Group 2 density over the entire canopy.

The most stringent requirement found in the applicable NFPA standard or Factory Mutual (FM) Datasheet was used to determine the sprinkler system design density. The rooms previously discussed in detail are summarized in Table 11 below.

Table 11. HPM Rooms & Design Densities

Room / Area (Room Number)	Density (gpm/sq. ft.)	Area of Operation (sq. ft.)	NFPA Reference	FM Datasheet
Bulk Aqueous Chemical Room (F11121)	0.20	3,000	NFPA 430, Section 5.3.2 (3)	7-84
Specialty Gas Dispensing (F111122)	0.25	3,000	NFPA 55, Section 6.9.2.2	7-50
Bulk Gas Purifier Room (F11821)	0.30	2,500	NFPA 13, Figure 11.2.3.1.1 / AM&M #12	-

Room / Area (Room Number)	Density (gpm/sq. ft.)	Area of Operation (sq. ft.)	NFPA Reference	FM Datasheet
Aqueous Chemical Room (F111021)	0.20	Entire Room (~2,400)	NFPA 430, Table 6.4.1	-
Solvent Room (F141211)	0.30	Entire Room (~3,250)	-	FM DS 7-88, Table 11.
Solvent Offloading (Deluge System)	0.30	Entire Area (<3,900)	NFPA 15, Section 7.3.3.2	FM DS 4-1N
Cold Storage (F141214)	0.60	Entire Room (~693)	-	FM DS 7-29, Table 15
Bottle Staging (F111212/F111213)	0.60	Entire Room (~442)	-	FM DS 7-29, Table 15
Acid/Base Small Pack (F111205)	0.60	Entire Room (~220)	-	FM DS 7-29, Table 15
Solvent Waste Room (F111402)	0.30	Entire Room (<3,000)	NFPA 30, Table 16.5.2.2	-
Waste Pit & IWD Treatment (F11011)	0.20	3,000	NFPA 13, Figure 11.2.3.1.1	-
Hazardous Material Delivery Area (F111301)	0.20	Entire Area (<3,900)	NFPA 13, Figure 11.2.3.1.1 and Section 11.2.3.2.5	-
NE Offload Dock (outside F111402)	0.20	Entire Area (<3,900)	NFPA 13, Figure 11.2.3.1.1 and Section 11.2.3.2.5	-

Engineering plans showing the different rooms and sprinkler density requirements throughout the facility are provided in Appendix C for reference.

6.1. Piping Layout

Fire protection plans are provided in Appendix D showing the detailed piping layout on Level 1 of the Fab for two specific zones. The zone containing the Solvent Storage Room and the zone containing the Solvent Offload Canopy are included for reference. The majority of the unique sprinkler requirements are contained on Level 1 with the presence of all the different hazards previously discussed in Table 4. Levels 2, 3, and 4 contain predominantly H-5 occupancies with Ordinary Hazard Group 2 sprinkler design throughout. For brevity, sprinkler system piping layouts for these floor levels are not provided, but are available for reference if necessary.

6.2. Hydraulic Calculations

Hydraulic calculations have been performed for two areas in the building. The worst-case sprinkler density inside the building is found within the Solvent Storage Room with a density of 0.30 gpm per square foot over the entire room (3,250 square feet). The worst case dry system (deluge) design is 0.30 gpm per square feet over the entire Solvent Offload Canopy (~3,900 square feet).

Due to the Solvent Storage Room being a gridded system, computer based calculations were performed using HASS software, provided in Appendix E. The supply versus demand curve is provided below in Figure 2.

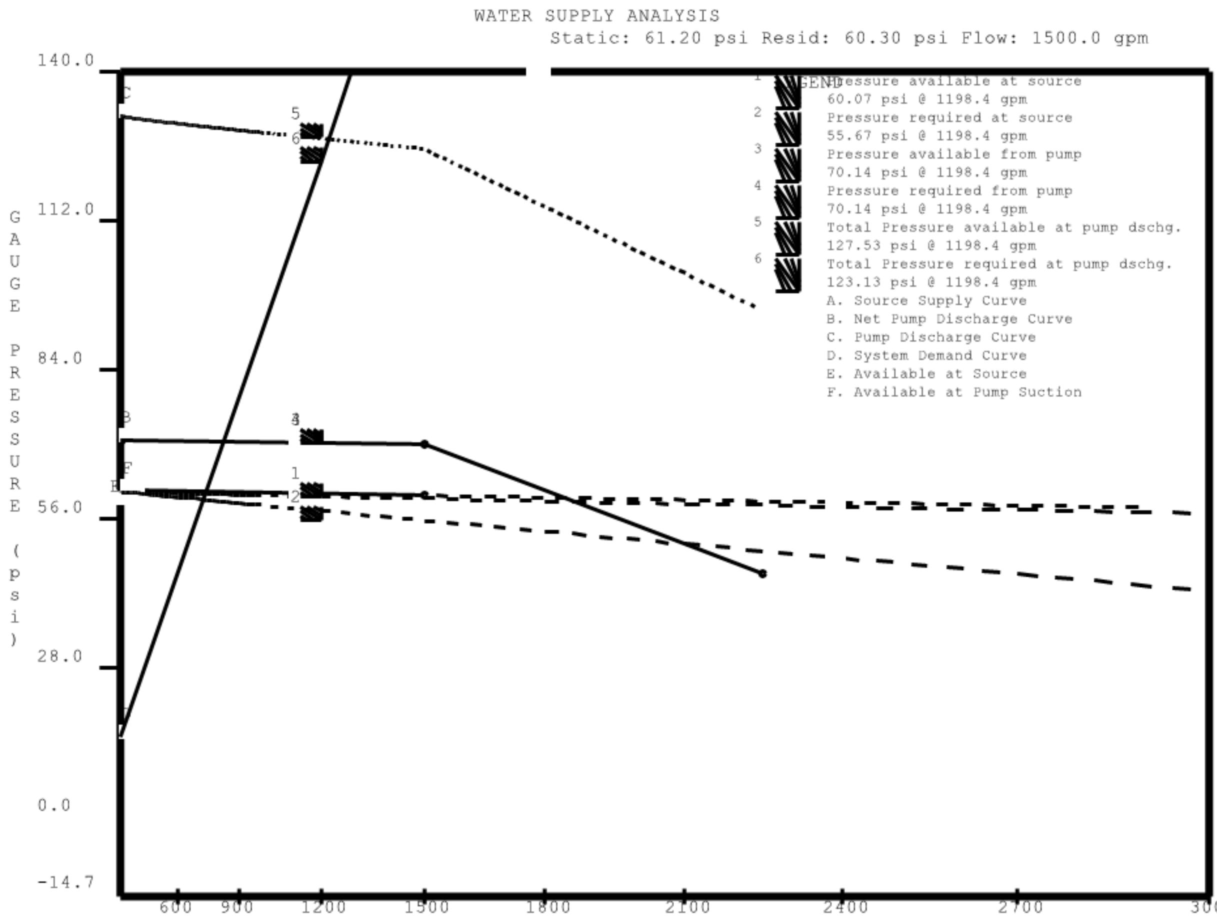

Figure 2. Solvent Storage Room Supply/Demand Curve

SPRINKLER SYSTEM HYDRAULIC ANALYSIS Page 3
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JOB TITLE: FPE S523 Project Report - Solvent Room

NFPA WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI)	@ FLOW (GPM)	AVAIL. PRESS. (PSI)	@ TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
SRC	61.2	60.3	1500.0	60.1	1698.4	55.7

Required pressure is 4.4 psi (7%) less than available pressure.

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	1698.4 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	500.0 GPM
OTHER HOSE STREAM ALLOWANCES	0.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	1198.4 GPM

Figure 3. Solvent Storage Room HASS Calculation Summary

The hydraulic calculation summary is provided above in Figure 3. The results of the HASS calculation show a 4.4 pound per square inch (psi) safety margin between the required pressure and the available pressure. This constitutes only a 7% margin; however, a 10% safety factor has already been applied to the water supply static and residual pressures.

For the Solvent Offload Canopy deluge sprinkler system, provided in Appendix F for reference, hand calculations were completed as shown in Figure 4, Figure 5, and Figure 6. The hand calculations show a system demand of 60.8 psi and 1,062.4 gpm at the source node (SRC). From the supply/demand curve in Figure 2, one can see that the available flow at 60 psi (± 1 psi) is approximately 1,200 gpm.

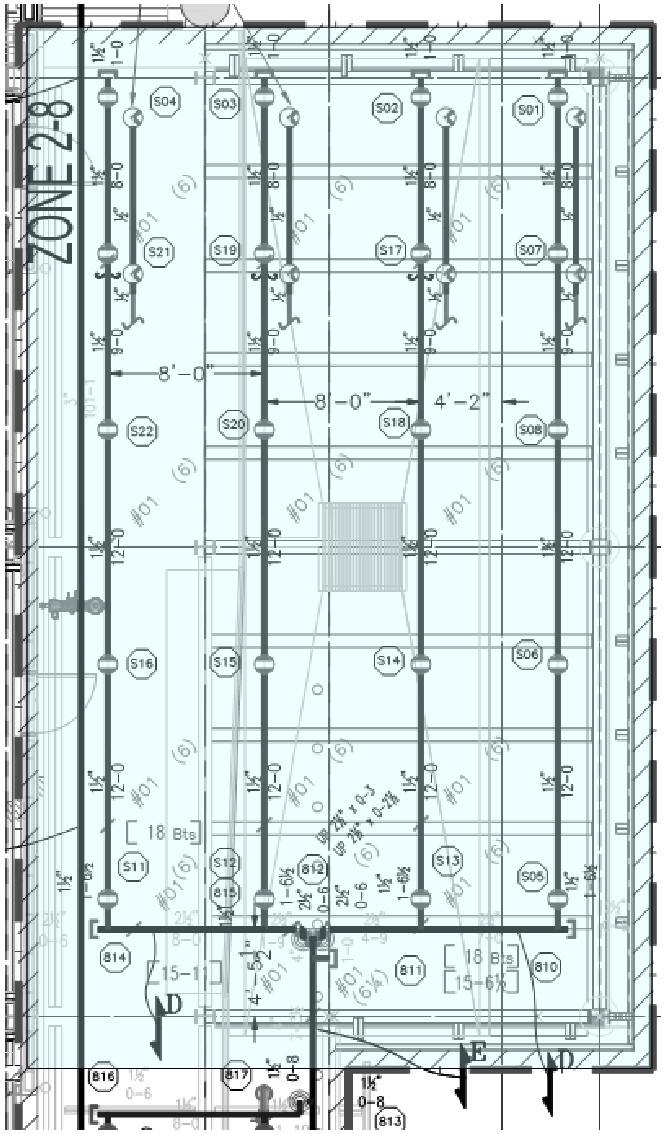

Figure 4. Solvent Offload Canopy Pipe Layout

NOZZLE IDENT. AND LOCATION	FLOW IN GPM	PIPE SIZE	PIPE FITTINGS AND DEVICES	EQUIV. PIPE LENGTH	FRICTION LOSS PSI/FT	PRESSURE SUMMARY	NORMAL PRESSURE	$P_f = \frac{4.52 Q^{1.85}}{c^{1.85} d^{4.87}}$ NOTES
501	q 25.2	1.610	–	L 8.0	C = 120	Pt 9.92	Pt	$P_f = (6.4 \times 10^{-4}) \frac{Q^{1.85}}{d^{4.87}}$
			–	F –	K = 8.0	Pe –	Pv	12 × 7 COVG AREA ON
	Q –		–	T 8.0	0.025	Pf 0.197	Pn	BL-1 0.30(84) = 25.2 GPM
507	q 25.45	1.610	–	L 9.0		Pt 10.12	Pt	$\frac{50.65^{1.85}}{10.17} = 139.980$
			–	F –		Pe –	Pv	
	Q 50.65		–	T 9.0	0.090	Pf 0.81	Pn	
508	q 26.44	1.610	–	L 12.0		Pt 10.93	Pt	
			–	F –	0.195	Pe	Pv	
	Q 77.1		–	T 12.0		Pf 2.34	Pn	
506	q 29.14	1.610	–	L 12.0		Pt 13.27	Pt	
			–	F –	0.353	Pe	Pv	
	Q 106.2		–	T 12.0		Pf 4.23	Pn	
505	q 33.5	1.610	–	L 1.54		Pt 17.5	Pt	$139.7 = K\sqrt{23.1}$
			T = 8	F 8.0	0.585	Pe –	Pv	BL-1 K = 29.1
	Q 139.7			T 9.54		Pf 5.58	Pn	
810	q –	2.469	–	L 7.0		Pt 23.1	Pt	9302.79
			–	F –	0.073	Pe –	Pv	
	Q 139.7		–	T 7.0		Pf 0.511	Pn	
811	q 141.4	2.469		L 4.75		Pt 23.61	Pt	$Q_{BL2} = 29.1\sqrt{23.61}$
			T = 12	F 12.0	0.266	Pe –	Pv	
	Q 281.1			T 16.75		Pf 4.46	Pn	81.57887
814	q 139.7	2.469	–	L 8.0		Pt 23.1	Pt	
			–	F –	0.073	Pe	Pv	
	Q –		–	T 8.0		Pf 0.584	Pn	
815	q 141.62	2.469		L 1.75		Pt 23.7	Pt	
			T = 8	F 8.0		Pe	Pv	
	Q 281.3			T 9.75		Pf	Pn	
812	q –	2.469		L 0.75		Pt 23.7	Pt	
			L = 4	F 4.0	0.96	Pe 0.325	Pv	
	Q 562.4			T 4.75		Pf 4.56	Pn	
TDEL	q –	4.026	4L = 16	L 48.83		Pt 28.6	Pt	$\frac{562.4^{1.85}}{882.54} = 138.63$
				F 16.0	0.088	Pe –	Pv	
	Q 562.4			T 64.83		Pf 5.75	Pn	
						Pt 34.4		

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Figure 5. Solvent Offload Canopy Calculations, Page 1

NOZZLE IDENT. AND LOCATION	FLOW IN GPM	PIPE SIZE	PIPE FITTINGS AND DEVICES	EQUIV. PIPE LENGTH	FRICTION LOSS PSI/FT	PRESSURE SUMMARY	NORMAL PRESSURE	NOTES
BDEL	q —	4.026	DELUGE VALVE	L 14.0	0.088	Pt 34.4	Pt	$\Delta P = Q^2/C_v^2 = 562.4^2/350^2$
			DV=21.0	F 12.0		Pe 6.062	Pv	$\Delta p = 9.214$
	Q 562.4		B=12	T 26.0		Pf 2.288	Pn	
AF17	q —	8.249	B=14.1	L 18.0	0.003	Pt 51.96	Pt	
			L=21.1	F 35.2		Pe 2.6	Pv	
	Q 562.4			T 53.2		Pf 0.14	Pn	$8.249^{4.87} = 29031.83$
UG17	q —	10.28	L=18.13	L 83.0	C=140 (DIP)	Pt 54.7	Pt	FTG FACTOR = 1.133
			G=5.66	F 80.43		Pe —	Pv	$140^{1.85} = \frac{4.52}{9339.8} = 4.8\times10^{-4}$
	Q 562.4		T=56.6	T 163.43	0.0006	Pf 0.113	Pn	$10.28^{4.87} = 84802.073$
UG11	(HOSE) q 500	11.65	6(45)=69	L 653.0	C=140	Pt 54.8	Pt	FTG FACTOR = 0.888
			T=53.3	F 146.5	0.00122	Pe —	Pv	
	Q 1062.4		E=24	T 799.5		Pf 0.976	Pn	$11.65^{4.87} = 155957.86$
UG2	q —	11.65	4(45)=46.2	L 420	C=140	Pt 55.78	Pt	
			T=53.3	F 115.5	0.00122	Pe —	Pv	
	Q 1062.4		3G=16	T 535.5		Pf 0.654	Pn	
UG3	q —	11.65	G=5.3	L 1025	C=140	Pt 56.4	Pt	
			T=53.3	F 58.6	0.00122	Pe —	Pv	
	Q 1062.4			T 1083.6		Pf 1.32	Pn	
UG4	q —	11.65	G=5.3	L 95.0	C=140	Pt 57.7	Pt	
			45=11.6	F 32.8	0.00122	Pe —	Pv	
	Q 1062.4		L=16	T 127.8		Pf 0.156	Pn	
FAF4	q —	10.02	T=50	L 20.0	C=120	Pt 57.86	Pt	6.4×10^{-4} (C=120)
			L=16 G=5	F 126.0	0.0034	Pe —	Pv	
	Q 1062.4		C=55	T 146.0		Pf 0.5	Pn	$10.02^{4.87} = 74855.86$
FAF0	q —	10.28	2E=49.8	L 1000.0	C=140	Pt 58.4	Pt	FTG FACTOR = 1.133
			2(45)=24.9	F 86.03	0.0022	Pe —	Pv	
	Q 1062.4		2G=11.3	T 1086.		Pf 2.44	Pn	
SRC	q —			L		Pt 60.84	Pt	
				F		Pe	Pv	
	Q 1062.4			T		Pf	Pn	
	q			L		Pt	Pt	
				F		Pe	Pv	
	Q			T		Pf	Pn	
						Pt		

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Figure 6. Solvent Offload Canopy Calculations, Page 2

6.3. Inspection, Testing, & Maintenance

The inspection, testing, and maintenance requirements are governed by IFC, Section 901.6 which references NFPA 25. The standard recommends inspection frequency and testing intervals for the various components in both the wet pipe and dry pipe systems. A summary of some of the test and maintenance requirements for various system components is presented in Table 12 below.

Table 12. Fire Sprinkler Inspection, Testing, Maintenance Requirements

System Component	Inspection	Testing	Maintenance
Sprinklers	Annually (5.2.1)	20 years (fast response) 50 years (standard response)	As Needed.
Riser Check Valves - Gauges	Monthly Weekly/monthly	Annually 5 years (13.2.7.2)	As Needed.
Dry Valves - Enclosure - Interior - Gauges	Monthly Daily/Weekly (during cold weather) Annually Weekly/monthly	3 years (full trip test) n/a n/a 5 years (13.2.7.2)	Annually (13.4.4.3)
Deluge Valve - Enclosure - Interior - Gauges	Monthly Daily/Weekly (during cold weather) Annually Weekly/monthly	3 years (full trip test) n/a n/a 5 years (13.2.7.2)	Annually (13.4.3.3.2)
Switches - Pressure switch - Low-air supervisory	 Quarterly Quarterly	 Annually (during trip test) Quarterly	As needed.
Low-Point Drains (Drum Drips)	Daily during the start of cold weather and decreasing frequency with less and less water accumulation.	Annually – during trip test.	As needed.

The building is equipped throughout with an automatic sprinkler system, Class I automatic wet standpipes, and portable fire extinguishers. The previous sections describe each of these fire protection features showing code compliance in accordance with the more stringent requirements of NFPA or FM Global. The building also contains fire and smoke detection systems capable of providing an earlier warning to building occupants. The fire detection and alarm systems are presented in the following Section 7.

7. Fire Alarm System

The ACME Semiconductor Fab Expansion is protected by numerous detection systems, some standard sensitivity smoke detection, but many are early warning, highly sensitive systems. Being a semiconductor fab, the occupancy is at high risk in terms of lost product and business interruption if smoke particulates are ever created or migrate into the cleanroom portion of the facility.

The fire alarm system consists of an emergency voice alarm communication (EVAC) system produced by Simplex. A model 4100ES network annunciator panel with voice command center (NDU-VCC) is located in the Security Emergency Response (SER) room. Separate fire alarm control panels (FACP) are located in each of the Life Safety Systems (LSS) rooms throughout the building. A network one-line diagram is provided on sheet F-FA-200 in the drawings provided in Appendix G.

A manual fire alarm system is required in accordance with IBC Section 907.2.5. Sprinkler system supervision and monitoring is also provided in accordance with IBC Section 903.4. Occupant notification is provided throughout the building by wall mounted speaker/strobes and ceiling mounted speaker/strobes within the cleanroom.

7.1. Fire & Smoke Detection Devices

Smoke detection is provided on each air handling unit by duct mounted smoke detectors to facilitate AHU shutdown. Early warning smoke detection (EWSD) is provided in the return air chases associated with the cleanroom to facilitate advanced detection of a fire event. Cleanrooms are particularly susceptible to smoke damage and the use of EWSD provides a means to mitigate this potential damage. Fire detection is provided throughout via water-based fire sprinkler systems and within flammable liquid and gas rooms via ultraviolet / infrared (UV/IR) detection.

Smoke control, in accordance with IBC Section 909, is not required in this building. As the highest occupied floor level is less than 75-feet above the fire department vehicle access elevation, the building is not classified as a high-rise. The building is completely above grade and therefore not subject to the underground building provisions which would also require smoke control. As an active smoke control system is not provided, the only means to prevent the migration of smoke is through the use of passive barriers as described previously in Section 5.

7.2. Analysis of Fire Detector Response

Fire Scenario – Solvent Waste tank rupture and ignition of ethanol pool: An aboveground ethanol tank is centrally located in the Solvent Waste room, represented in Figure 7, and is surrounded by a 6-inch tall concrete containment curb to provide hazardous material spill containment in accordance with IFC 5004.2.

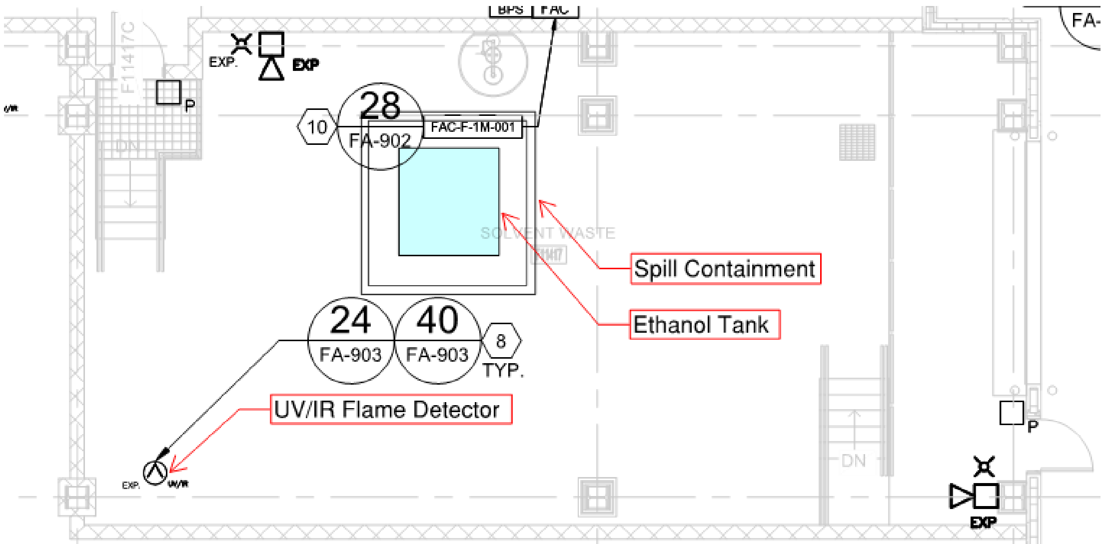

Figure 7. Solvent Waste Room

The scenario includes a leak from the bottom of the tank and subsequent ignition of the liquid pool. The pool was modeled with an initial radius of 5 inches and an assumed spread rate of 3% per second. At approximately 87 seconds the pool has filled the containment basin and thus reached its peak heat release rate (HRR) based on the following equation:

$$Q = \dot{m}'' A \Delta H_C$$

Where:

Q = heat release rate (kW)

$\dot{m}''$ = ideal mass loss rate (g / m²-s)

A = area of pool fire (m²)

ΔH_C = net heat of combustion (kJ/g)

As the pool reaches the maximum area (the containment basin), the peak HRR is 5,672 kW, as shown in Figure 8. A three-dimensional representation of the solvent waste room, shown in Figure 9, provides clarification of the arrangement of the vertical storage tank, containment basin, and proximity of the pool fire to the UV/IR detector.

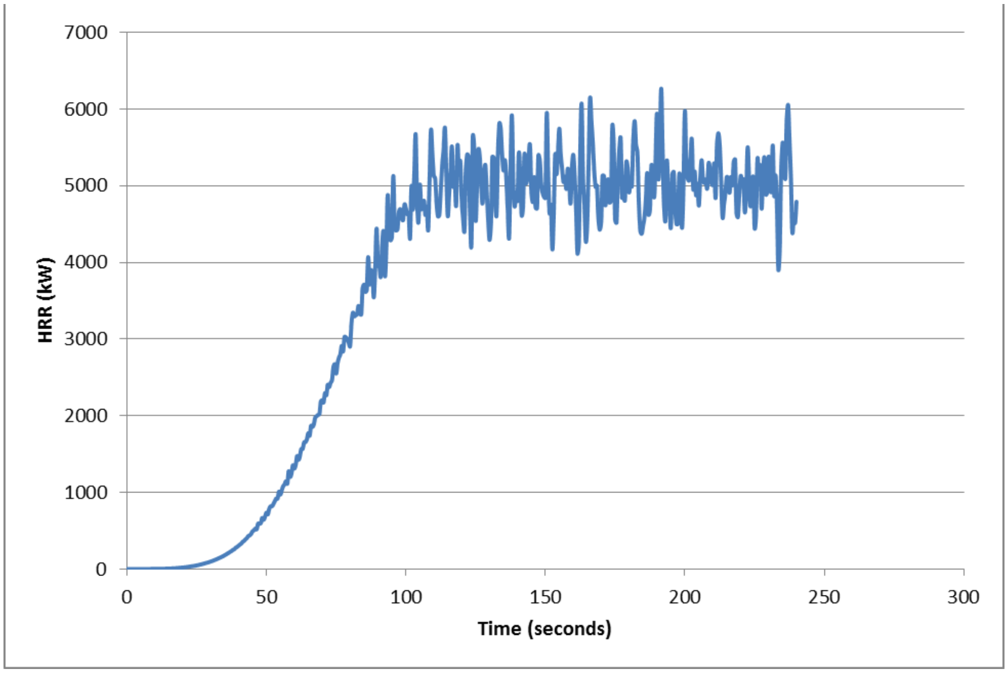

Figure 8. Fire Scenario 1 Heat Release Rate

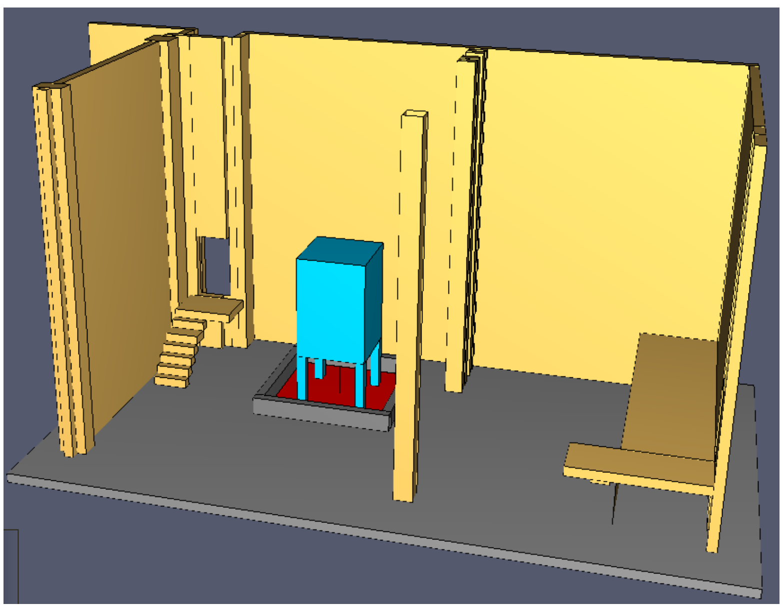

Figure 9. Solvent Room Three-Dimensional Representation

Sprinkler system as-built drawings were utilized to evaluate sprinkler system spacing and detection times under the proposed design fire. Both the DETACT model and Fire Dynamics Simulator (FDS) were used to evaluate the response time of SPRK14, as shown below in Figure 10. SPRK14 is the furthest adjacent sprinkler from the fire origin at a radial distance of 8 feet 1 inch. SPRK14 was modeled as a standard response, high-temperature rated sprinkler with a Response Time Index (RTI) of 100 m-s½ and activation temperature of 141°C (286°F).

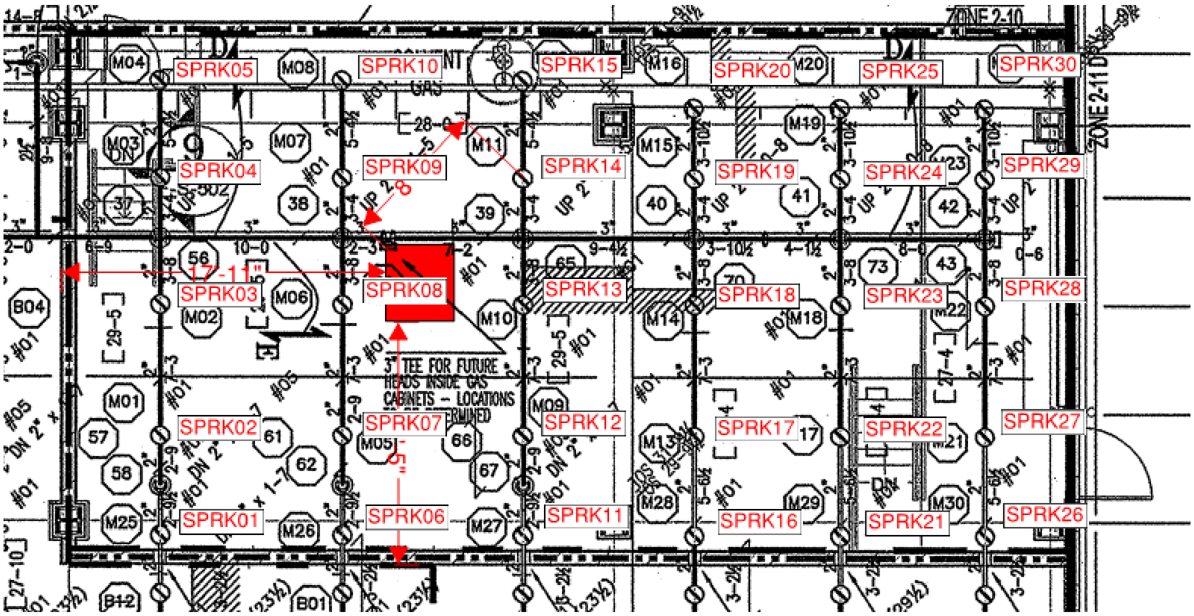

Figure 10. Solvent Room Sprinkler As-Builts

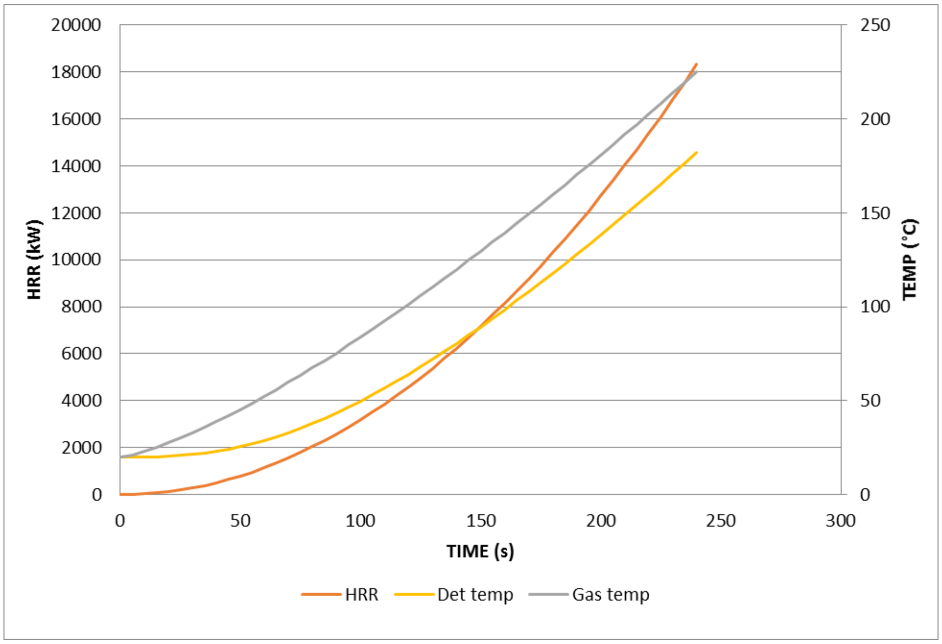

Figure 11. DETACT Graphical Results

The input and numerical calculations of the DETACT spreadsheet are presented in Appendix H. A sprinkler with radial distance of 8 feet 1 inch reaches the activation temperature at 205 seconds and with an HRR of over 13 MW when using the DETACT model. This model is limited to utilizing a t^2 fire curve. When modeled in FDS, the HRR was given a RAMP function and radial spread rate to more appropriately model a flammable liquid pool fire. The RAMP function was based on the peak HRR as a function of the surface area of the pool fire. Under this fire curve the sprinkler activation time was 185 seconds with an HRR of 4.4 MW, shown in Figure 12.

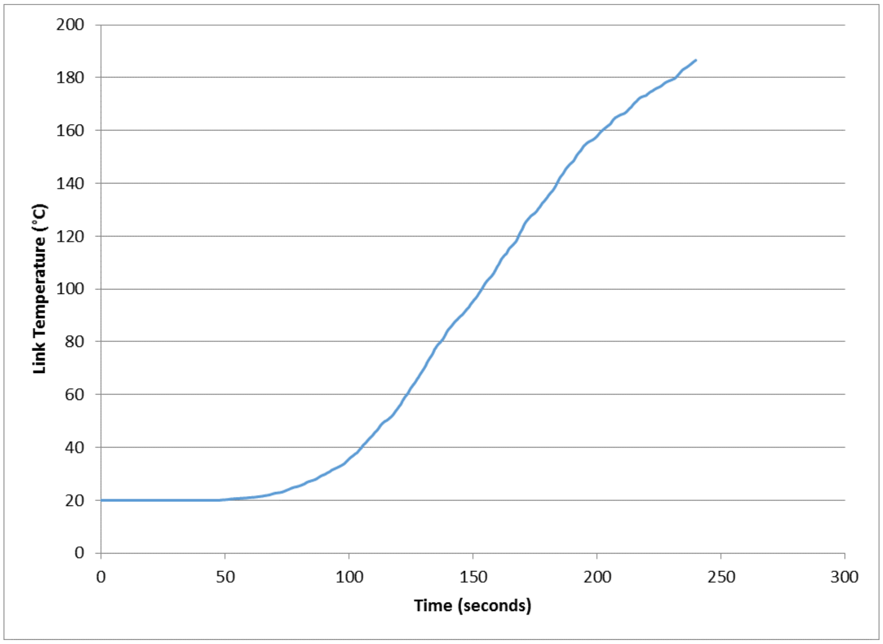

Figure 12. FDS SPRK14 Results

This sort of detector response time would not be adequate for the protection of this flammable liquid storage room. Alternative detection in the form of UV/IR flame detectors could provide much quicker response times to aid in occupant evacuation or firefighting efforts.

The UV/IR flame detector is located in the southwest corner of the Solvent Waste room as shown in Figure 7. The detector is situated a radial distance of 11.3 meters from the assumed point source of the design fire. Manufacturer datasheet information, provided in Figure 13, for a similar radiant-energy sensing detector shows the device to be listed for detection of a 1 ft^2 ethanol pool fire in 5.7 seconds at a distance of 18.3 meters.

Response Testing

Fuel	Size	Distance (ft/m)	Average Response Time (Seconds)
n-Heptane	1' x 1'	140/42.7	10.6
Methanol	1' x 1'	40/12.2	9.7
Methane	36" Plume	100/30.5	5.9
Propane	16" Plume	35/10.6	4.0
Jet Fuel	1' x 1'	90/27.4	4.7
Diesel	1' x 1'	80/24.4	5.1
Lube Oil	1' x 1'	50/15.2	6.7
Ethanol	1' x 1'	60/18.3	5.7
Gasoline	1' x 1'	120/36.6	5.9

NOTE: The response time is based on zero time delay and maximum sensitivity.

Figure 13. UV/IR Detector Datasheet excerpt

7.1. Alarm, Supervisory, & Trouble Signal Disposition

The fire alarm system is a protected premises system and is required to provide signal disposition to a listed central station. The disposition of signals is defined within the system Sequence of Operation found on sheet F-FA-800 in the drawings located in Appendix G.

7.2. Alarm Notification Appliances

The in-building emergency voice alarm communication (EVAC) system is required to utilize speakers to automatically transmit alarm signals and voice messages to building occupants. The voice message is preceded by a distinctive signaling tone of the temporal three pattern common to fire alarm signals in buildings equipped with a horn system.

Visual notification is also required in common and public areas or in areas where employees may be hearing impaired. It is common to see visual coverage provided throughout a building where the state of an employee's hearing capabilities may not be known. In this industrial occupancy, equipment noise levels could be sufficient to warrant visual coverage to ensure all occupants are aware of the alarm condition.

7.3. Notification Spacing Requirements

Spacing of notification appliances is based on the ability of a device to achieve the necessary sound pressure levels (SPL) throughout the building and for visual devices to achieve the required light intensity to all areas. Wall-mounted speaker/strobe devices are spaced according to the candela rating of the strobes. Where acoustical characteristics of a building space prevent the strobe spacing from providing adequate audible coverage, additional speakers can be installed at intermediate points between speaker/strobe devices.

Wall mounted speaker/strobes in this facility are typically rated for 110 candela output and are tapped for 1 Watt. Visual coverage for wall mounted strobes set to 110 cd is adequate for an area 54 feet by 54 feet (NFPA 72, Table 18.5.5.4.1(a)).

Audible coverage with speakers tapped at 1 Watt will ensure a minimum of 15 decibels (dB) above the average ambient SPL is provided. The manufacturer datasheet for the Simplex 4906 wall-mount speaker/strobe, provided in Figure 14, shows the device to be listed for 83 dBA output at 10 feet from the device. Although this is an industrial occupancy (manufacturing), the majority of the building will be cleanroom space which acts more like a business occupancy (NFPA 72, Table A.18.4.3). In areas with ambient SPL at or above 80 dB (industrial use), increased speaker output or additional speakers are required to achieve the minimum dB differential.

		Wattage Tap	¼ W	½ W	1 W	2 W
Speaker Output Ratings @ 10 ft (3 m) (see Note 1 below)	UL Listed Models, Reverberant Chamber Test, per UL 1480		76 dBA	79 dBA	82 dBA	85 dBA
	Wall Mount Models **4906-9151** and **4906-9153**, Anechoic Chamber Test, per ULC-S541		77 dBA	80 dBA	83 dBA	86 dBA*
	Ceiling Mount Model **4906-9157**, per ULC-S541	25 VRMS Input	81.6 dBA	84.3 dBA	87.1 dBA*	89.7 dBA*
		70.7 VRMS Input	80.9 dBA	84.1 dBA	87.3 dBA*	90.2 dBA*

Figure 14. Speaker/Strobe Datasheet excerpt

Audible and visual coverage has been provided throughout the building which is compliant with the notification requirements of the IBC and IFC.

7.4. Mass Notification

Mass notification is not provided. The building is equipped with an EVAC system which provides voice messages preceded by a temporal three signal.

7.5. Voltage Drop & Battery Calculations

One typical visual notification circuit has been calculated for voltage drop to ensure the system operates as intended during an alarm condition. Voltage drop calculations are provided in Appendix I and one power supply battery calculation is provided in Appendix J. Battery calculations assumed 30 speakers tapped at 1 W per amplifier which yielded an alarm current of 7.2 Amps (for a 24 Volt audio circuit). Under these conditions, with the alarm current for additional initiation devices, the battery capacity is required to be 10 amp-hours.

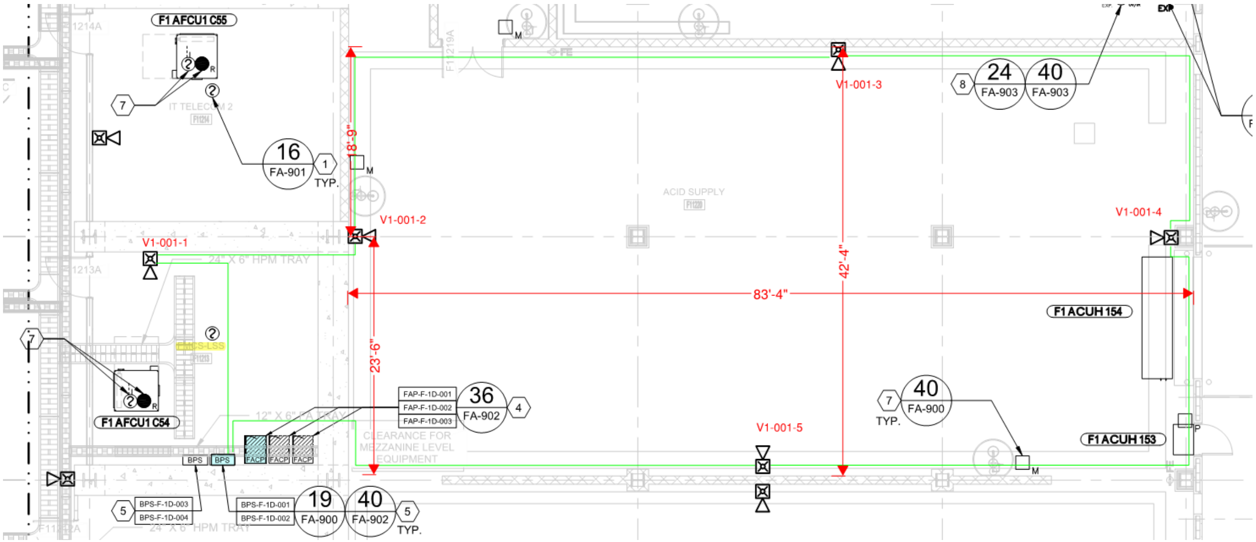

Figure 15. Typical Notification Circuit – Plan View

The notification circuit shown in Figure 15 consists of five wall-mounted speaker/strobe appliances with Class A wiring (NFPA 72, 12.3.1) which allows for operational capability past a single open circuit condition, and a single fault condition will annunciate a trouble signal at the panel. Voltage drop calculations are provided for this circuit in Appendix I. The visual strobe appliances are spaced on opposite walls with listed coverage areas of 54 feet. The room, in Figure 15, is approximately 83 feet in width. The room could be covered by just these two devices; however, floor-mounted equipment and other visual obstructions may prevent an adequate light intensity from being measured in all areas of the room. Additional devices are provided on the north and south walls of the room to account for these visual obstructions.

7.6. Inspection, Testing, & Maintenance

The inspection, testing, and maintenance requirements are governed by IFC, Section 907.8 which references NFPA 72. The standard recommends inspection frequency and testing intervals for the various components in both the fire alarm and communication systems. A summary of some of the test and maintenance requirements for various system components is presented in Table 13 below.

Table 13. Inspection, Testing, Maintenance Requirements

System Component	Inspection	Testing	Maintenance
Fire Alarm Control Unit	Visual inspection annually to verify a system normal condition where the system is monitored for alarm, supervisory, and trouble signals.	Annually	As Needed.
Batteries	Visually inspected monthly (where lead-acid type).	Load voltage test semiannually.	Replacement intervals of 5 years or as

			directed by the manufacturer.
Initiating Devices - Air Sampling - Duct Detectors - Manual Pull Stations - Flame Detectors - Smoke Detectors	Visual inspections to verify cleanliness, free of obstructions. Semiannually Semiannually Semiannually Quarterly Semiannually	Test devices annually. Flame detectors to be tested semiannually.	Per manufacturer's instructions (14.5.1)
Notification Appliances - Audible - Visual	Visually inspect for location/condition Semiannually Semiannually (verify candela rating)	Annually test	As Needed.

8. Means of Egress

The ACME Semiconductor Fab Expansion contains 6 enclosed exit stairs with Level 1 exhibiting 14 exterior exit openings. Two horizontal exits are provided from the expansion building into the existing Fab building at Levels 1 and Level 3. Three of the stairs discharge directly to the exterior of the building at grade level and the remaining three discharges to interior exit passageways. The exit passageways are constructed as 2-hour fire resistance rated corridors that discharge directly to the exterior of the building at grade level.

8.1. Occupancy Classification

The ACME Semiconductor Fab Expansion will contain multiple separated uses. Table 14 provides the occupancy classification of the multiple occupancies within the building as defined in both the IBC and the Life Safety Code (LSC):

Table 14. Building Occupancies

Description of Use	IBC Occupancy Classification	LSC Occupancy Classification
Fabrication Areas	Semiconductor (Group H-5)	Special-Purpose Industrial
Flammable Liquid Storage	High Hazard (Group H-2)	High Hazard Industrial
Hazardous Material Storage	High Hazard (Group H-3)	High Hazard Industrial
Corrosive/Oxidizer Storage	High Hazard (Group H-4)	High Hazard Industrial
Mechanical & Electrical Rooms	Factory (Group F-1)	General Industrial

8.2. Exit Capacity and Travel Distances

Life safety plans are provided in Appendix K defining the locations for each exit and the exit widths provided. Maximum exit access travel distances (MTD) are shown on the plans. Exit access and exit components are indicated by a blue tag as shown in Figure 16 below:

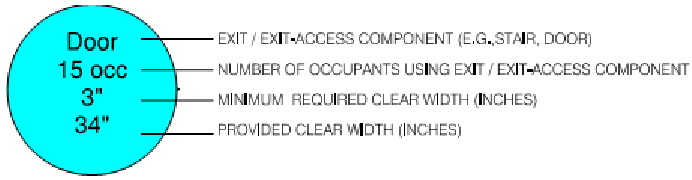

Figure 16. Exit component information tag

Minimum required exit widths were determined using Table 15 (Table 7.3.3.1 in the Life Safety Code), for buildings with High-hazard contents:

Table 15. Exit component capacity factors (Table 7.3.3.1 of the LSC)

Use Area	Stairways	Level Components & Ramps
Board and Care	0.4 in. / person	0.2 in. / person
Health Care, sprinklered	0.3 in. / person	0.2 in. / person
Health Care, unsprinklered	0.6 in. / person	0.5 in. / person
High hazard contents	0.7 in. / person	0.4 in. / person
All others	0.3 in. / person	0.2 in. / person

Where exit capacities are less than the minimum required width for a particular exit component, the minimum width is provided with the blue exit tag, for example, doors are required to be a minimum of 32 inches in clear width (LSC, 7.2.1.2.3.2) regardless of the exit load utilizing the door and stairs are required to be a minimum of 44 inches in clear width (LSC, 7.2.2.2.1.2). The total number of occupants and required exit width are presented for each floor level in Table 16.

Table 16. Occupant Loads and Required Exits (Doors)

Floor Level (Floor Name) (Elevation above grade)	No. of Occupants	No. of Exits Required	No. of Exits Provided	Exit Width Required	Exit Width Provided**
Level 1 (Subfab) (0'-0")	659	3	14	263.6"	476"
Level 1-M (Equip. Platform) (13'-0")	312				
Level 2 (Mechanical Mezzanines) (17'-4")	117				
Level 1-M & Level 2 converge	429	2	4	171.6"	**136"**
Level 3 (Cleanroom) (32'-4")	703	3	8	281.2"	**352"**
Level 4 (Interstitial catwalks) (60'-2")	152	2	4	60.8"	136"
TOTAL	**1,918**				

**The exit width provided from the converging occupant loads of the Equipment Platform and Mechanical Mezzanine does not meet the minimum clear width required in accordance with the LSC. The exit width provided from Level 3 does not meet the minimum clear width required in accordance with the LSC. If the building were designed in accordance with the IBC, the required clear width for Levels 2 and 3 would be 85.8 inches and 140.2 inches, respectively, and an adequate exit width would be provided. The Life Safety Plans in Appendix K identify areas of non-compliance for both door widths and stair widths with exit access component tags outlined in a red cloud.

Where more than two exits are required, at least two of the exits are required to be separated by not less than one-third of the maximum diagonal dimension of the floor or space that the exits serve (LSC, 7.5.1.3.3). The diagonal dimension of each floor is approximately 612'-2". At least two of the exits are separated by more than 317 feet which complies with the exit remoteness requirements of the LSC. One space or area contains an occupant load greater than 50 requiring remoteness of exits. On Level 3, the east side Fan Deck has an occupant load of 80. The maximum overall diagonal dimension of the space is shown to be approximately 302 feet. The two exits serving the space are separated by more than 150 feet which is compliant with the LSC requirement.

8.3. Exit Signs

1. The following is a summary of the required exit sign locations and luminance levels within the building in accordance with the LSC, Section 7.10.1.5. Exits and exit access doors will be marked by an approved exit sign readily visible from any direction of egress travel. Access to exits will be marked by readily visible exit signs in cases where the exit or the path of egress travel is not immediately visible to the occupants. Exit sign placement will be such that no point in an exit access corridor is more than 100 feet, or the listed viewing distance for the sign, whichever is less, from the nearest visible exit sign. Exit signs are not required in rooms or areas that require only one (1) exit or exit access.

2. Exit signs will be internally illuminated (LSC, 7.10.5.2.1).

3. Electrically powered, self-luminous and photoluminescent exit signs are required to be listed and labeled in accordance with UL 924 and be installed in accordance with the manufacturer's instructions (LSC, 7.10.7.2).

Exit signs are adequately provided throughout the building at each required exit and properly identifying exit access routes along the path of egress.

8.4. Calculated Egress Times

The egress capacity of the building is compliant with IBC; however, it is non-compliant with the LSC. If the building were subject to the provisions of the LSC the reduced egress capacity could be evaluated using a performance based approach. This report presents some of initial study required to conduct that performance based analysis; determining the required safe egress time (RSET) and establishing the tenability criteria. A further study is required to evaluate the RSET and tenability criteria to the anticipated fire and toxic gas exposures under credible fire scenario.

The calculated egress time includes several time components. The alarm time, pre-movement time, and evacuation time are as defined in the paragraphs below.

Alarm Time (t_d+t_a)

The alarm time is the elapsed time from fire ignition to activation of the occupant notification system. The Semiconductor manufacturing environment requires an extreme level of cleanliness. As part of this, any trace amounts of smoke could be detrimental to the manufacturing process and Very Early Warning Aspirating Smoke Detection is employed throughout the facility. As the spaces are relatively open, early detection of a fire condition is assumed to be either through visual observation of the rising smoke or burning smell, or by aspirating smoke detector activation. The sensitivity of the early warning detector could be as much as 5,000 times more sensitive than conventional smoke detectors. The response time of the detection system is assumed to be no more than 10 seconds after ignition. NFPA 72 Section 10.12 permits a maximum of 10 seconds delay between activation of an initiating device and actuation of the alarm notification devices. A total delay of 20 seconds is used in the analysis to represent the fire detection and the occupant notification delay.

$t_d + t_a$ = 20 seconds

Pre-Movement Time (t_o+t_i)

The pre-movement time varies widely in different emergency scenarios. Upon receiving initial information of a fire situation, occupants may decide on several courses of action. The key factors that affect the pre-movement time are: 1) occupant notification system; 2) the alertness of the people; 3) mobility of the people; 4) if the individuals are alone; 5) focal point; and 6) familiarity to the surroundings. Occupants who receive more cues about the emergency spend less pre-movement time. According to Table 3-12.2 in the SFPE Handbook, t_o+t_i is generally less than 1 minute for a three-story department store, which is being used here for comparison. This building could be deemed similar to the large open floor plan of a department store with mostly alert occupants and trained staff to aid in evacuation initiation.

During an event, the building is assumed to be well occupied. The occupants are focused and alert. As the majority of the building is a wide open space, a fire condition can be detected by visual observation of the rising dark smoke or the evacuation behavior of other occupants near the fire origin. Personal belongings brought to individual workspaces by the occupants are considered limited while the majority of the occupants are required to be in cleanroom smocks and booties attending to different processes. As trained staff, the Emergency Response Team (ERT) will be onsite and present during normal business hours for assistance, the egress process can be via live directions. Therefore, using a maximum 1-minute pre-movement delay is considered appropriate.

$t_o + t_i$ = 1 minute

Evacuation Time t_e

The evacuation time is determined by employing the hydraulic model for assessing emergency movement (SFPE, 3-13). The time for evacuation includes two components, the travel time and the time spent in congestion. The time spent in congestion is controlled by the flow characteristics of the egress components.

Egress components have a nominal width, shown on the Life Safety Plans in Appendix K, and an effective width, We. The effective width is the usable width of a particular component. Occupants maintain a boundary layer between themselves and other occupants or other objects (railings, walls, doors). Where handrails protrude less than 2.5 inches, the boundary layer required for the stair clear width

governs the determination of effective clear width. This building is provided with 50 inch nominal width stairs so the W_e is 38 inches or 3.17 feet.

The flow of occupants passing through a particular egress component (door or stair) is dependent on the population density utilizing the component and the effective width. The population density, D, is the density of the occupants queueing at the exit, not the overall density of the floor or area of the building. This building has ample space for occupants to queue but the empirical equations don't correlate well below a density of 0.05 occupants per square foot. A factor of 0.06 occupants per square foot is used here to determine the specific flow and passage speeds of occupants. The specific flow, Fs is determined as follows:

$$F_s = k\,(D - aD^2)$$

For doors, k = 275 and Fs = 13.7 occupants per minute per foot of effective width. For the purposes of these calculations, all doors have a nominal width of 36 inches and effective width of 24 inches, or 2 feet. The calculated flow through a door, Fc, is equal to the specific flow multiplied by the effective width. For these calculations, doors will all have a calculated flow of 27.4 occupants per minute.

For level travel with unimpeded egress paths, the maximum walking speed utilized here is 235 feet per minute. For travel on vertical exit components the following equation is used to determine travel speeds:

$$S = k - akD, \text{ where:}$$

S = speed along the line of travel
D = population density (persons per square foot)
k = constant (212 for 7 by 11 stair treads and risers)
a = 2.86

The assumed travel speed in the stairs is 175.6 feet per minute.

The specific flow of the stairs is assumed to be the maximum specific flow of a stair, 18.5 occupants per minute per foot of effective width (SFPE, Table 3-13.5). All of the stairs are assumed to have a nominal width of 50 inches and an effective width of 38 inches, or 3.17 feet. The maximum calculated flow for any of the stairs is equal to the specific flow multiplied by the effective width, 58.58 occupants per minute.

As is shown on the Life Safety Plans in Appendix K, the worst-case exit access travel distances and occupant load utilizing a single exit, for each floor level are shown in Table 17 as follows:

Table 17. Worst-case exit travel distance and occupant load usage

Floor Level (Floor Name)	Total No. of Occupants	Occupants using a single exit	Travel Distance
Level 1 (Subfab)	659	80	211'-3"
Level 1-M & Level 2	429	124	231'-11"
Level 3 (Cleanroom)	703	86	215'-11"
Level 4 (Interstitial catwalks)	152	47	208'-2"
TOTAL	**1,918**		

The evacuation time, t_e, from each floor is broken down into several components:

t_{TRAV} = time to reach an exit, travelling across the floor level

$t_{p,Door}$ = time in passage through the exit door leading into the stair

$t_{TRAV,Stair}$ = time to travel down the stair unimpeded to the exit passageway at Level 1

$t_{p,Stair}$ = time in passage down the stair with other occupants

Using the speed and calculated flows discussed above, the evacuation times for each floor level are presented below in Table 18.

Table 18. Floor Level Evacuation Times (minutes)

Floor Level (Floor Name)	t_{TRAV}	$t_{p,Door}$	$t_{TRAV,Stair}$	$t_{p,Stair}$	t_e
Level 1 (Subfab)	0.9	2.9	0.1	n/a	3.9
Level 1-M & Level 2	1.0	4.5	0.5	2.1	8.1
Level 3 (Cleanroom)	0.9	3.1	0.7	1.5	6.2
Level 4 (Interstitial catwalks)	0.9	1.7	1.2	0.8	4.6

The total Required Safe Egress Time (RSET), graphically represented in Figure 17, is the summation of each egress time component, presented in Table 19.

Table 19. Floor Level RSET

Floor Level (Floor Name)	t_d (sec)	t_a (sec)	$t_o + t_i$ (sec)	t_e (sec)	RSET (sec)
Level 1 (Subfab)	10	10	60	234	314
Level 1-M & Level 2	10	10	60	486	566
Level 3 (Cleanroom)	10	10	60	372	452
Level 4 (Interstitial catwalks)	10	10	60	276	356

The available safe egress time is prescriptively taken to be 1.5 times the RSET. For this performance-based egress study, the Available Safe Egress Time (ASET) would be required to meet 14.2 minutes or 849 seconds.

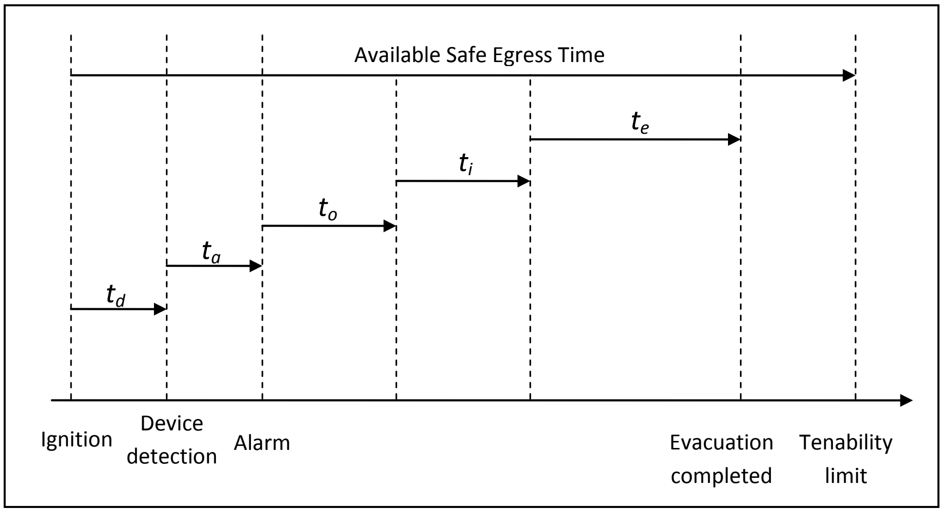

Figure 17. Graphical representation of RSET

8.5. Computer Egress Model

A computer-based egress model of the building was prepared for comparison with the hand based calculations and prescriptive code requirements. The model was completed using Pathfinder modeling software, 2015 Edition.

Simulations using the maximum occupant loading of the building yield a total egress time of 440 seconds. The total egress time of 440 seconds is the time for all the occupants of the building to reach the 2-hour fire-rated egress passageways on Level 1 of the building. The computer based model overpredicts the occupants rapid egress from the floors. One aspect of this overprediction is the lack of obstructions to occupants' egress. Within this building, large pieces of equipment are going to be installed throughout, making occupants choose more rectilinear routes to the exits. Through the simulation many of the occupants choose direct routes to an exit when those paths would realistically require numerous right angle turns.

The computer model assumes the same average walking speed for all occupants, by default this value is 235 feet per minute. The population density for queueing can be adjusted and was set to a minimum value of 0.06 persons per square foot, however the model allows for a maximum value as well which is set to 0.30 persons per square foot. This allows for more dense queuing and faster passage times.

Further refinement of the computer model, for example altering the numerous occupant characteristics and inclusion of building equipment, would provide a more accurate and potentially more conservative estimate of the total evacuation time.

8.6. Tenability Analysis

The ASET is determined by use of a fire model or other engineering analysis to evaluate when conditions in the building (egress paths) have become untenable. The inclusion of smoke control, ventilation, compartmentation, or other building systems can be utilized to extend the available safe egress time beyond the time required for safe egress.

Within the semiconductor foundry, the horizontal plane located 6 feet above the walking surfaces would be considered as the region to maintain tenability. The following information from the SFPE Handbook of Fire Protection Engineering is used to determine tenability thresholds:

Visibility

For evaluation of the smoke layer, a visibility of 30 feet (9.1 meters) is commonly used as the threshold. Jin[1] suggested that when visibility is maintained at 30 feet or greater, occupants are generally assumed to continue to exit the building. Under this circumstance, normal egress times are anticipated. Where the visibility distance is less than 30 feet, occupants of the building are assumed to slow their egress progress through the building. A computational fluid dynamics (CFD) fire model can be used to determine smoke optical density along the egress paths in the building for a given fire scenario.

Temperature

Purser[2] suggested a correlation between the exposure time and the thermal tolerance for humans at rest, naked skin exposed, with low air movement. For an exposure time of approximately 20 minutes, 176 degrees Fahrenheit (80 degrees Celsius) is the highest temperature a human can sustain without adverse physical effects. In the event the air is water-saturated, a limit of 140 degrees Fahrenheit (60 degrees Celsius) is the maximum temperature that is breathable for 20 minutes. The air is likely to contain a considerable amount of moisture as the products of combustion include water. Therefore, a temperature of 140 degrees Fahrenheit is assumed to be a tenable environment.

Carbon Monoxide

Carbon monoxide (CO) is recognized as the primary toxic hazard in fires. It is the accumulation of CO in the body that is most critical. Purser[3] suggested that the CO concentration, at which there would be danger of incapacitation after approximately 30 minutes of exposure, is 1,400 parts per million (ppm) to 1,700 ppm. A CO concentration of 1,400 ppm or less can be used as the limiting criterion.

The methodology of the Life Safety Code for performance based egress design is to establish eight fire scenarios, evaluating each to determine several worst-case options. These selected fire scenarios are used to determine the tenability conditions during the occupant egress time. A safety factor needs to be determined at the outset of the project and agreed to by all stakeholders. All assumptions must be clearly documented.

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[1] Society of Fire Protection Engineering Handbook of Fire Protection Engineering, 4th edition, Section 3, Chapter 11, *Behavioral Response to Fire and Smoke*.
[2] Society of Fire Protection Engineering Handbook of Fire Protection Engineering, 4th Edition, Section 2, Chapter 6, *Assessment of Hazards to Occupants from Smoke, Toxic Gases, and Heat*.
[3] Ibd. Purser

This egress evaluation is limited to the determination of RSET and establishing the tenability thresholds. Further study is required to compare the RSET and tenability limits to the fire and toxic gas exposures under various design fire scenario. An alternative performance based approach was chosen as the focus of this report related to the exposed structural steel, presented in the following Section 9.

9. Performance Based Design

The objective of the Performance Based Design is to define the fire safety problem in qualitative terms, so a detailed analysis of the design can be performed with quantifiable results. The methodologies and approaches utilized are described in the SFPE Engineering Guide to Performance Based Design.

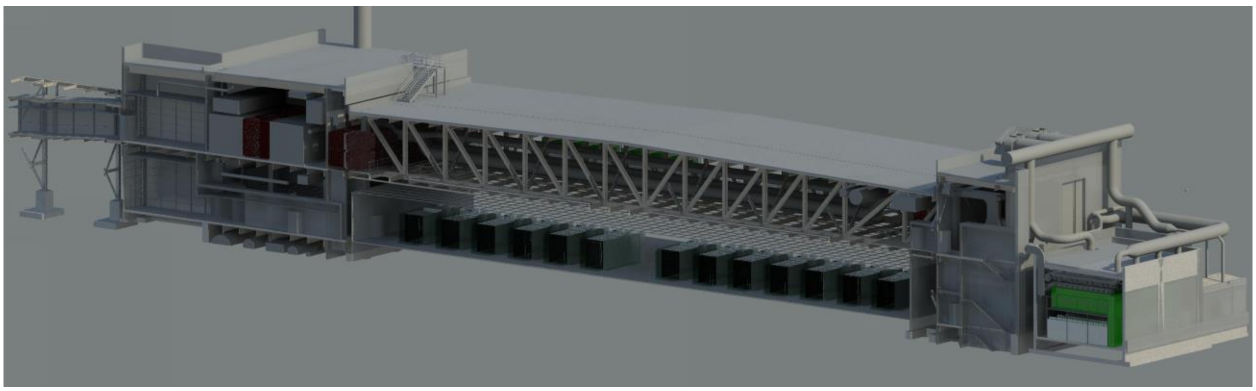

Figure 18. 3-dimensional Section through Cleanroom

9.1. Project Scope

The project scope consists of the primary structural framing located in the interstitial space of the ACME Fab Expansion building that supports only the roof system. The primary structural frame consists of wide-flange beam steel trusses, visible in Figure 18. The roof trusses are 14-feet in depth and span approximately 232-feet between column supports. The bottom chord of the truss consists of W14x283 wide-flange steel beams. Columns on either end of the truss consist of W14x342 steel. The roofing system is comprised of lightweight concrete over 16-gauge corrugated steel decking with built-up thermoplastic olefin (TPO) material on the exterior surface.

The building is required to be of Type I-B construction which requires primary structural frame components to meet a minimum 2-hour fire-resistance rating. Where the frame supports roof structure only, the rating requirement may be reduced to 1-hour. The fire resistance rating is prescriptively determined by full-scale testing of a building component or assembly in accordance with the ASTM E119 test criteria. IBC Section 703.3 allows alternative methods to be used in determining the fire-resistance rating of building elements. This project is seeking approval of an alternative method in accordance with IBC Section 104.11.

9.2. Project Goals

The goal of this performance based design is to show that the exposed steel structures meet the minimum fire-resistance ratings as required in the IBC, without the use of spray-applied fire resistive materials (SFRM), under anticipated worst-case fire conditions.

This performance based approach is going to focus on the first phase of a structural performance based design; determining the fire thermal exposure. This information can be further analyzed for the remaining phases of a structural performance-based analysis shown in Figure 19. The second phase is to determine the heat transfer within a steel member and the final phase consists of a structural engineer evaluating the fire affected structural member or assembly in a structural model.

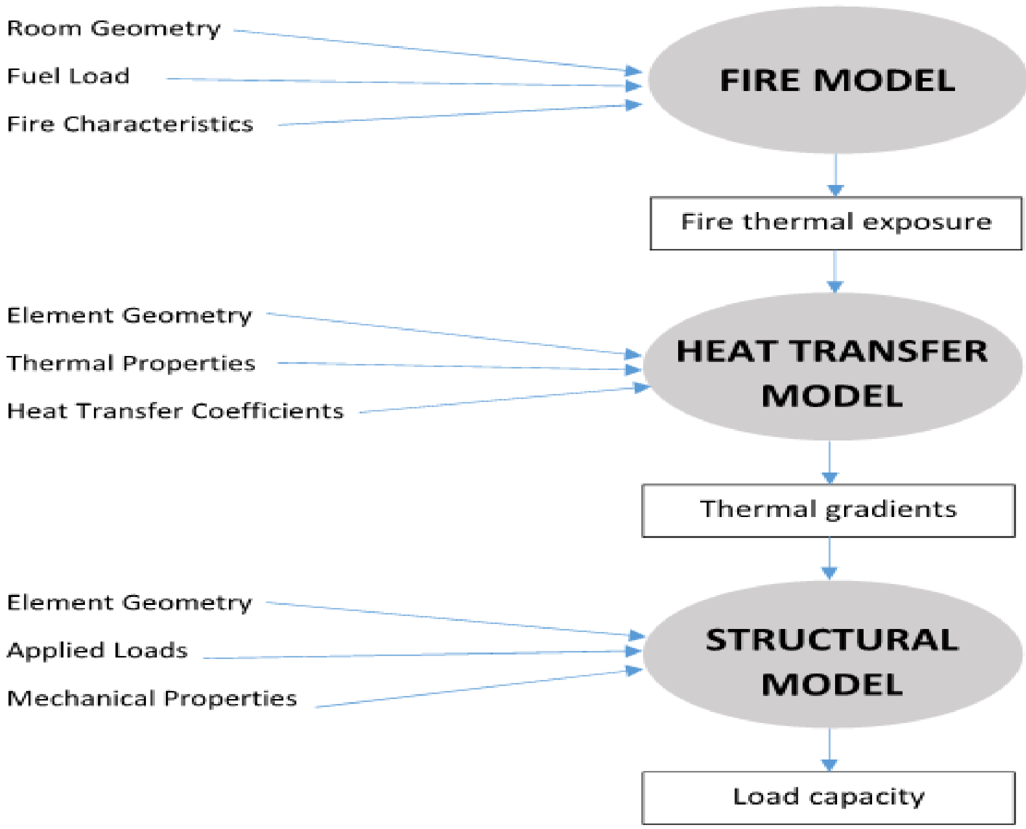

Figure 19. Structural load capacity flow chart[4]

[4] Buchanan, A., Structural Design for Fire Safety, *Fig. 6.5*, 2001

9.3. Stakeholders and Design Objectives

Stakeholders are individuals, a group or organization who may affect, be affected by, or perceive itself to be affected by a decision, activity or outcome of the project. The project stakeholders one might typically find in a performance-based analysis such as this are shown in Table 20.

Table 20. Project Stakeholders

Group	Stakeholder	Role
Owner	John Doe	Owner's Representative
Owner	John Coe	HSE
Design Professional	John Boe	Architect
Fire Protection Engineer	Jacob Epstein	Consultant
Structural Engineer	John Foe	Consultant
City Building Department	John Goe	Code Official
City Fire Department	John Moe	Deputy Chief
FM Global	John Noe	Insurance Representative

The design objective is to evaluate a credible design fire scenario and utilize a fire model to support the use of exposed structural steel trusses.

9.4. Performance Criteria

Using the design fire scenario and fire model:

- The exposed steel structure does not reach a critical temperature for simulation duration of one hour.

Based on the ASTM E119 test criteria for loaded, restrained beams, the average temperature shall not exceed 1,100 °F (593 °C) as recorded by four thermocouples at any section in the beam.[5] Depending on other factors the critical steel temperature can vary from this prescriptive threshold. Gas temperatures adjacent to the surface of the steel were used to evaluate the steel exposure temperature. These gas temperatures, along with radiant heating, could then be used to conduct a heat transfer analysis to determine the steel material properties during the fire exposure.

[5] ASTM E119 – 16a, Standard Test Methods for Fire Tests of Building Construction and Materials, Section 8.7.5.2, p. 11.

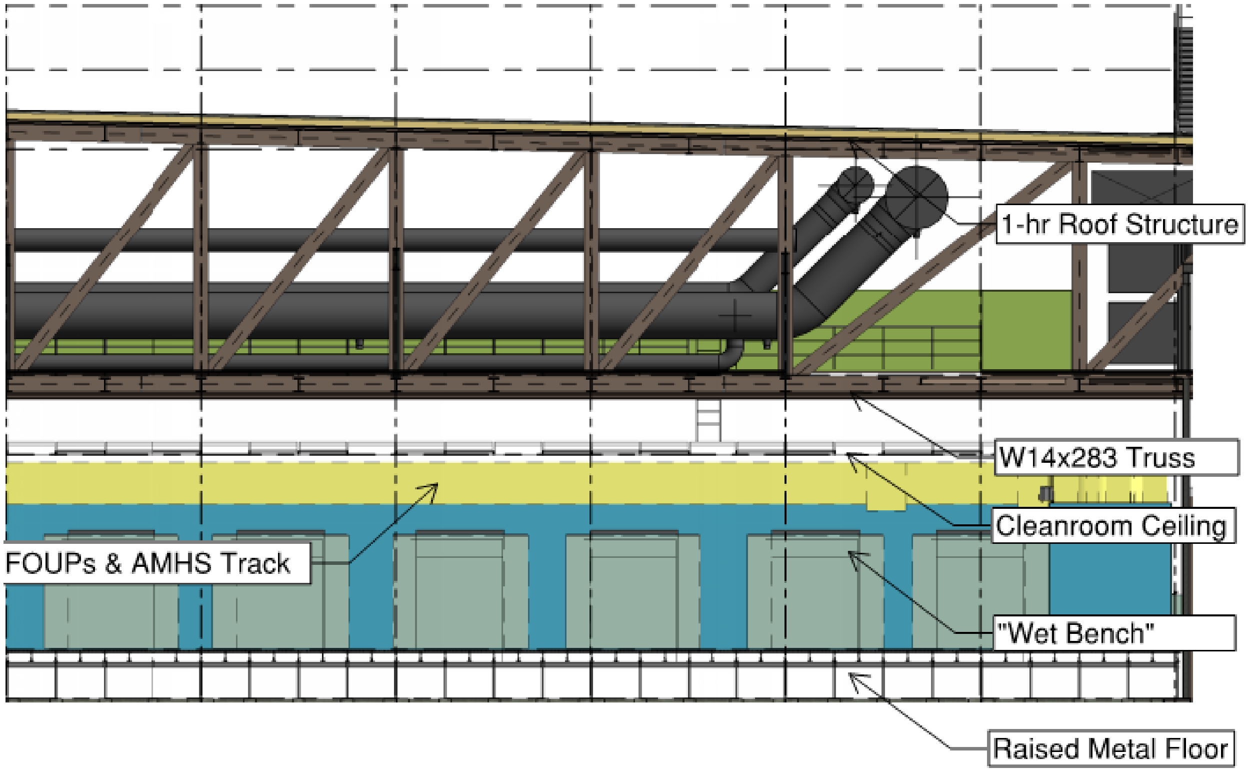

Figure 20. Building Section at fire location

9.5. Design Fire Scenarios

The interstitial level of the Fab utilizes entirely non-combustible materials of construction for the structure, walls, and grated catwalks. Below the interstitial catwalks is the cleanroom ceiling constructed of stainless steel and aluminum honeycomb sandwich panels and an extruded aluminum ceiling grid. In the cleanroom ceiling, there are fluorescent light fixtures, fan-filter units, and sprinkler system piping.

The most credible fire scenario exists in the cleanroom level within one of the wafer processing tools which contains quantities of combustible materials and utilizes combustible/flammable liquids or gases during part of the semiconductor manufacturing process. Many of the tools utilize different types of plastic as their material of construction. Some of the hazardous chemicals dispensed and utilized in the workstations are as follows:

- Isopropyl Alcohol (IPA)
- Tetramethylammonium Hydroxide (TMAH)

The tools/workstations are in close proximity to each other potentially creating multiple fuel packages.

The evaluated fire scenario consists of a fire originating in one of the wafer cleaning tools (wet bench). The heat release and proximity of the tools ignites nearby front opening universal pods (FOUPs) and two adjacent wet benches. The fire consists of small quantities of flammable liquids igniting the plastic components within the tool.

9.6. Fire Modeling With FDS

9.6.1. Input

To develop an accurate representation of the probable fire scenario, certain conditions are factored into the fire models to establish acceptable fundamental mechanics. The model has been run using FDS Version 6.3.2, which is the most current version of the software providing the most accurate calculations for fire production and smoke flow. See Appendix M for a description of the FDS program.

The building, structure, and tools were input into the FDS program based on the Revit models provided by the building design professional. The bounds of the modeling area extend approximately 50 feet beyond the origin of the fire. Conservative factors have been used for input into the FDS model. All objects within the model are considered inert for there to be no heat loss through the floors or walls. The ceiling has been modeled as a thin steel sheet to provide maximum heat transfer.

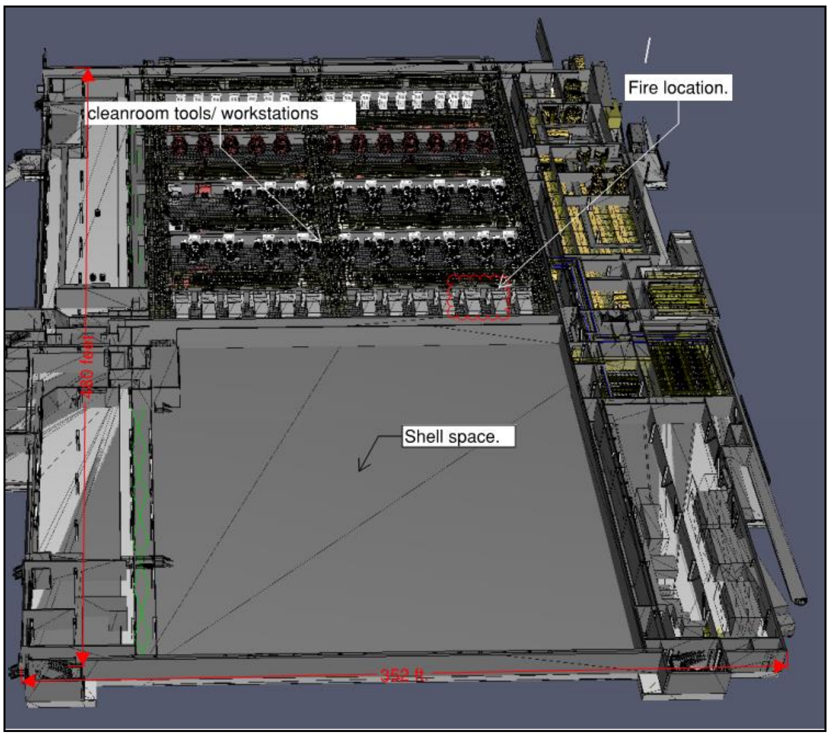

Figure 21. Fire Scenario Location

9.6.2. Climate

The location of the design fire is on the interior of the buildings and ambient conditions will not have an adverse effect on the fire model. The airflow within the cleanroom is downward away from the ceiling which would tend to drive heat away from the interstitial level. The fan filter units are interlocked with smoke detection in the subfloor below the cleanroom. This airflow is assumed to be shut down during the fire scenario to provide the maximum heat transfer into the ceiling and above ceiling space. The ambient cleanroom temperature is assumed to be 68°F (20°C).

9.6.3. Design Fires

The performance based approach uses qualitative engineering judgment supported by quantitative methods to achieve performance based criteria when prescriptive requirements are not available. In many cases a fire test matching the actual design fire scenario is not available and a review of available fire testing data using engineering judgment provides a basis to achieve performance based criteria. This engineering judgment is discussed in the IBC Section 909.9, the rational analysis for the design fire should make use of the best available data and should not be based on excessively stringent limitations of combustible materials. It should consider factors like fuel characteristics, load, spacing, configuration, and whether the fires are likely to be steady or unsteady. In addition, the analysis should consider heat release and sprinkler effectiveness assumptions.

9.6.4. Fuel Characteristics and Fuel Loads

The fuel load in this case is a workstation constructed of mostly non-combustible materials with limited quantities of combustible plastics and closed-use chemicals. The DNS Electronics, Single Wafer Cleaner, has been utilized as an example of this type of equipment. The model SU-3100, shown in Figure 22, is provided with only minimal exterior openings for ventilation. There are several different fuel packages within the tool. The interior finishes are primarily steel construction. Plastic materials within the equipment, FOUPs, and small quantities of flammable liquids within the equipment will be considered as a composite fuel package.

Figure 22. **Fuel Package**

9.6.5. Heat Release Rate Assumptions

The heat release rate to be used in the fire model is a critical factor in the computation of the model affecting the size and velocity of the fire plume. Without a specific fire test of these discrete fuel packages, additional resources have to be consulted and a fire model constructed to determine the potential outcome.

The SPFE Handbook Section 3, Chapter 6 provides a correlation for determining the maximum heat release rate potential for a particular compartment. The correlation uses the area and height of openings on the exterior of the compartment to determine the maximum HRR possible. With a ventilation limited compartment fire, the maximum HRR is dependent on the quantity of oxygen available for combustion of the materials within the compartment. Adequate vents are not readily observed on the SU-3100 Single Wafer Cleaning System. It was assumed that two of the upper doors on both sides of the equipment are open or have been removed to provide a worst-case ventilation condition. Using the Babrauskas Method[6], the maximum HRR for a ventilation-limited fire within a compartment is:

$HRR = 1500\, A_o \sqrt{H_o}$, where:

A_o = area of vent opening (m^2)
H_o = height of bottom of vent opening (m)

Each of the four assumed openings has an area of approximately 0.27m^2 and a height of 2.4m. Therefore, the maximum HRR for this compartment, regardless of internal fuels, is 2,509.7 kW.

The SU-3100 Single Wafer Cleaning System contains approximately 845 kilograms (kg) of combustible materials. Utilizing the individual component masses, a weighted average for various material properties was calculated. The material properties utilized in these calculations are shown in Appendix L. Under perfect burning conditions, with all combustible components assumed to be a single entity, the maximum HRR is found using the following formula:

The rate of heat release in open fires is expressed as the product of the burning rate (i.e. rate of mass loss, m" [kg/m^2s]) and the net heat of combustion of the fuel (ΔH_c [kJ/kg]).

$$HRR = Q_c = \dot{m}'' x \Delta H_c \qquad \text{(Eq.24)}$$ [7]

Using the weighted average heat of combustion of 7.94 MJ/kg and the mass loss rate (MLR) of 0.0040 kg/m^2s, the HRR is equal to 31.76 kW/m^2 of combustible material. If this material were to ideally occupy the entire area within the confines of the equipment, 16.5 m^2, the maximum HRR would be 524 kW.

Due to the presence of combustible and flammable liquids in small quantities, the more conservative value of 2,509.7 kW will be utilized, equally divided over four vents on the exterior of the equipment. The fire will conservatively be modeled as an ultra-fast fire which reaches peak heat release at approximately 180 seconds. No HRR decay is accounted for either from limited fuel or sprinkler system activation.

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[6] The SFPE Handbook of Fire Protection Engineering, Quincy, MA, 2008, 4th Edition, Page 3-214.

[7] The SFPE Handbook of Fire Protection Engineering, Quincy, MA, 2008, 4th Edition, Page 1-96.

The FOUPs are assumed to be constructed of polycarbonate. Polycarbonate has an ideal burning rate of 0.025 kg/m²s and a heat of combustion of 21.2 MJ/kg. Using the actual surface dimension of a single FOUP (0.15m²), the maximum HRR is 79.5 kW. Three FOUPs are located at the end of the equipment and will be included in the fire scenario. The FOUPs are also modeled as ultra-fast fires reaching steady state HRR in approximately 25 seconds without any decay.

Due to the close proximity of the equipment to adjacent equipment, additional heat release will be provided from four (4) similarly located vents and two (2) additional FOUPs, shown graphically in Figure 23.

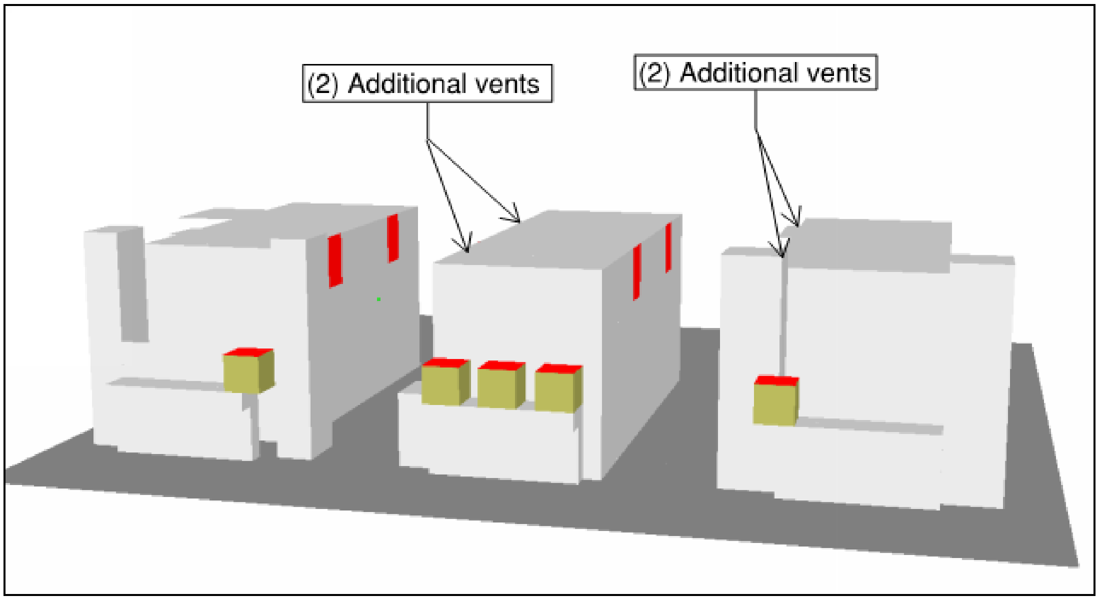


Figure 23. Fuel Package Graphical Representation

The fire scenario conservatively assumes simultaneous ignition of each discrete fuel package, with the total heat released being the sum of each item, tabulated in Table 21.

Table 21. Fuel Package HRR description

Fuel Source	Peak HRR	
Wet Bench (center)	2510 kW	(divided equally among (4) vents)
FOUPs (on center bench)	237 kW	(divided equally among (3) FOUPs)
Wet Bench #2 (left)	1205 kW	(divided equally among (2) vents)
Wet Bench #3 (right)	1205 kW	(divided equally among (2) vents)
Adjacent FOUPs (on adjacent wet benches)	158 kW	(divided equally among (2) FOUPs)
TOTAL	**5,415 kW**	

9.7. Evaluation of Exposed Steel

The fire scenario was modeled and gas temperature measurements recorded at below the cleanroom ceiling, immediately above the cleanroom ceiling, and at the surface of the bottom chord of the steel truss. The peak heat release rate shown in Table 21 was achieved at approximately 180 seconds into the simulation (see Figure 24).

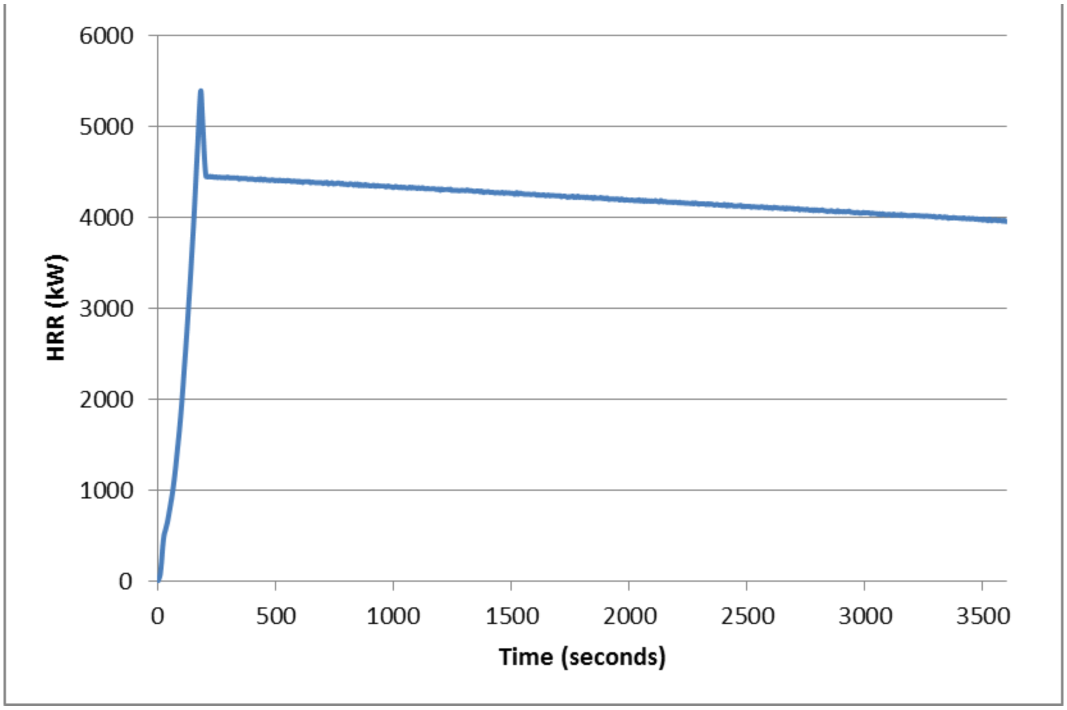


Figure 24. Heat Release Rate of Fuel Package in FDS

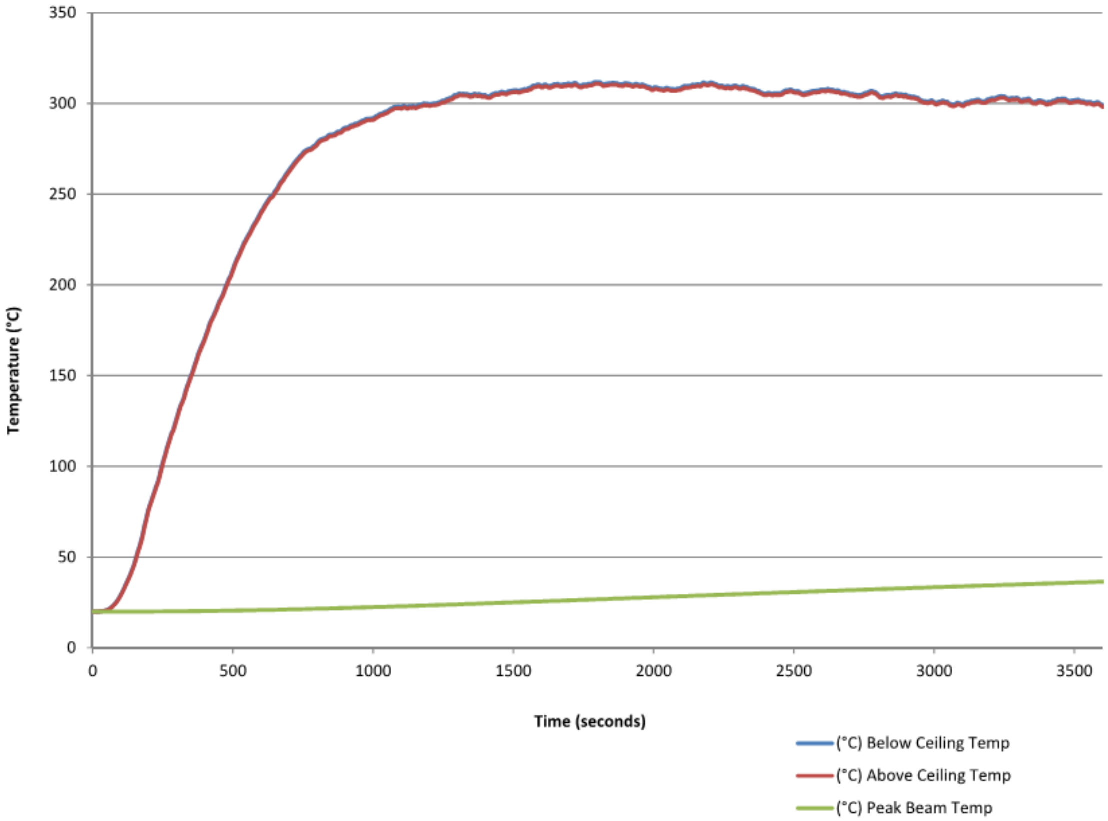


Figure 25. Time evolution of grid ceiling and steel truss gas temperatures

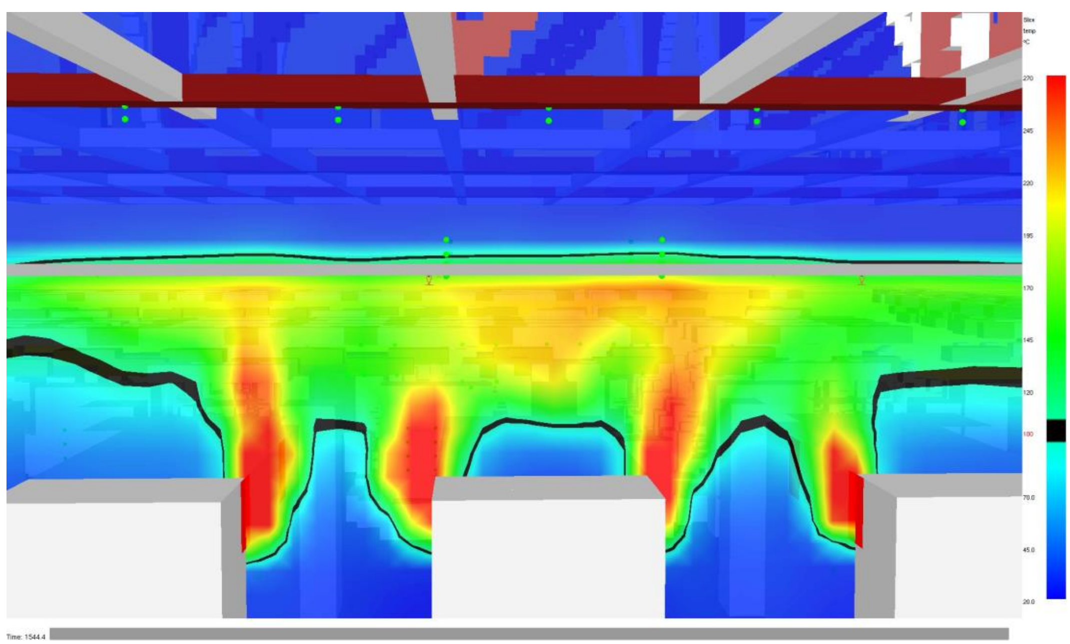


Figure 26. Temperature slice file showing heat transfer through ceiling

The cleanroom ceiling was modeled as a thin steel sheet to allow for the maximum transfer of heat into the interstitial space. A peak above ceiling temperature of 305°C occurs at the top surface of the ceiling (see Figure 25 and Figure 26). A maximum gas temperature exposure to the unprotected steel truss is 37°C.

The cleanroom ceiling consists of an extruded aluminum grid structure with steel and aluminum honeycomb ceiling panels. Aluminum loses half of its yield strength at approximately 250 °C[8]. An additional scenario was created to evaluate an aluminum ceiling failure at 200 seconds. A vent, equivalent to one ceiling panel, was opened in the ceiling directly over the fire source allowing smoke and hot gases to enter the interstitial space. A subsequent model was completed with approximately 40 ceiling tiles removed.

A peak beam exposure temperature of 153°C occurred during the single tile failure. The gas temperature surrounding the bottom chord of the steel truss does not exceed 37°C, as shown in Figure 27.

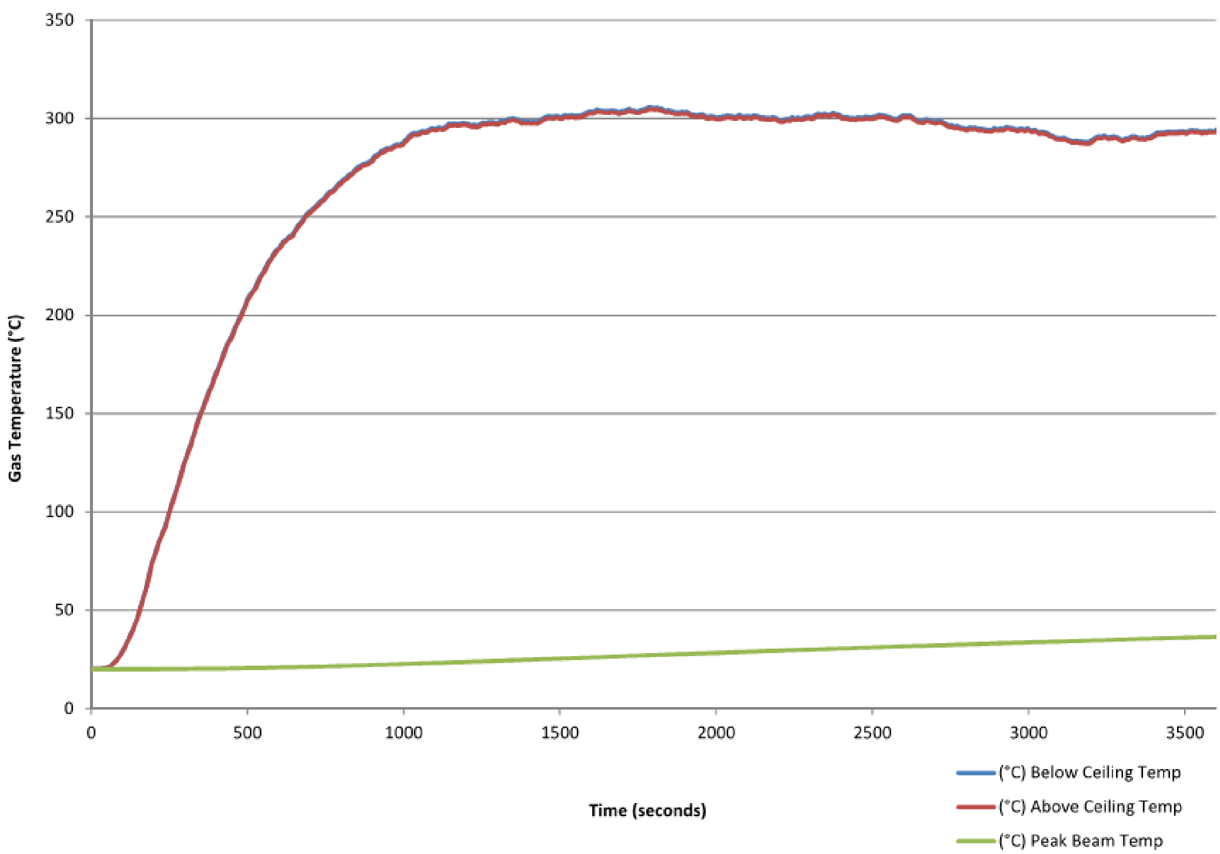


Figure 27. Time evolution of grid ceiling and steel truss gas temperatures with single tile failure

[8] **Summers, et. al., "Overview of aluminum alloy mechanical properties during and after fires," *Fire Science Reviews*, 2015**

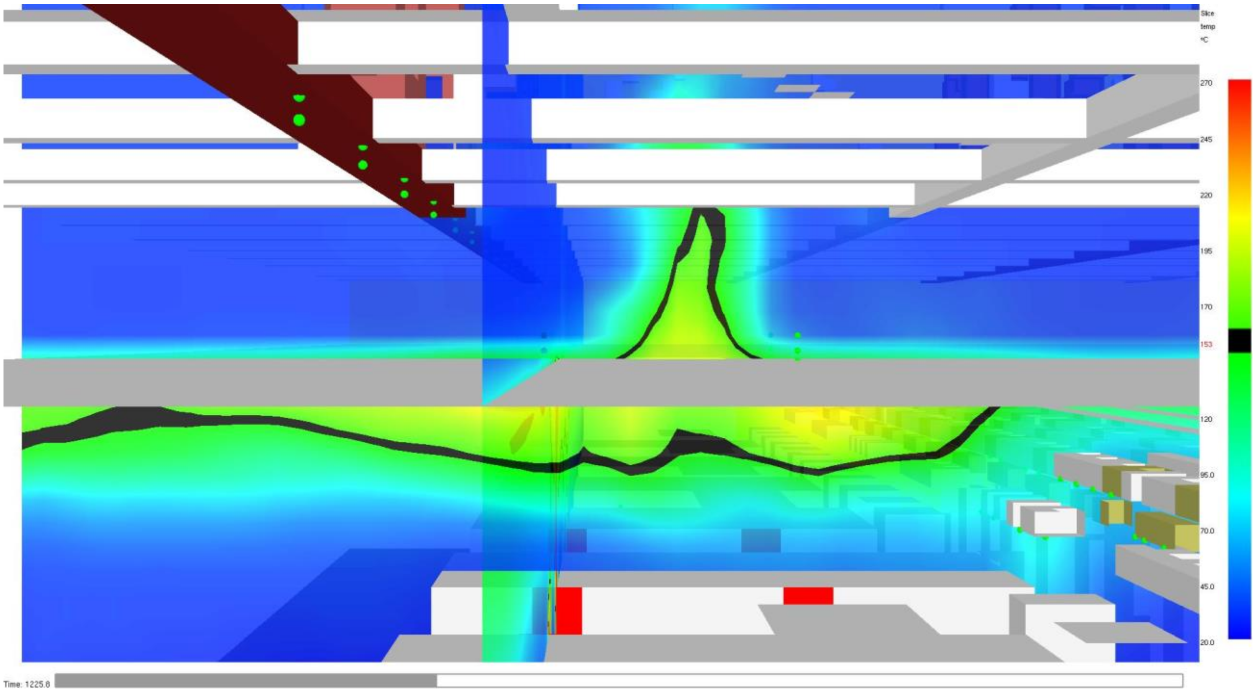


Figure 28. **Temperature slice file showing peak interstitial temperatures with single tile failure**

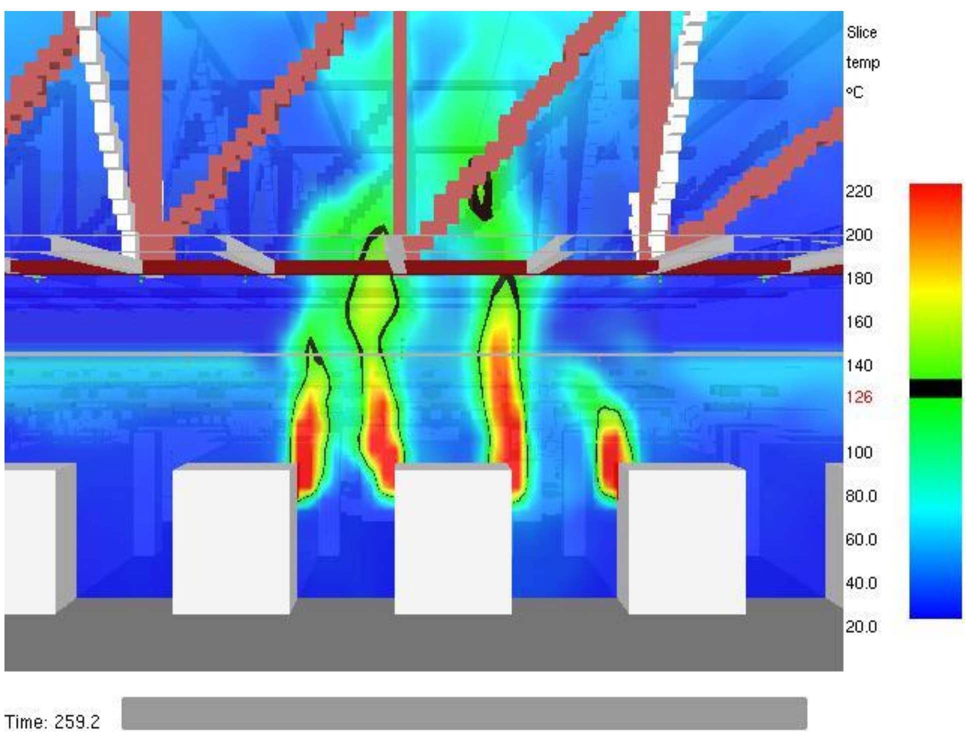


Figure 29. **Temperature slice file showing peak interstitial temperatures with multiple tile failure**

A slice file shows the heat entering the interstitial space through a single tile failure in Figure 28 and catastrophic multiple tile failure in Figure 29. A peak beam exposure temperature of 325°C occurred during the multiple tile failure. The gas temperature at the surface of the bottom chord of the steel truss does not exceed 125°C.

As a conservative assumption the sprinkler activation and suppression or control of the fire were excluded from the previously discussed scenario. While it is possible to have a sprinkler system shutdown, the likelihood this occurs in unison with a fire is highly remote. The activation of the cleanroom ceiling sprinkler system would provide cooling to adjacent equipment, suppression of the fire, and decreased heat transfer into the interstitial space.

Nine sprinklers were modeled with an approximate 12 feet by 10 feet spacing (see Figure 30). Sprinklers were modeled using the properties of a quick response sprinkler (response time index of 50 m-s$^{1/2}$) and ordinary temperature rating (68.33°C). The first sprinkler activates at approximately 102 seconds, the second sprinkler at 108 seconds, and the third sprinkler at 113 seconds (see Figure 31).

The heat release rate (HRR) at the time of sprinkler activation was found to be approximately 1,915 kW (see Figure 32). This HRR was then modeled assuming sprinkler control but no suppression or decay. The HRR was maintained at a steady-state for the duration of the simulation (see Figure 33).

Figure 30. Modeled sprinkler locations

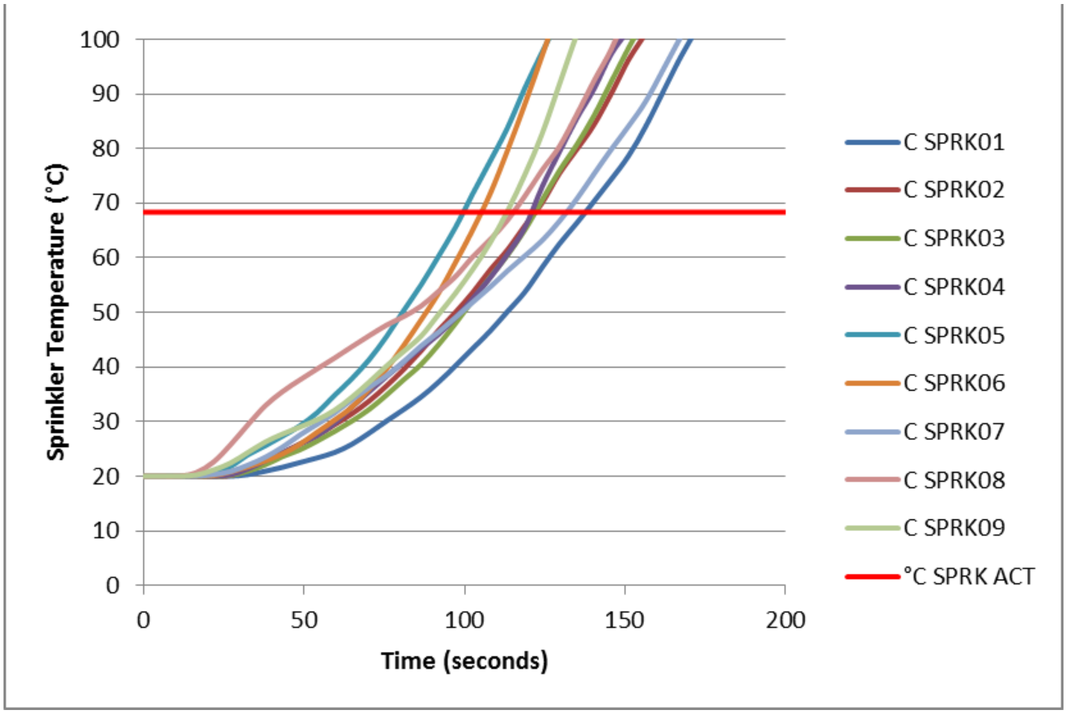


Figure 31. Sprinkler activation times

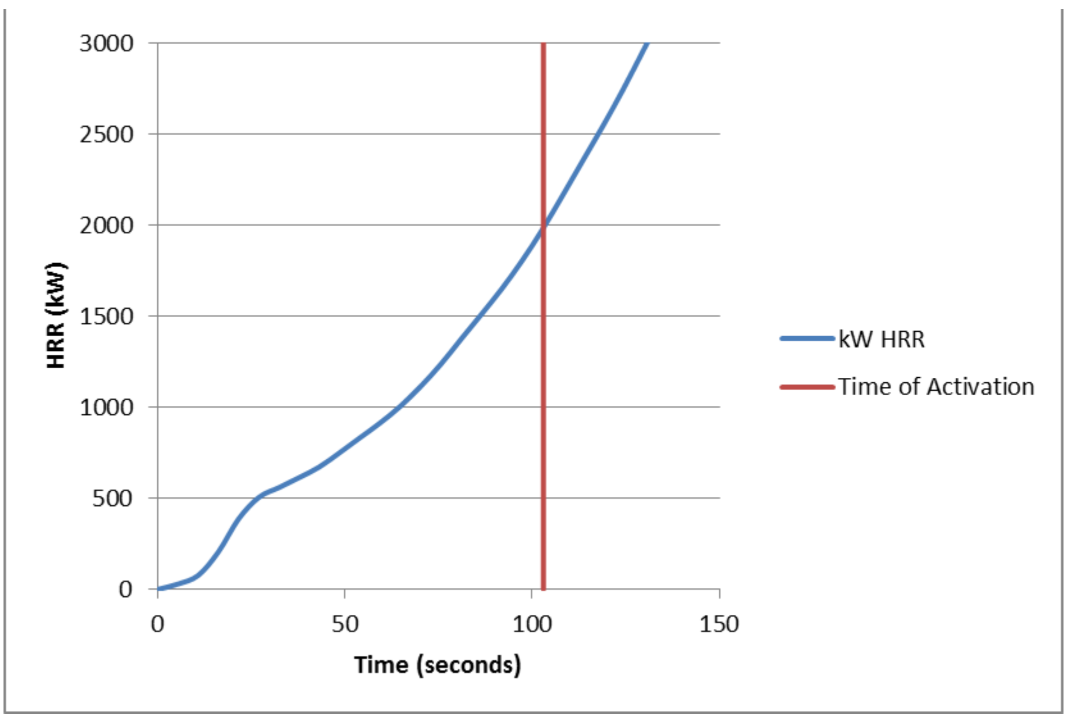


Figure 32. HRR at Sprinkler activation

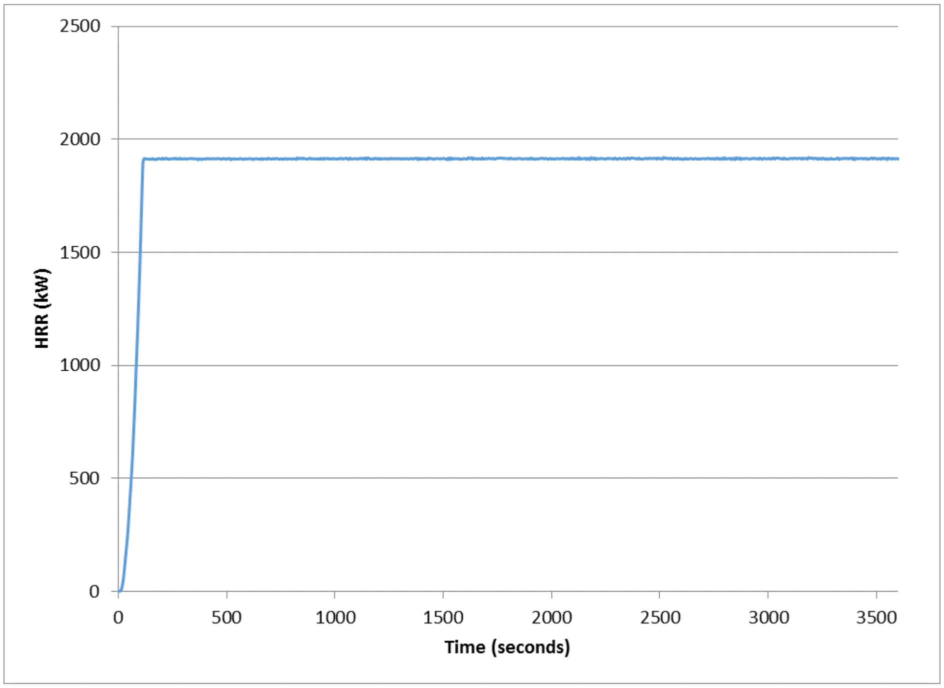


Figure 33. Steady state sprinkler controlled HRR

The aluminum ceiling temperature is shown to be less than the failure criteria established previously (250°C). The maximum steel truss surrounding gas temperature is less than 28°C (see Figure 34).

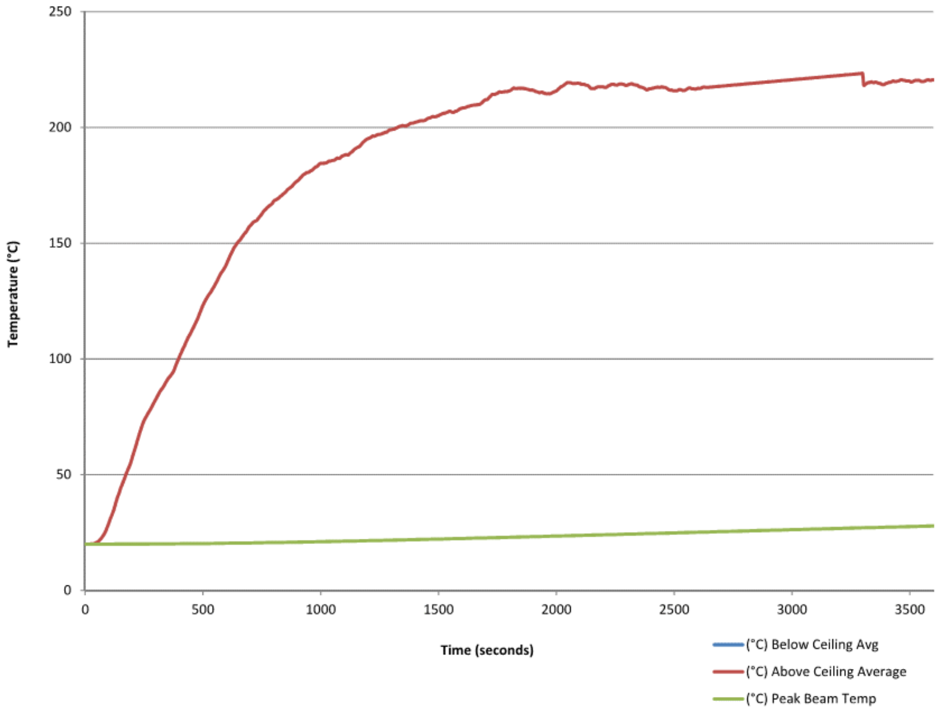


Figure 34. Sprinklered ceiling and beam temperatures

9.8. Performance Based Design Conclusion

The preceding pages of this section provide the technical analysis of the proposed exposed steel trusses in the interstitial space of the ACME Fab Expansion. The findings are such that the exposed steel trusses are subjected to a peak thermal exposure of 325 °C during the worst case fire condition with a catastrophic ceiling failure as outlined in this document. The next step in the structural capacity evaluation would be to conduct a heat transfer analysis using the FDS time-temperature curve. With the heat transfer analysis, a structural engineer could incorporate the material properties at elevated temperatures to be evaluated under the imposed structural loads.

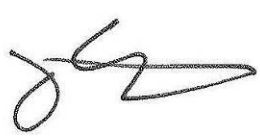
10. Conclusion

This report presents the relevant fire protection/life safety requirements for the ACME Semiconductor Fab Expansion. Building Construction Documents are provided in Appendix A showing compliance with the requirements found herein.

This report presents the relevant sprinkler system design requirements for the ACME Semiconductor Fab Expansion. A site plan has been provided in Appendix A showing the water supply arrangement and points of connection to the new building. Hazard analysis has been performed and hydraulic calculations presented for the worst-case sprinkler system design density located within the building. A summary of the inspection, testing, and maintenance requirements related to the fire sprinkler systems has been provided.

This report presents the relevant fire detection, alarm and communication system design requirements for the ACME Semiconductor Fab Expansion. An excerpt of fire alarm design drawings has been provided in Appendix A showing the general code requirements, typical notification device layout and spacing, and a unique detection situation utilizing radiant-energy sensing detectors. Detection response analysis has been performed using DETACT, FDS, and manufacturer's data for the unique flame detector situation. A summary of the inspection, testing, and maintenance requirements related to the fire alarm systems has been provided.

This report presents the relevant egress requirements for the ACME Semiconductor Fab Expansion. Life Safety Plans are provided in Appendix K showing areas of non-compliance with the prescriptive requirements of the LSC. Use of the IBC would yield compliance acceptable to many authorities having jurisdiction. The egress calculations shown and simulated provide the basis for a performance based design of the egress systems in this building. This report can be used to establish the RSET value to be compared to an ASET value determined using a CFD fire model.



Jacob Epstein, PE
Consultant

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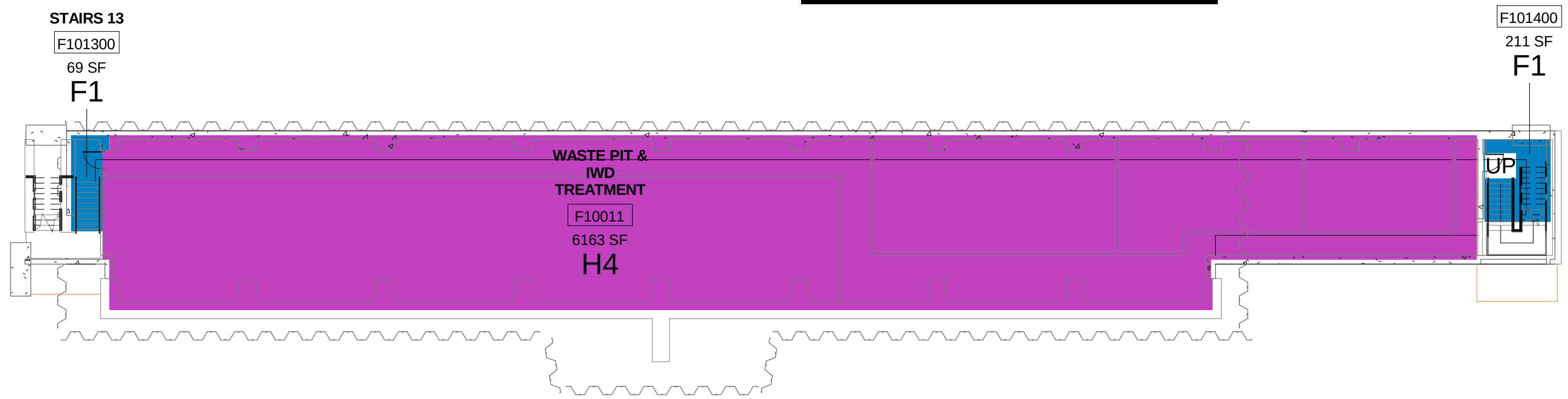
Appendix A – Occupancy & Structural Construction Documents

LEVEL 00 - PIT

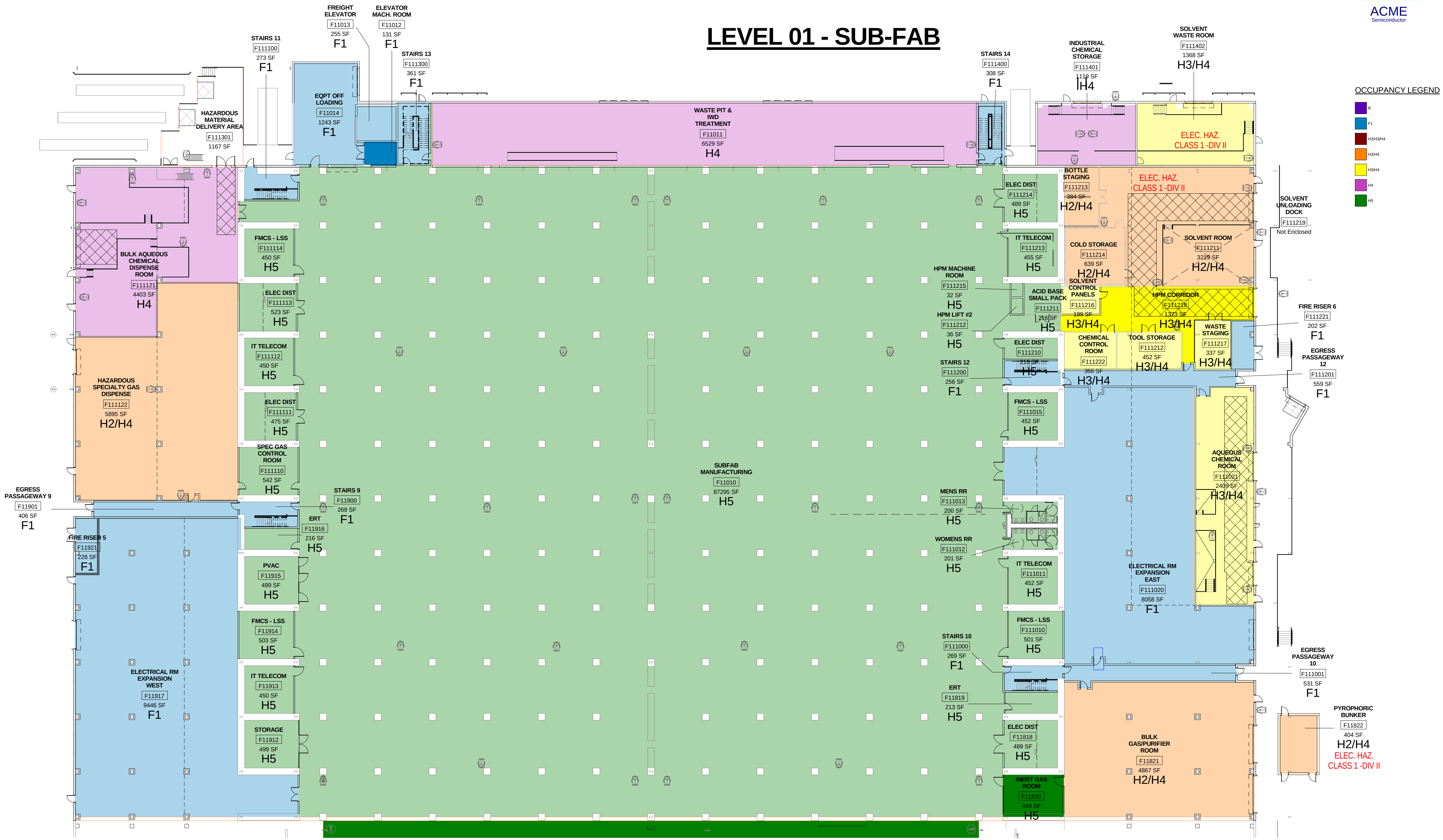


ACME
Semiconductor

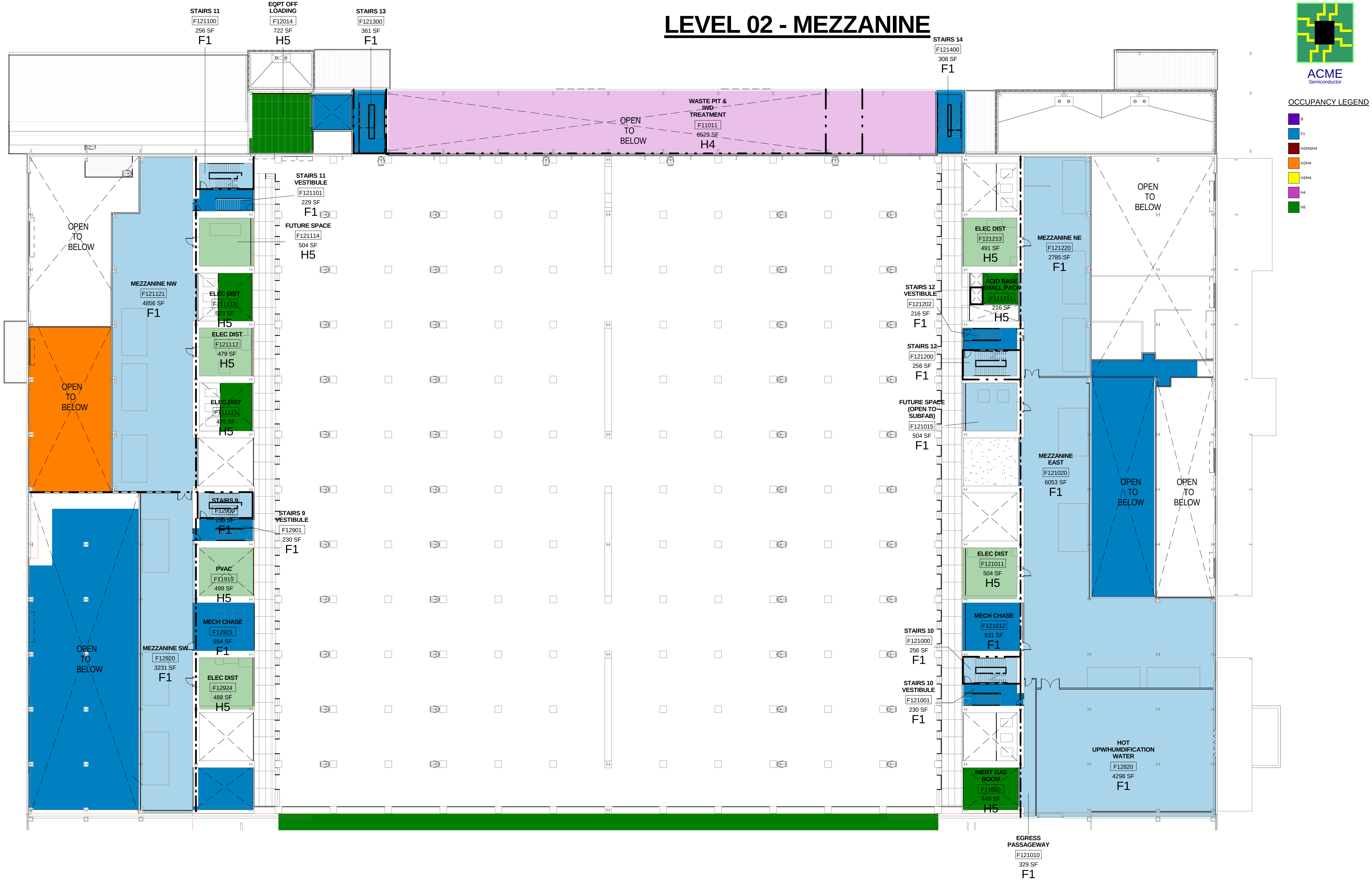
OCCUPANCY LEGEND

- B
- F1
- H2/H3/H4
- H2/H4
- H3/H4
- H4
- H5

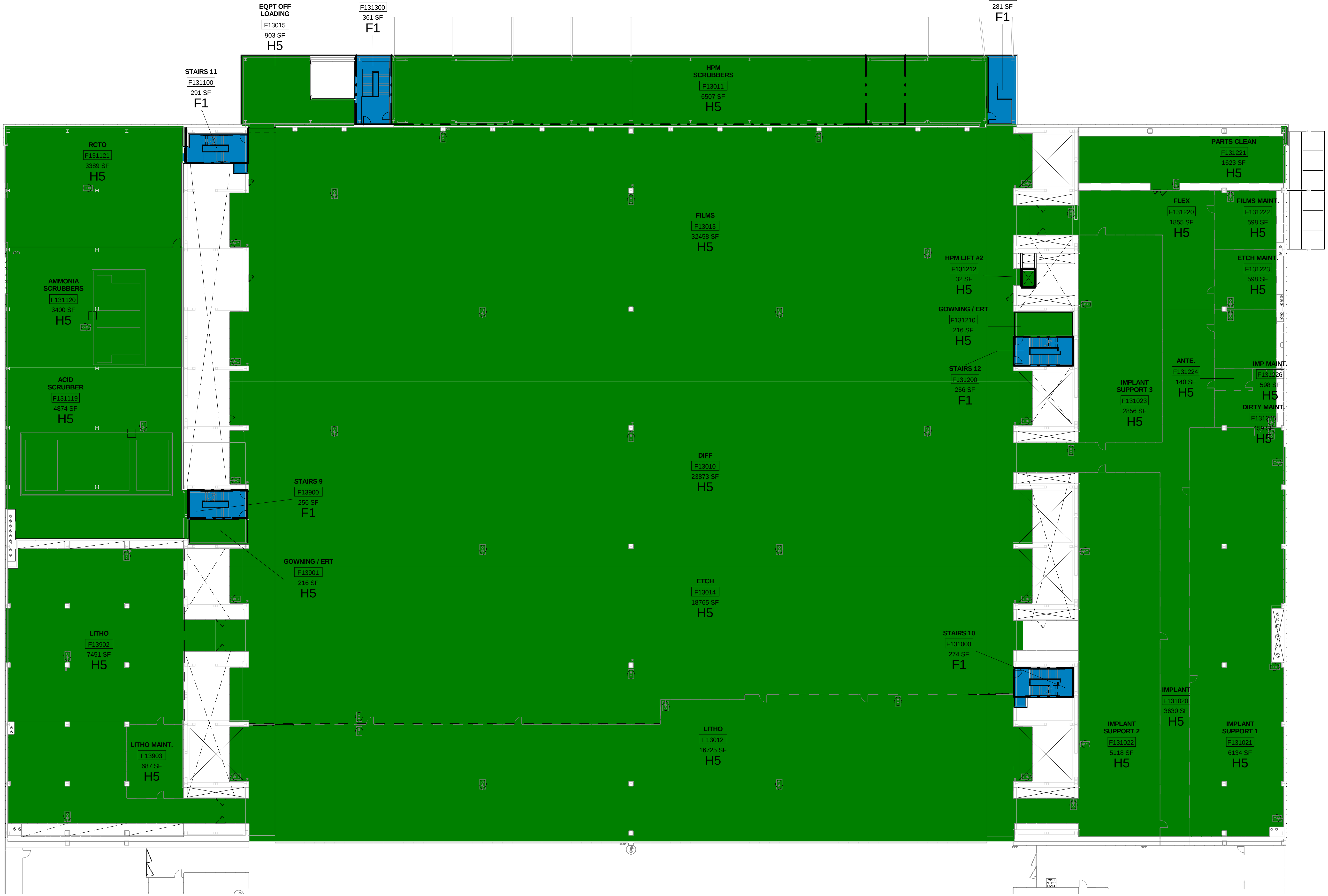
LEVEL 01 - SUB-FAB



LEVEL 02 - MEZZANINE



LEVEL 03 - FAB

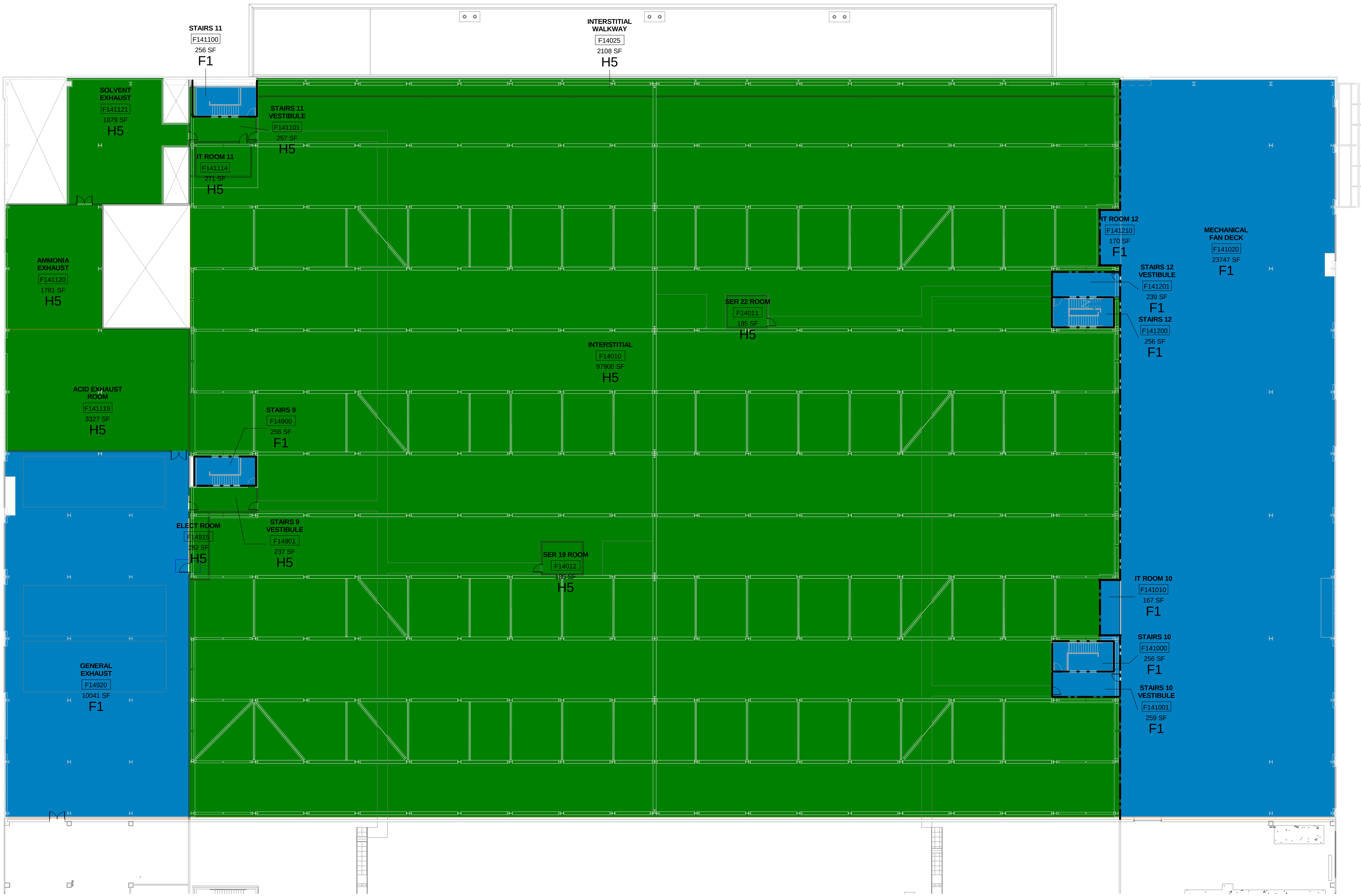


ACME
Semiconductor

OCCUPANCY LEGEND

- B
- F1
- H2/H3/H4
- H2/H4
- H3/H4
- H4
- H5

LEVEL 04 - INTERSTITIAL

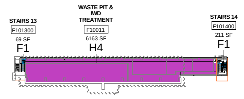


ACME
Semiconductor

OCCUPANCY LEGEND

- B
- F1
- H2/H3/H4
- H2/H4
- H3/H4
- H4
- H5

CONFIDENTIAL

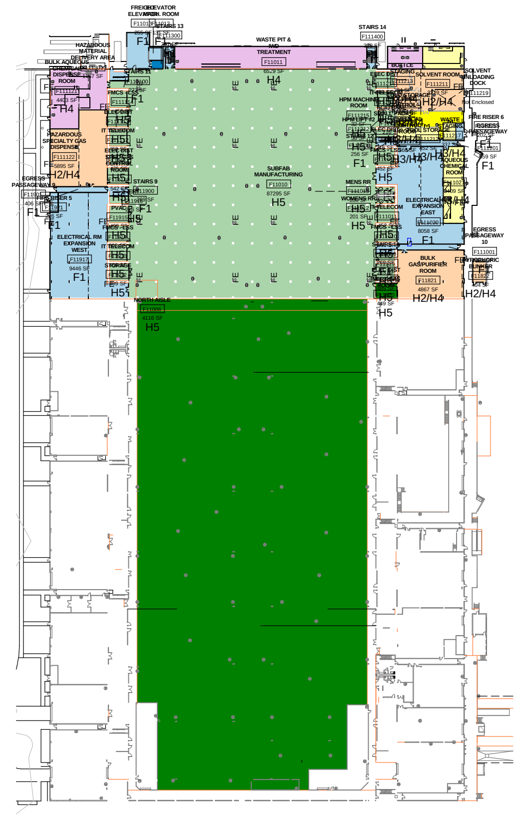


0 ZZ **Level 0 - Pit Level**
SCALE: 1" = 80'-0"

LEVEL	ROOM NUMBER	ROOM NAME	OCCUPANCY	AREA	Occupant Load Factor	Occupants per Room	Occupancy Load (room)
LEVEL 0 (PIT LEVEL)	F101300	STAIRS 13	F1	69 SF			
LEVEL 0 (PIT LEVEL)	F101400	STAIRS 14	F1	211 SF			
F1				280 SF		0	
LEVEL 0 (PIT LEVEL)	F10011	WASTE PIT & IWD TREATMENT	H4	6163 SF			
H4				6163 SF		0	
LEVEL 0 (PIT LEVEL)				6443 SF		0	
Grand total: 3				6443 SF		0	

LEVEL	ROOM NUMBER	ROOM NAME	OCCUPANCY	AREA	Occupant Load Factor	Occupants per Room	Occupancy Load (room)
LEVEL 1	F111301	HAZARDOUS MATERIAL DELIVERY AREA		1167 SF			
				1167 SF		0	
LEVEL 1	F11012	ELEVATOR MACH. ROOM	F1	131 SF			
LEVEL 1	F11013	FREIGHT ELEVATOR	F1	255 SF			
LEVEL 1	F11014	EQPT OFF LOADING	F1	1243 SF			
LEVEL 1	F11900	STAIRS 9	F1	269 SF	0 SF		3
LEVEL 1	F11901	EGRESS PASSAGEWAY 9	F1	406 SF			
LEVEL 1	F11917	ELECTRICAL RM EXPANSION WEST	F1	9446 SF			
LEVEL 1	F11921	FIRE RISER 5	F1	226 SF			
LEVEL 1	F111000	STAIRS 10	F1	269 SF	0 SF		
LEVEL 1	F111001	EGRESS PASSAGEWAY 10	F1	531 SF			
LEVEL 1	F111020	ELECTRICAL RM EXPANSION EAST	F1	8058 SF			
LEVEL 1	F111100	STAIRS 11	F1	273 SF	0 SF		
LEVEL 1	F111200	STAIRS 12	F1	256 SF	0 SF		
LEVEL 1	F111201	EGRESS PASSAGEWAY 12	F1	559 SF			
LEVEL 1	F111221	FIRE RISER 6	F1	202 SF			
LEVEL 1	F111300	STAIRS 13	F1	361 SF			
LEVEL 1	F111400	STAIRS 14	F1	308 SF			
F1				22793 SF		0	
LEVEL 1	F11821	BULK GAS/PURIFIER ROOM	H2/H4	4867 SF			51
LEVEL 1	F11822	PYROPHORIC BUNKER	H2/H4	404 SF			
LEVEL 1	F111122	HAZARDOUS SPECIALTY GAS DISPENSE	H2/H4	5895 SF			
LEVEL 1	F111211	SOLVENT ROOM	H2/H4	3219 SF			
LEVEL 1	F111213	BOTTLE STAGING	H2/H4	384 SF			
LEVEL 1	F111214	COLD STORAGE	H2/H4	639 SF			
H2/H4				15408 SF		0	
LEVEL 1	F111021	AQUEOUS CHEMICAL ROOM	H3/H4	2409 SF			
LEVEL 1	F111212	TOOL STORAGE	H3/H4	452 SF			
LEVEL 1	F111216	SOLVENT CONTROL PANELS	H3/H4	199 SF			
LEVEL 1	F111217	WASTE STAGING	H3/H4	337 SF			
LEVEL 1	F111218	HPM CORRIDOR	H3/H4	1373 SF			
LEVEL 1	F111222	CHEMICAL CONTROL ROOM	H3/H4	366 SF			
GRADE	F111402	SOLVENT WASTE ROOM	H3/H4	1368 SF			
H3/H4				6505 SF		0	
LEVEL 1	F11011	WASTE PIT & IWD TREATMENT	H4	6529 SF			
LEVEL 1	F111121	BULK AQUEOUS CHEMICAL DISPENSE ROOM	H4	4403 SF			33
GRADE	F111401	INDUSTRIAL CHEMICAL STORAGE	H4	1119 SF			12
H4				12050 SF		0	
LEVEL 1	F11010	SUBFAB MANUFACTURING	H5	87295 SF			881
LEVEL 1	F11818	ELEC DIST	H5	489 SF	300 SF	2	5
LEVEL 1	F11819	ERT	H5	213 SF			3
LEVEL 1	F11820	INERT GAS ROOM	H5	449 SF			5
LEVEL 1	F11912	STORAGE	H5	499 SF			
LEVEL 1	F11913	IT TELECOM	H5	450 SF	300 SF	2	5
LEVEL 1	F11914	FMCS - LSS	H5	503 SF			6
LEVEL 1	F11915	PVAC	H5	499 SF			
LEVEL 1	F11916	ERT	H5	216 SF			3
LEVEL 1	F111010	FMCS - LSS	H5	501 SF			
LEVEL 1	F111011	IT TELECOM	H5	452 SF	300 SF	2	
LEVEL 1	F111012	WOMENS RR	H5	201 SF			
LEVEL 1	F111013	MENS RR	H5	200 SF			
LEVEL 1	F111015	FMCS - LSS	H5	452 SF			
LEVEL 1	F111110	SPEC GAS CONTROL ROOM	H5	542 SF			
LEVEL 1	F111111	ELEC DIST	H5	475 SF	300 SF	2	5
LEVEL 1	F111112	IT TELECOM	H5	450 SF	300 SF	2	
LEVEL 1	F111113	ELEC DIST	H5	523 SF	300 SF	2	5
LEVEL 1	F111114	FMCS - LSS	H5	450 SF			
LEVEL 1	F111210	ELEC DIST	H5	216 SF	300 SF	1	
LEVEL 1	F111211	ACID BASE SMALL PACK	H5	216 SF			
LEVEL 1	F111212	HPM LIFT #2	H5	36 SF	0 SF		
LEVEL 1	F111213	IT TELECOM	H5	455 SF	300 SF	2	
LEVEL 1	F111214	ELEC DIST	H5	489 SF	300 SF	2	
LEVEL 1	F111215	HPM MACHINE ROOM	H5	32 SF			
H5				96303 SF		17	
Grand total: 58				154227 SF		17	

LEVEL	ROOM NUMBER	ROOM NAME	OCCUPANCY	AREA	Occupant Load Factor	Occupants per Room	Occupancy Load (room)
LEVEL 3	F111220	Room		Not Enclosed			
				0 SF		0	
LEVEL 3	F13900	STAIRS 9	F1	256 SF	0 SF		
LEVEL 3	F131000	STAIRS 10	F1	274 SF	0 SF		
LEVEL 3	F131100	STAIRS 11	F1	291 SF	0 SF		
LEVEL 3	F131200	STAIRS 12	F1	256 SF	0 SF		
LEVEL 3	F131300	STAIRS 13	F1	361 SF	0 SF		
LEVEL 3	F131400	STAIRS 14	F1	281 SF	0 SF		
F1				1720 SF		0	
LEVEL 3	F13010	DIFF	H5	23873 SF	200 SF	120	
LEVEL 3	F13011	HPM SCRUBBERS	H5	6507 SF	300 SF	22	
LEVEL 3	F13012	LITHO	H5	16725 SF	200 SF	84	
LEVEL 3	F13013	FILMS	H5	32458 SF	200 SF	163	
LEVEL 3	F13014	ETCH	H5	18765 SF	200 SF	94	
LEVEL 3	F13015	EQPT OFF LOADING	H5	903 SF	200 SF	5	
LEVEL 3	F13901	GOWNING / ERT	H5	216 SF	200 SF	2	
LEVEL 3	F13902	LITHO	H5	7451 SF	200 SF	38	
LEVEL 3	F13903	LITHO MAINT.	H5	687 SF	200 SF	4	
LEVEL 3	F131020	IMPLANT	H5	3630 SF	200 SF	19	
LEVEL 3	F131021	IMPLANT SUPPORT 1	H5	6134 SF	200 SF	31	
LEVEL 3	F131022	IMPLANT SUPPORT 2	H5	5118 SF	200 SF	26	
LEVEL 3	F131023	IMPLANT SUPPORT 3	H5	2856 SF	200 SF	15	
LEVEL 3	F131119	ACID SCRUBBER	H5	4874 SF	300 SF	17	
LEVEL 3	F131120	AMMONIA SCRUBBERS	H5	3400 SF	300 SF	12	
LEVEL 3	F131121	RCTO	H5	3389 SF	200 SF	17	
LEVEL 3	F131210	GOWNING / ERT	H5	216 SF	200 SF	2	
LEVEL 3	F131212	HPM LIFT #2	H5	32 SF	0 SF		
LEVEL 3	F131220	FLEX	H5	1855 SF	200 SF	10	
LEVEL 3	F131221	PARTS CLEAN	H5	1623 SF	200 SF	9	
LEVEL 3	F131222	FILMS MAINT.	H5	598 SF	200 SF	3	
LEVEL 3	F131223	ETCH MAINT.	H5	598 SF	200 SF	3	
LEVEL 3	F131224	ANTE.	H5	140 SF	200 SF	1	
LEVEL 3	F131225	DIRTY MAINT.	H5	459 SF	200 SF	3	
LEVEL 3	F131226	IMP MAINT.	H5	598 SF	200 SF	3	
H5				143104 SF		703	
Grand total: 32				144823 SF		703	



1 ZZ **Level 1 - Subfab**
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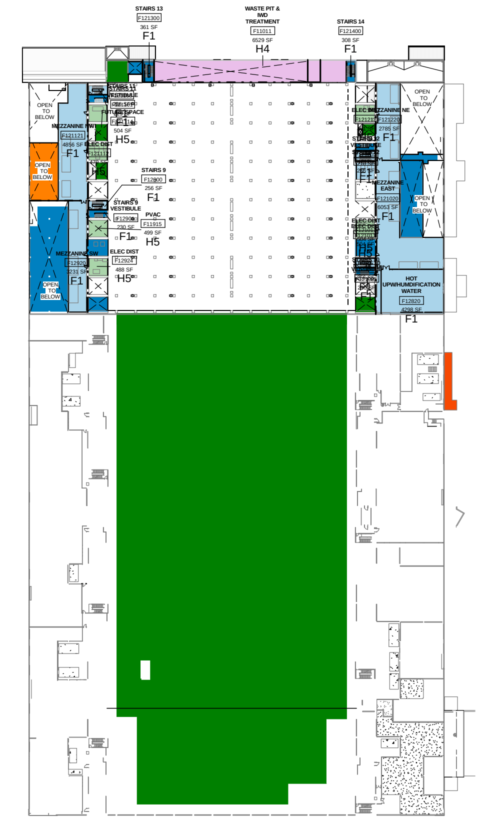

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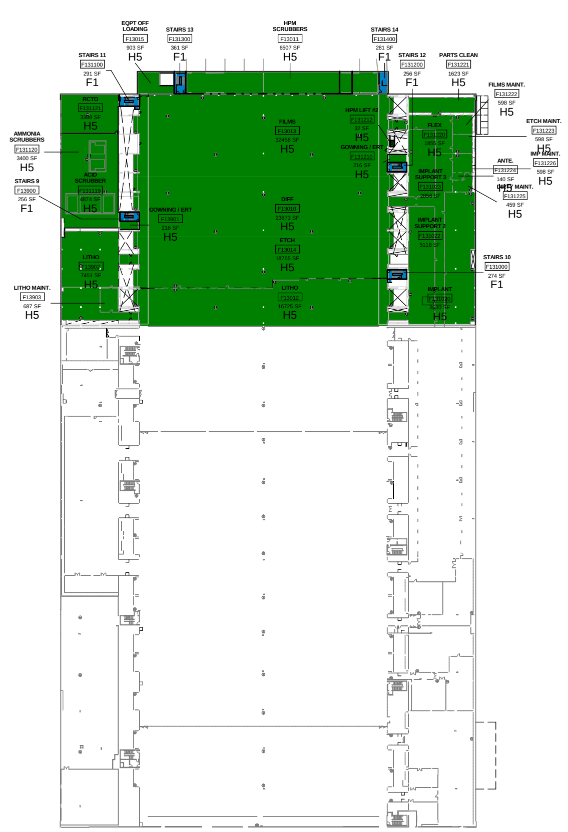

3 ZZ **Level 3 - Fab**
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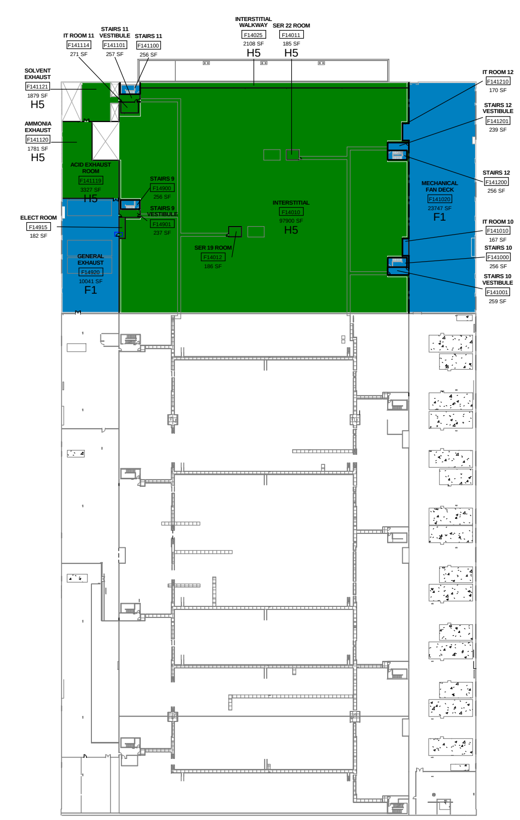


4 ZZ **Level 4 - Interstitial**
SCALE: 1" = 80'-0"

OCCUPANCY LEGEND

- B
- F1
- H2/H3/H4
- H2/H4
- H3/H4
- H4
- H5

LEVEL	ROOM NUMBER	ROOM NAME	OCCUPANCY	AREA	Occupant Load Factor	Occupants per Room	Occupancy Load (room)
LEVEL 1-M	F12014	EQPT OFF LOADING	H5	722 SF			
H5				722 SF		0	
LEVEL 1-M				722 SF		0	
LEVEL 2	F12820	HOT UPW/HUMDIFICATION WATER	F1	4298 SF			
LEVEL 2	F12900	STAIRS 9	F1	256 SF	0 SF		
LEVEL 2	F12901	STAIRS 9 VESTIBULE	F1	230 SF	0 SF		
LEVEL 2	F12920	MEZZANINE SW	F1	3231 SF			
LEVEL 2	F12923	MECH CHASE	F1	554 SF			
LEVEL 2	F121000	STAIRS 10	F1	256 SF	0 SF		
LEVEL 2	F121001	STAIRS 10 VESTIBULE	F1	230 SF	0 SF		
LEVEL 2	F121010	EGRESS PASSAGEWAY	F1	329 SF	0 SF		
LEVEL 2	F121012	MECH CHASE	F1	531 SF			
LEVEL 2	F121015	FUTURE SPACE (OPEN TO SUBFAB)	F1	504 SF			
LEVEL 2	F121020	MEZZANINE EAST	F1	6053 SF			
LEVEL 2	F121100	STAIRS 11	F1	256 SF	0 SF		
LEVEL 2	F121101	STAIRS 11 VESTIBULE	F1	229 SF	0 SF		
LEVEL 2	F121121	MEZZANINE NW	F1	4856 SF			
LEVEL 2	F121200	STAIRS 12	F1	256 SF	0 SF		
LEVEL 2	F121202	STAIRS 12 VESTIBULE	F1	216 SF	0 SF		
LEVEL 2	F121220	MEZZANINE NE	F1	2785 SF			
LEVEL 2	F121300	STAIRS 13	F1	361 SF	0 SF		
LEVEL 2	F121400	STAIRS 14	F1	308 SF	0 SF		
F1				25742 SF		0	
LEVEL 2	F12924	ELEC DIST	H5	488 SF	300 SF	2	
LEVEL 2	F121011	ELEC DIST	H5	504 SF	300 SF	2	
LEVEL 2	F121112	ELEC DIST	H5	479 SF	300 SF	2	
LEVEL 2	F121114	FUTURE SPACE	H5	504 SF			
LEVEL 2	F121213	ELEC DIST	H5	491 SF	300 SF	2	
H5				2466 SF		8	
LEVEL 2				28208 SF		8	
Grand total: 25				28930 SF		8	

LEVEL	ROOM NUMBER	ROOM NAME	OCCUPANCY	AREA	Occupant Load Factor	Occupants per Room	Occupancy Load (room)
LEVEL 4	F14900	STAIRS 9	F1	256 SF	0 SF		
LEVEL 4	F14920	GENERAL EXHAUST	F1	10041 SF	300 SF	34	
LEVEL 4	F141000	STAIRS 10	F1	256 SF	0 SF		
LEVEL 4	F141001	STAIRS 10 VESTIBULE	F1	259 SF	200 SF	2	
LEVEL 4	F141010	IT ROOM 10	F1	167 SF	300 SF	1	
LEVEL 4	F141020	MECHANICAL FAN DECK	F1	23747 SF	300 SF	80	
LEVEL 4	F141100	STAIRS 11	F1	256 SF	0 SF		
LEVEL 4	F141200	STAIRS 12	F1	256 SF	0 SF		
LEVEL 4	F141201	STAIRS 12 VESTIBULE	F1	239 SF	200 SF	2	
LEVEL 4	F141210	IT ROOM 12	F1	170 SF	300 SF	1	
F1				35647 SF		120	
LEVEL 4	F14010	INTERSTITIAL	H5	97900 SF	200 SF	490	
LEVEL 4	F14011	SER 22 ROOM	H5	185 SF	300 SF	1	
LEVEL 4	F14012	SER 19 ROOM	H5	186 SF	300 SF	1	
LEVEL 4	F14025	INTERSTITIAL WALKWAY	H5	2108 SF	300 SF	8	
LEVEL 4	F14901	STAIRS 9 VESTIBULE	H5	237 SF	200 SF	2	
LEVEL 4	F14915	ELECT ROOM	H5	182 SF	300 SF	1	
LEVEL 4	F141101	STAIRS 11 VESTIBULE	H5	257 SF	200 SF	2	
LEVEL 4	F141114	IT ROOM 11	H5	271 SF	300 SF	1	
LEVEL 4	F141119	ACID EXHAUST ROOM	H5	3327 SF	300 SF	12	
LEVEL 4	F141120	AMMONIA EXHAUST	H5	1781 SF	300 SF	6	
LEVEL 4	F141121	SOLVENT EXHAUST	H5	1879 SF	300 SF	7	
H5				108313 SF		531	
Grand total: 21				143960 SF		651	

ACME
Semiconductor

ARCHITECT/ENGINEER OF RECORD

Consultant

MODULE 1 EXTENSION

Project Name

PROGRESS PRINT
NOT FOR CONSTRUCTION

No	Date	Revision	By

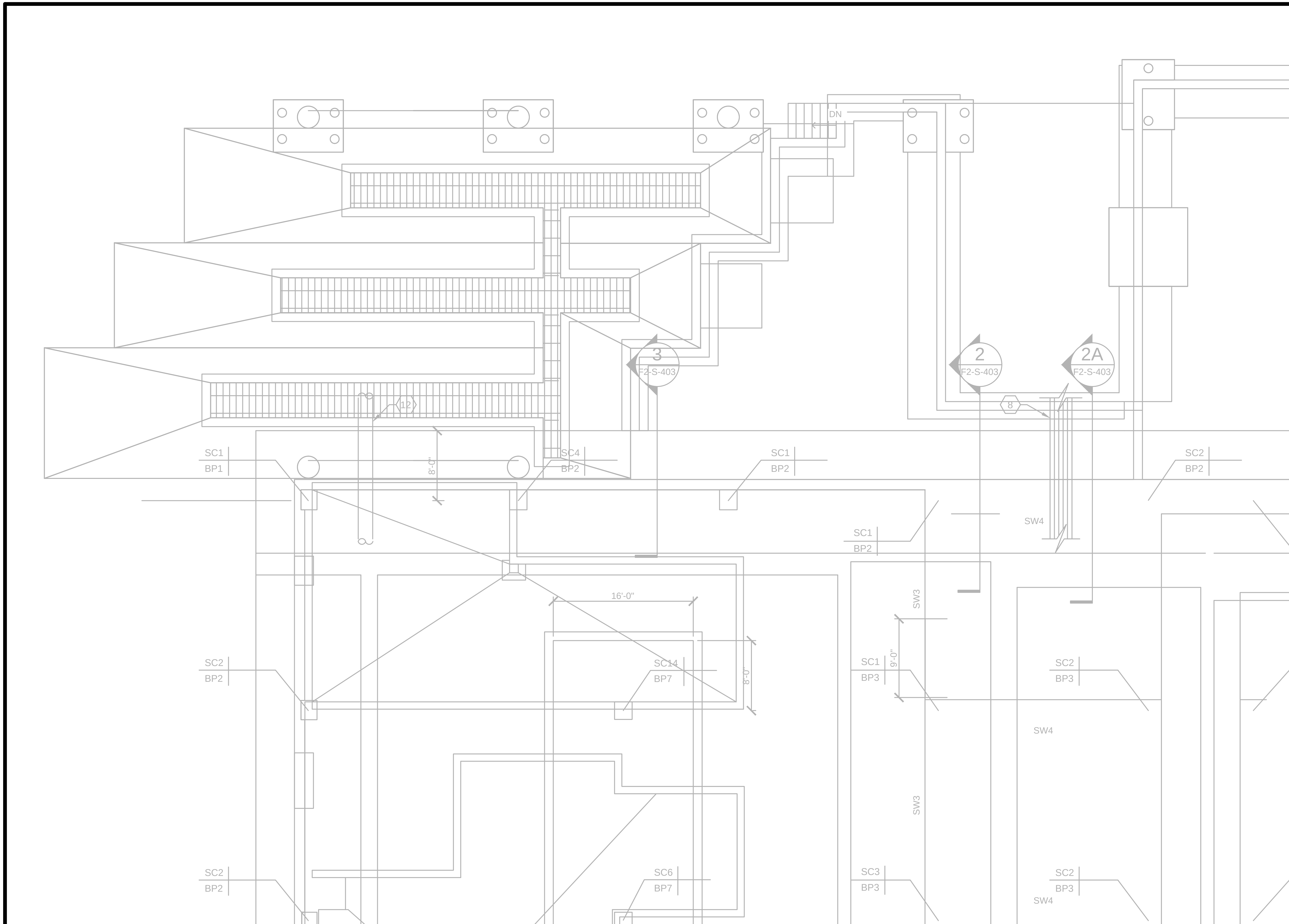
Date:
Proj:#
Checked By: Checker
Drawn By: Author

Sheet Title

Sheet No.

CONFIDENTIAL

CONFIDENTIAL



Consultant

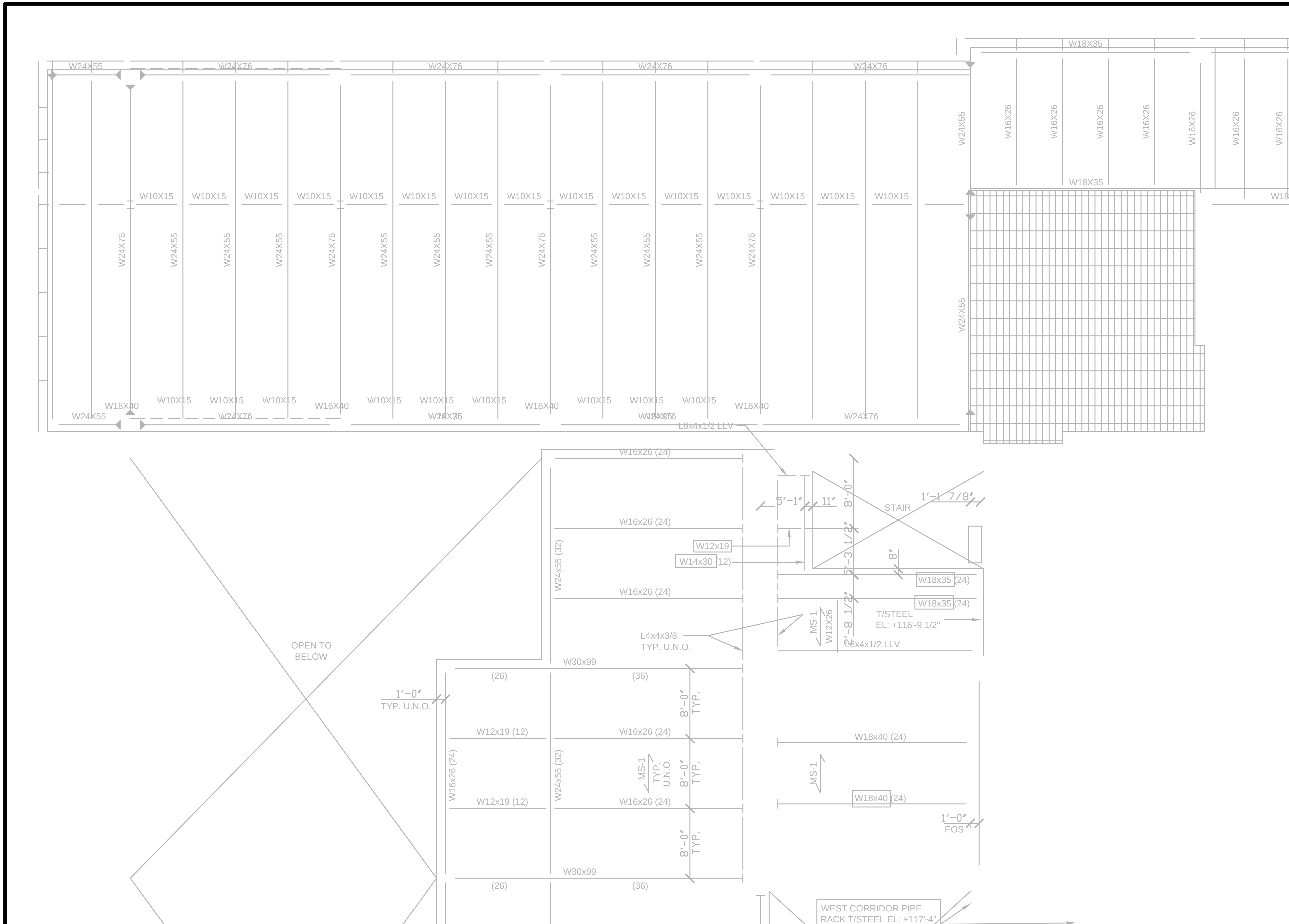
Project Title: ACME SEMICONDUCTOR FAB
MODULE 1 EXPANSION

Drawing Title: Level 1 - Structural
Northwest Quadrant

Drawn By:
Checked By:
Date:
Issue Type
Ref Drawing
Drawing No:

CONFIDENTIAL

CONFIDENTIAL



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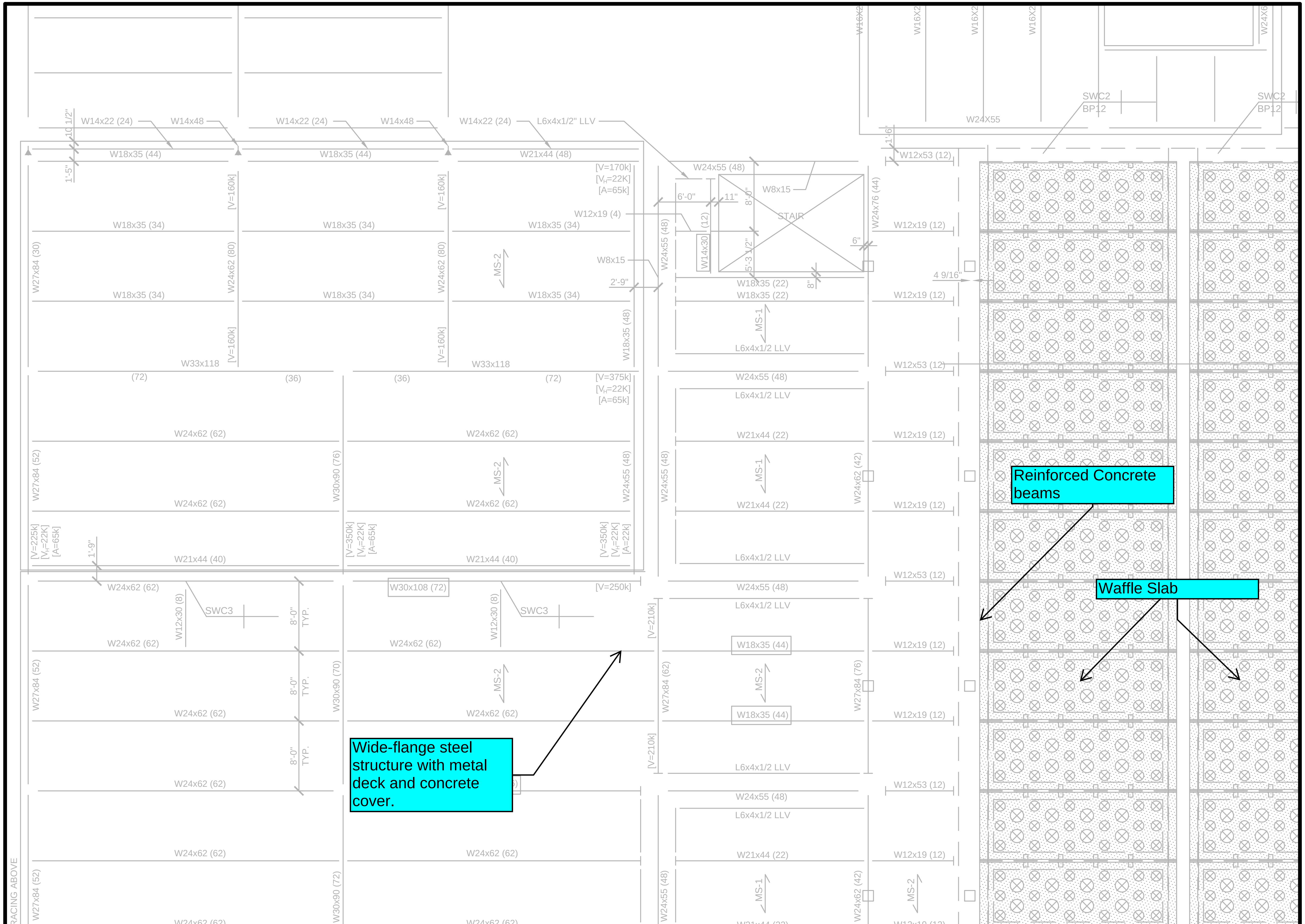
Project Title: ACME SEMICONDUCTOR FAB MODULE 1 EXPANSION

Drawing Title: Level 2 - Structural Northwest Quadrant

Drawn By:
Checked By:
Date:
Issue Type
Ref Drawing
Drawing No:



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Project Title: ACME SEMICONDUCTOR FAB
MODULE 1 EXPANSION

Drawing Title: Level 3 - Structural
Northwest Quadrant

Drawn By:
Checked By:
Date:
Issue Type
Ref Drawing
Drawing No:

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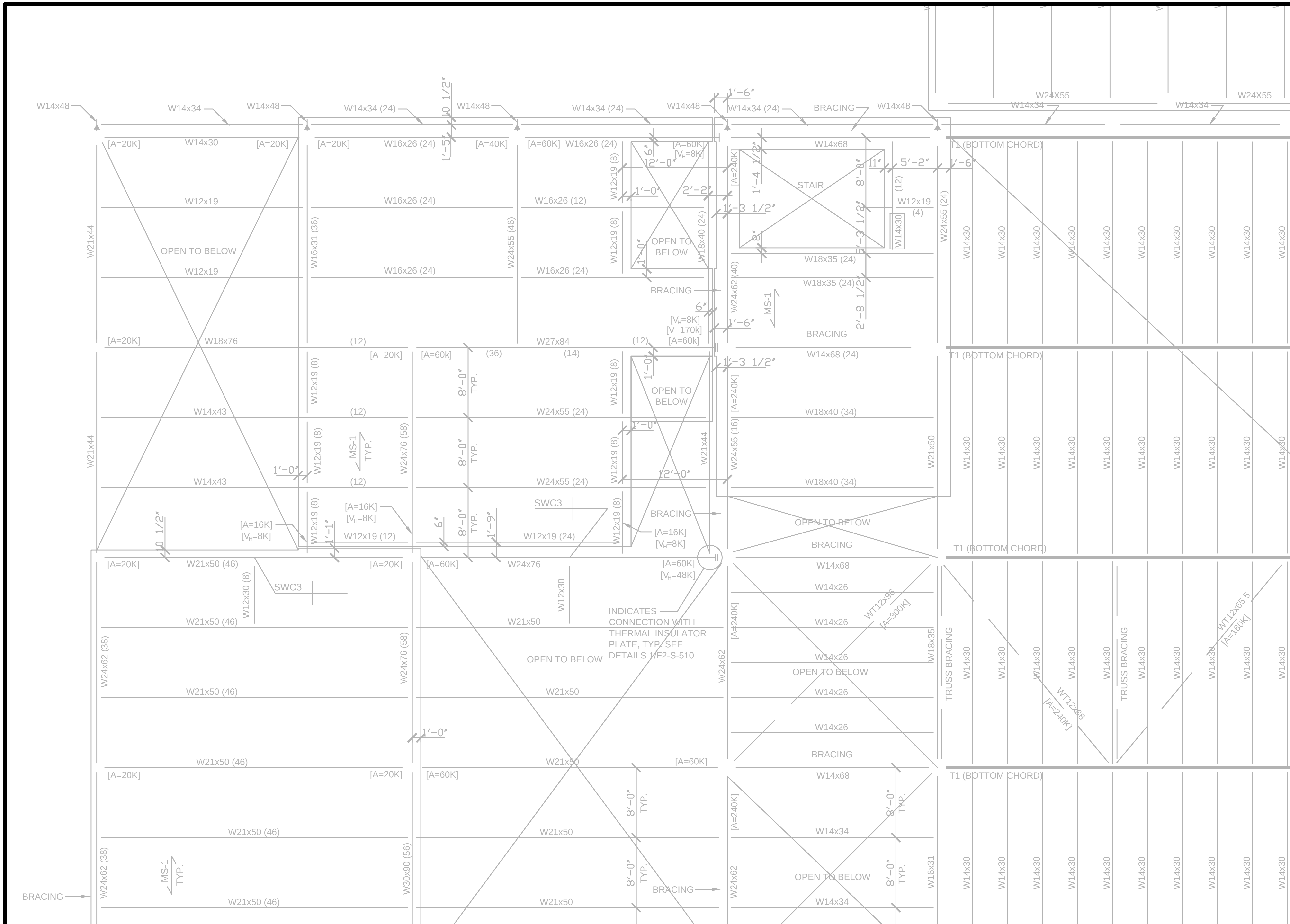

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Project Title: ACME SEMICONDUCTOR FAB MODULE 1 EXPANSION

Drawing Title: Level 4 - Structural Northwest Quadrant

Drawn By: ______
Checked By: ______
Date: ______
Issue Type ______
Ref Drawing ______
Drawing No: ______

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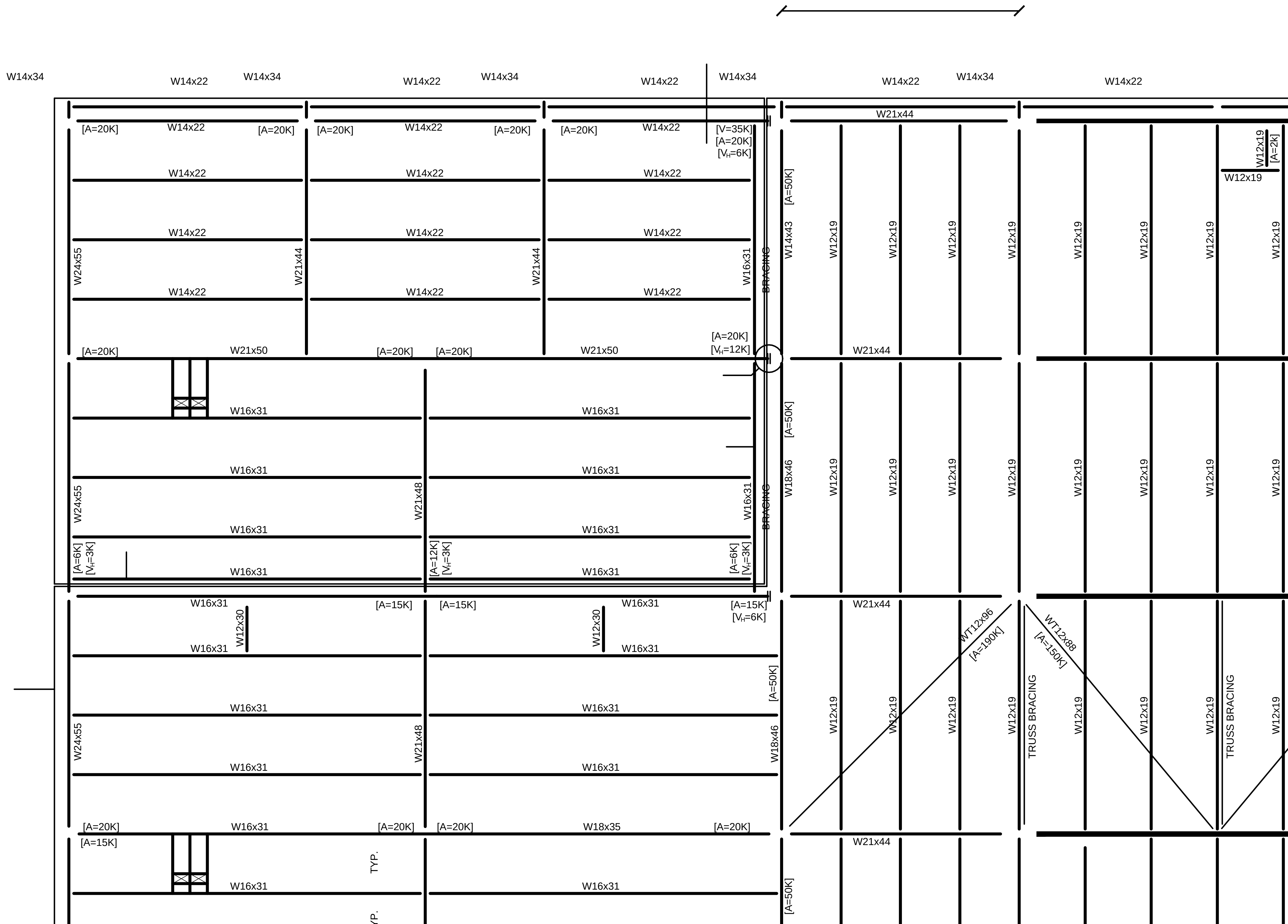

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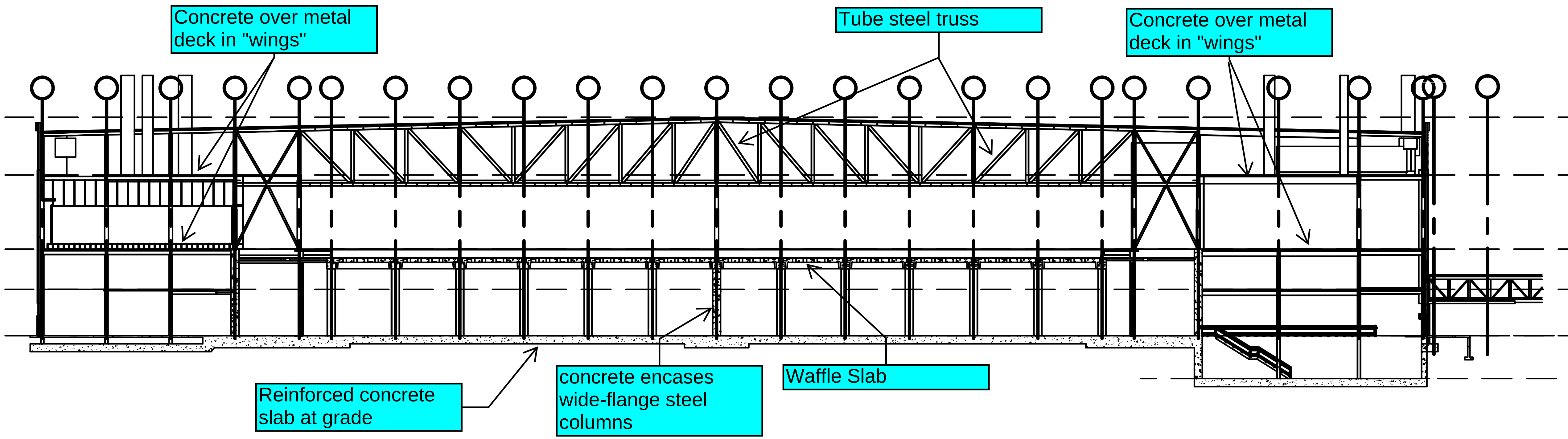
Project Title: ACME SEMICONDUCTOR FAB
MODULE 1 EXPANSION

Drawing Title: Level 5 (ROOF) - Structural
Northwest Quadrant

Drawn By:
Checked By:
Date:
Issue Type
Ref Drawing
Drawing No:



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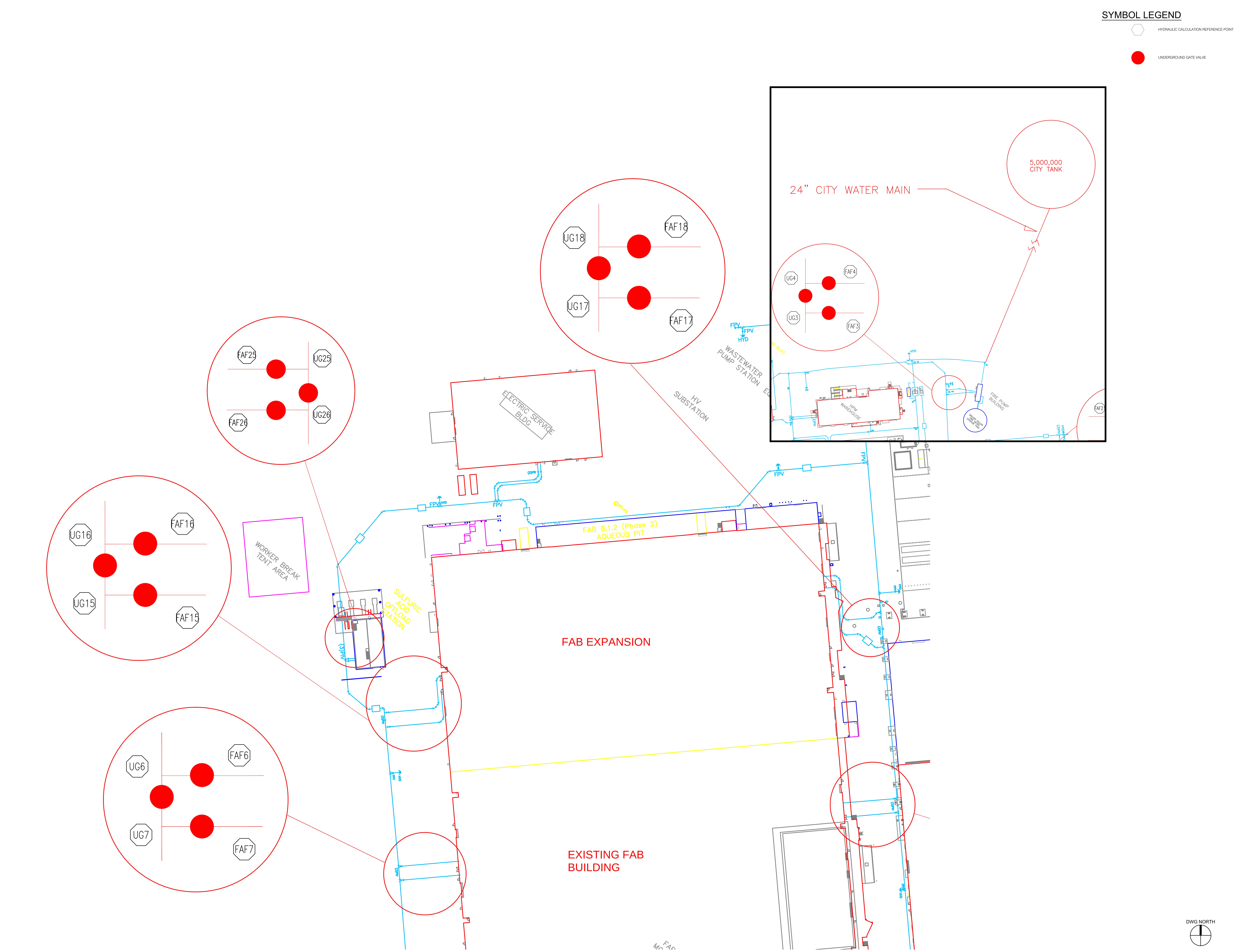
Project Title: ACME SEMICONDUCTOR FAB MODULE 1 EXPANSION

Drawing Title: Structural Section Drawing East-West Section View

Drawn By:
Checked By:
Date:
Issue Type
Ref Drawing
Drawing No:

Appendix B – Fire Protection Site Plan



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Project Title

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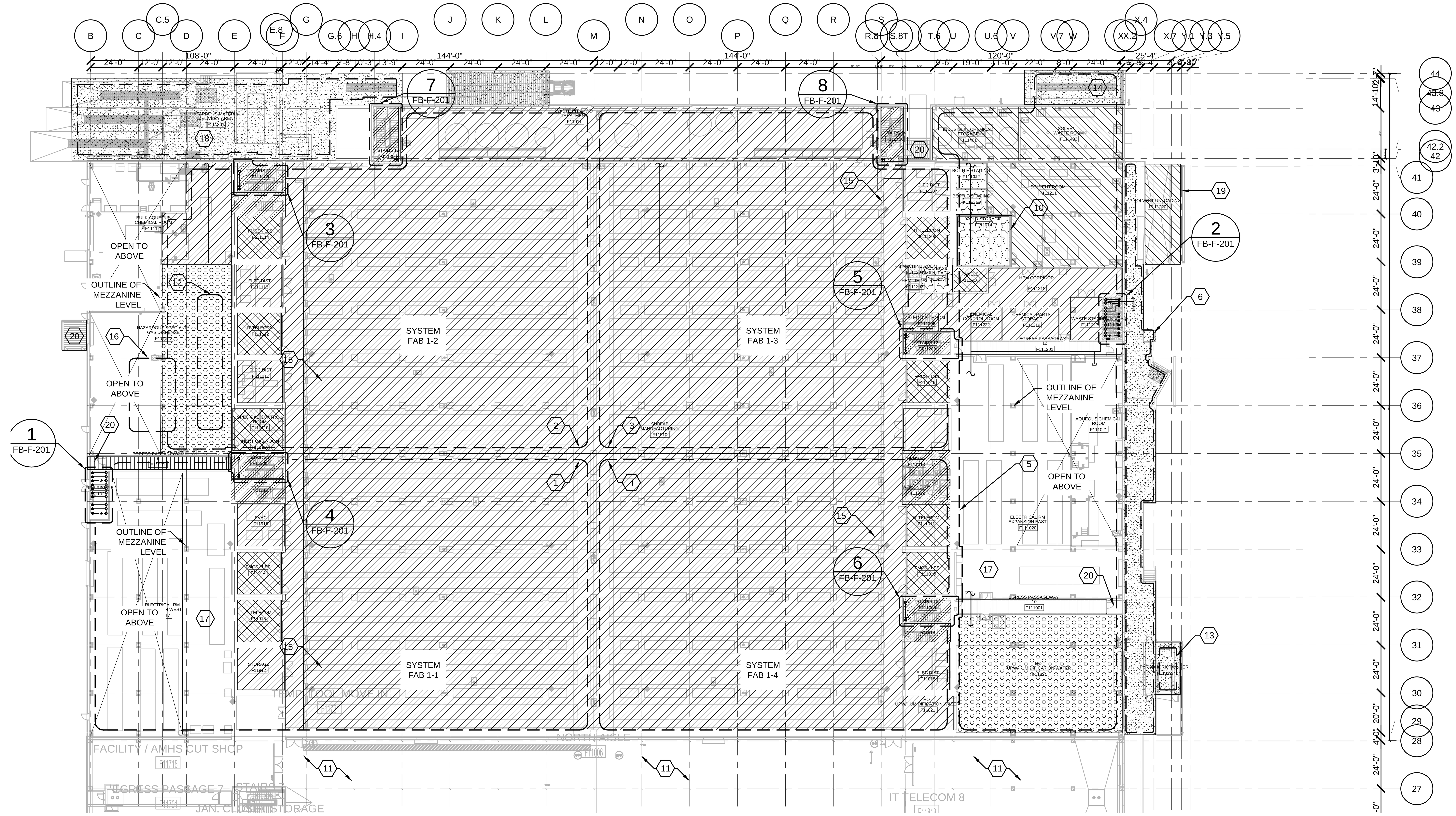
Drawn By: J. EPSTEIN

Sheet Title
FAB
SITE
PLAN

Sheet No.
FB-F
001

Appendix C – Fire Protection Engineering Drawings

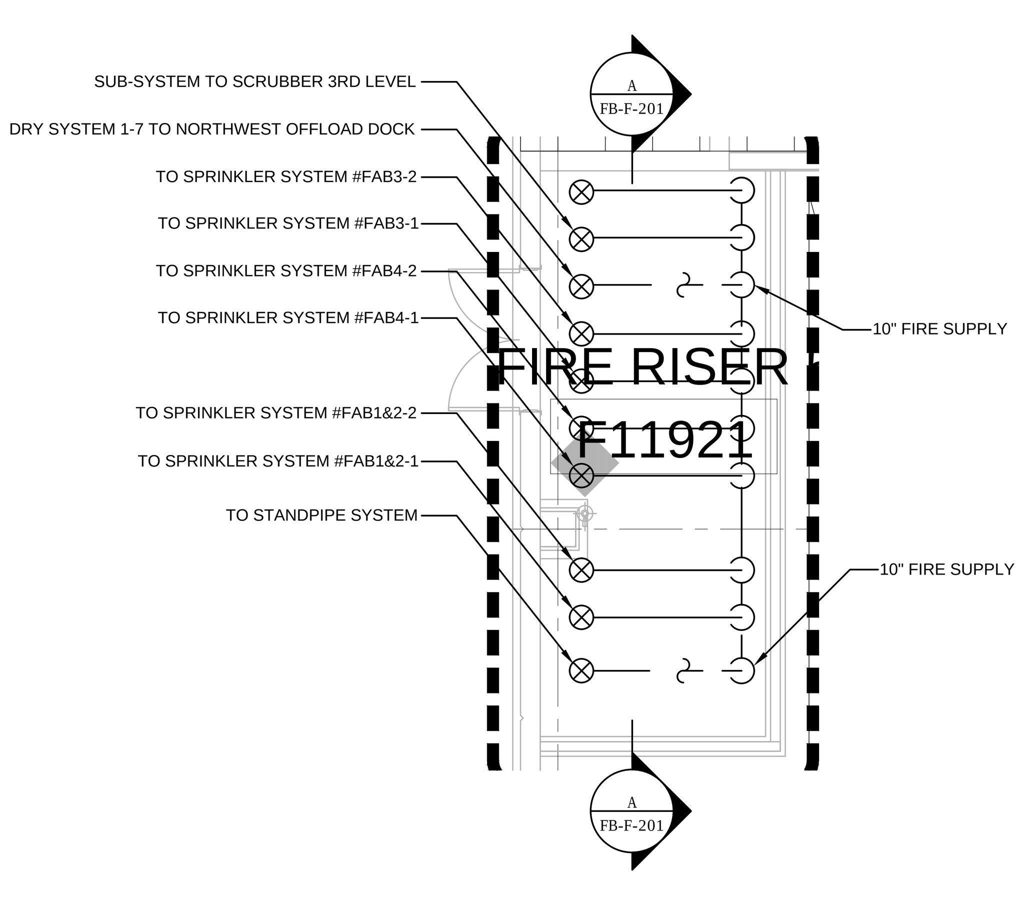


KEYED NOTES:

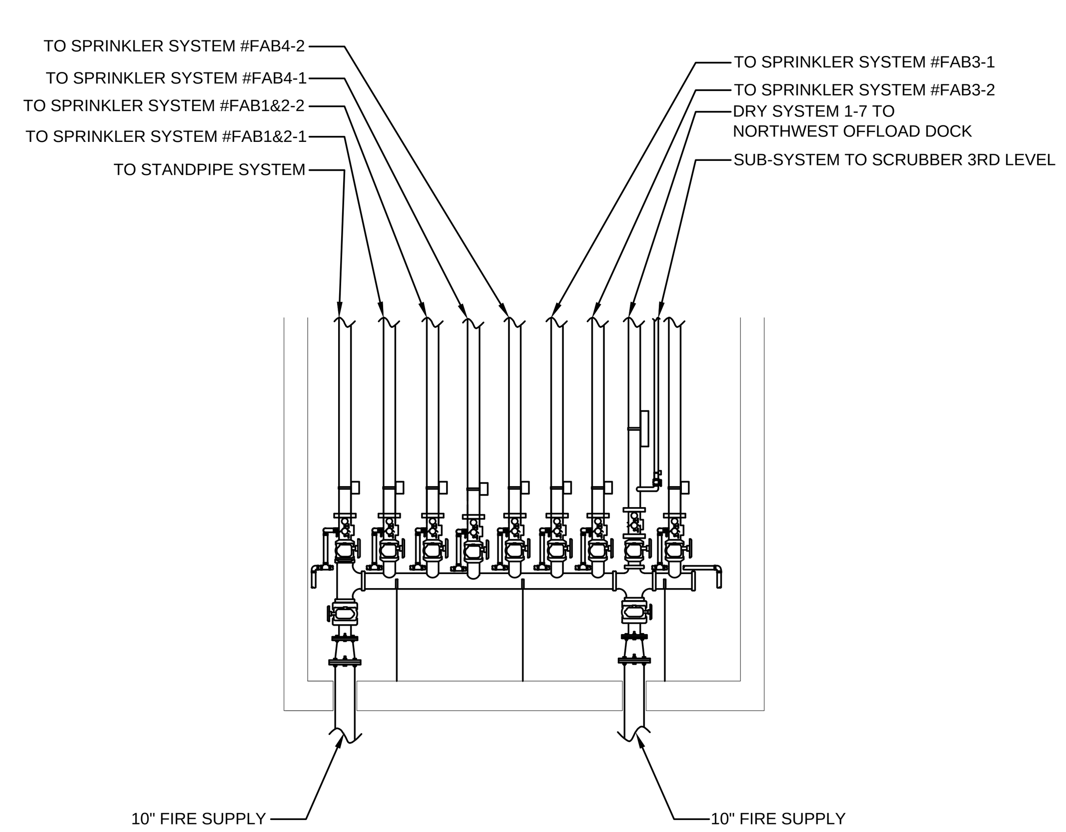
1. SPRINKLER ZONE 1 (FAB 1&2-1), LEVEL 1 (BELOW MEZZ) AND LEVEL 2 CLG.
2. SPRINKLER ZONE 2 (FAB 1&2-2), LEVEL 1 (BELOW MEZZ) AND LEVEL 2 CLG.
3. SPRINKLER ZONE 3 (FAB 2-3), LEVEL 2 CLG.
4. SPRINKLER ZONE 4 (FAB 2-4), LEVEL 2 CLG.
5. SPRINKLER ZONE 5 (FAB 1&2-5), LEVEL 1 (BELOW MEZZ) AND LEVEL 2 CLG.
6. SPRINKLER ZONE 6 (FAB 1-6), DRY SYSTEM TO LOADING DOCK.
7. TYPICAL 2-1/2 INCH FIRE HOSE VALVE AT 3 TO 4 FEET ABOVE FINISHED FLOOR.
8. TYPICAL PIPE OFFSET AT CEILING AND UP THROUGH FLOOR TO UPPER LEVEL.
9. TYPICAL EGRESS CLEARANCE (44-INCH MIN.) HOSE VALVE TO BE INSTALLED AWAY FROM CLEARANCE AREA.
10. PROVIDE TEE CONNECTION FOR VENDOR PROVIDED FREEZER TO BE PROTECTED WITH DRY PENDENT SPRINKLERS.
11. EXISTING SPRINKLER SYSTEM TO REMAIN.
12. PROVIDE SPRINKLER PROTECTION INSIDE GAS CABINETS, VMB, AND ABATEMENT EQUIPMENT. FINAL LOCATIONS AND QUANTITIES TO BE FIELD COORDINATED.
13. DRY SPRINKLER PROTECTION TO PYROPHORIC STORAGE BUNKER AND INSIDE CABINETS FROM DEDICATED DRY SYSTEM IN RISER ROOM 6.
14. NORTHEAST CANOPY SYSTEM SUPPLIED BY DRY SYSTEM 1-6.
15. PROVIDE SPRINKLER COVERAGE BELOW EQUIPMENT PLATFORM. SYSTEM TO BE SUPPLIED BY LEVEL 2 CEILING LEVEL SYSTEM WITH ISOLATION CONTROL VALVES AND AUXILIARY DRAINS.
16. PROVIDE SPRINKLER DROP DOWN TO DIRECTLY OVER EACH BULK GAS STORAGE TANK CONTAINING FLAMMABLE GAS. PROVIDE EACH SPRINKLER WITH A 12" X 12" STEEL HEAT SHIELD AND LISTED SPRINKLER GUARD. CONTRACTOR TO PROVIDE HYDRAULIC CALCULATIONS WITH A MIN. DISCHARGE DENSITY EQUIVALENT TO THE CEILING LEVEL SYSTEM. (4) SPRINKLER TO BE INCLUDED IN THE CEILING LEVEL REMOTE AREA CALCULATION. FINAL LOCATIONS AND QUANTITIES TO BE FIELD COORDINATED.
17. ELECTRICAL DISTRIBUTION ROOMS ABOVE AND BELOW MEZZANINE - NO SPRINKLER PROVIDED PER FCNYS SECTION 903.3.1.1.1. AUTOMATIC FIRE DETECTION REQUIRED IN ACCORDANCE WITH SECTION 907.2.
18. SPRINKLER ZONE 7 (FAB 1-7), DRY SYSTEM TO LOADING DOCK.
19. PROVIDE A DRY PILOT ACTUATED WATER SPRAY FIXED SUPPRESSION SYSTEM INSTALLED IN ACCORDANCE WITH NFPA 15 2007 EDITION AND FMDS 4-1N. AREA PROTECTED IS TO BE THE AREA OF THE SOLVENT UNLOADING BAY AND 10-FT BEYOND. UTILZE INTERMEDIATE SPRINKLERS TO PROVIDE DRY PILOT ACTUATION.
20. PROVIDE DRY HORIZONTAL SIDEWALL COVERAGE TO SMALL EXTERIOR CANOPIES.

DESIGN DENSITY LEGEND

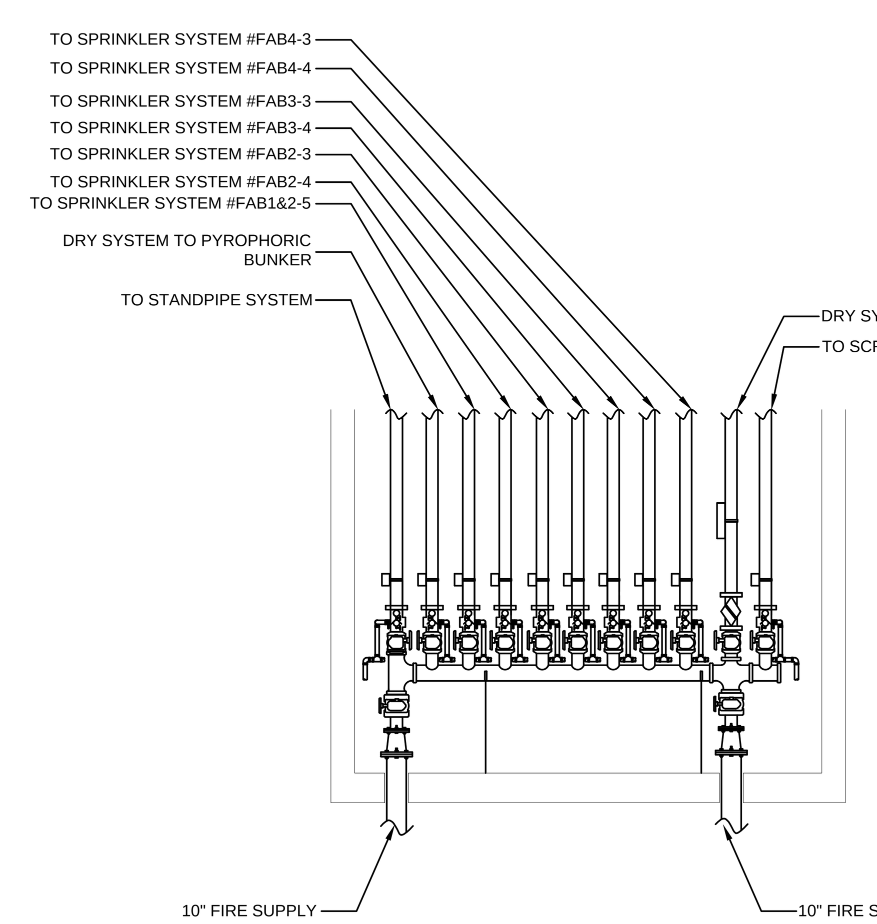
	NO SPRINKLERS REQUIRED. SEE KEYNOTE 17.
	0.10 gpm/sq ft / 1,500 sq ft - LIGHT HAZARD
	0.20 gpm/sq ft / ENTIRE AREA - ORDINARY HAZARD GROUP II
	OWNER SPECIFIED: 0.15 gpm/sq ft / 3,000 sq ft MIN. NFPA: 0.15 gpm/sq ft / 1,500 sq ft - ORDINARY HAZARD GROUP I
	OWNER SPECIFIED: 0.20 gpm/sq ft / 3,000 sq ft MIN. NFPA: 0.20 gpm/sq ft / 1,500 sq ft - ORDINARY HAZARD GROUP II
	OWNER SPECIFIED: 0.17 gpm/sq ft / 3,900 sq ft - DRY SYSTEM MIN. NFPA: 0.20 gpm/sq ft / 1,950 sq ft - OH G II - DRY SYSTEM
	OWNER SPECIFIED: 0.30 gpm/sq ft / 3,000 sq ft MIN. NFPA: 0.30 gpm/sq ft / 2,500 sq ft - EXTRA HAZARD GROUP I
	OWNER SPECIFIED: 0.25 gpm/sq ft / ENTIRE AREA (LESS THAN 3,000 SQ.FT.) MIN. NFPA: 0.25 gpm/sq ft / 2,500 sq ft - EXTRA HAZARD GROUP I
	OWNER SPECIFIED: 0.60 gpm/sq ft / ENTIRE AREA (LESS THAN 3,000 SQ.FT.) MIN. NFPA: 0.60 gpm/sq ft / ENTIRE AREA (LESS THAN 3,000 SQ. FT.)



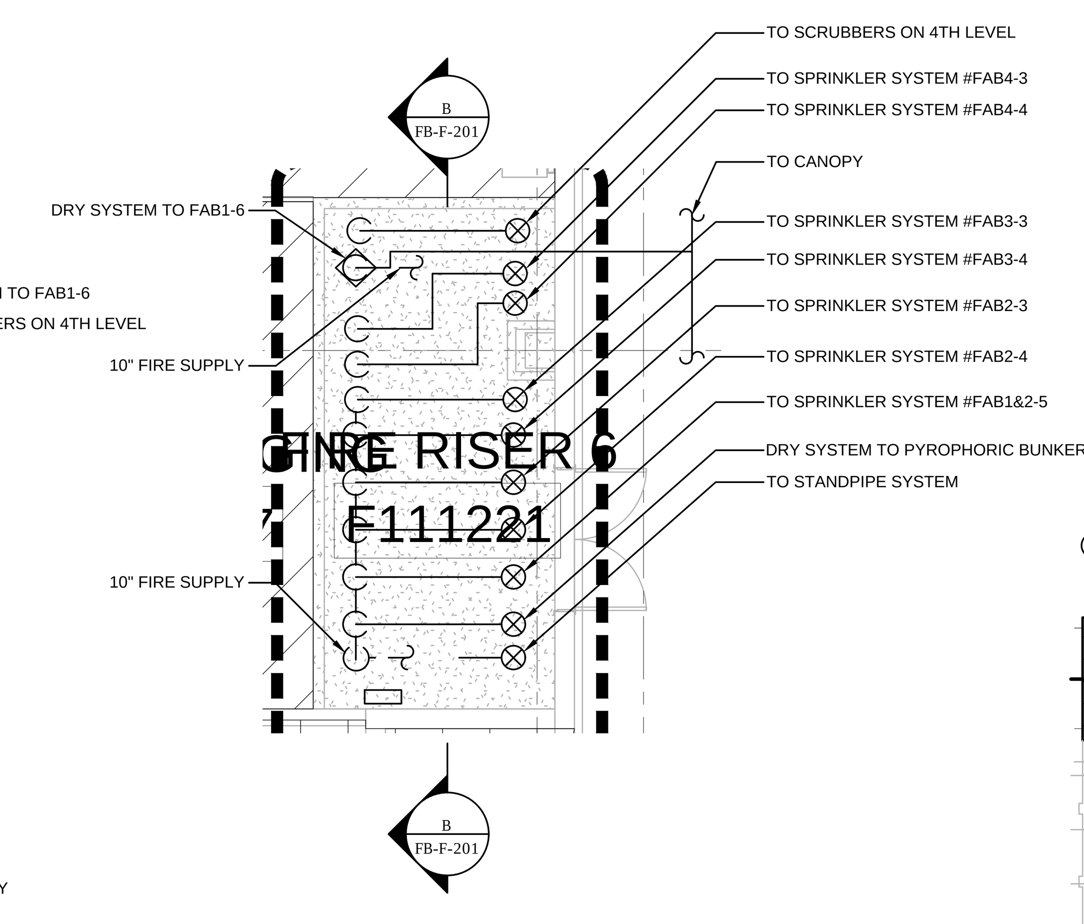
1 LEVEL 1 FIRE RISER ROOM 5 (F11921)
FB-F-201 SCALE: 3/16"=1'-0"



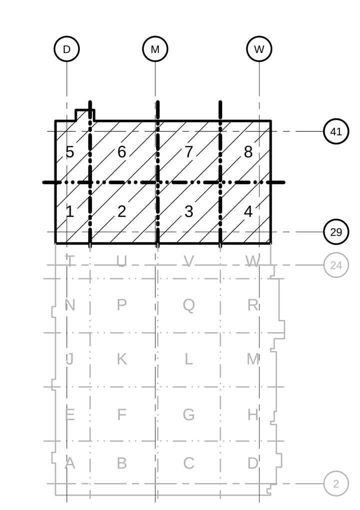
A FIRE RISER ROOM 5 ELEVATION
FB-F-201 SCALE: NTS



B FIRE RISER ROOM 6 ELEVATION
FB-F-201 SCALE: NTS



2 LEVEL 1 FIRE RISER ROOM 6 (F111221)
FB-F-201 SCALE: 3/16"=1'-0"



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

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0	03/15/16	FPE S523	JE

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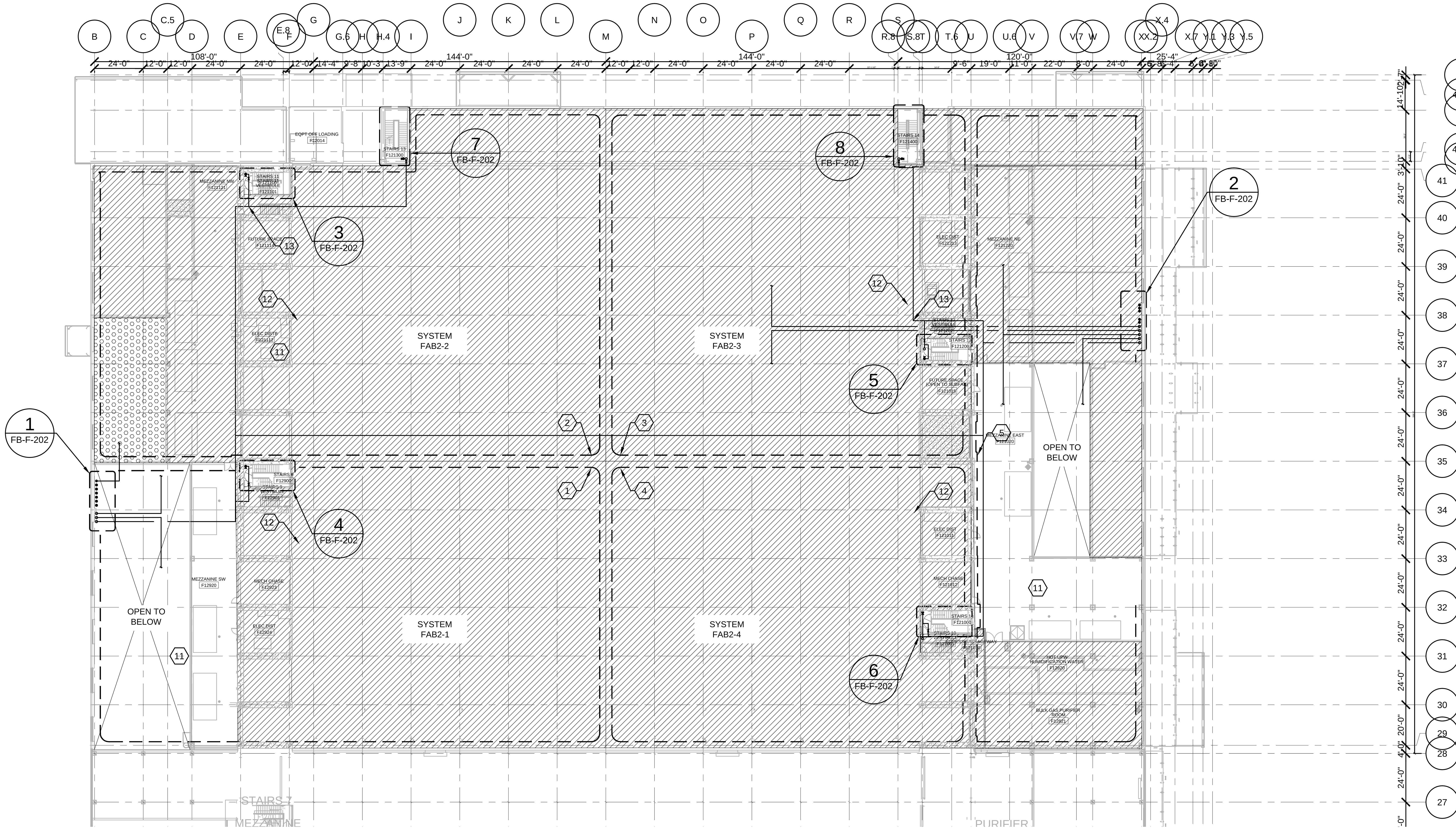
Drawn By:	J. EPSTEIN

Sheet Title
FAB FIRE PROTECTION SPRINKLER DESIGN DENSITY LEVEL 1

Sheet No.
FB-F 101

SYMBOL LEGEND

HYDRAULIC CALCULATION REFERENCE POINT



KEYED NOTES:

1. SPRINKLER ZONE 1 (FAB 1&2-1), LEVEL 1 (BELOW MEZZ) AND LEVEL 2 CLG.
2. SPRINKLER ZONE 2 (FAB 1&2-2), LEVEL 1 (BELOW MEZZ) AND LEVEL 2 CLG.
3. SPRINKLER ZONE 3 (FAB 2-3), LEVEL 2 CLG.
4. SPRINKLER ZONE 4 (FAB 2-4), LEVEL 2 CLG.
5. SPRINKLER ZONE 5 (FAB 1&2-5), LEVEL 1 (BELOW MEZZ) AND LEVEL 2 CLG.
6. TYPICAL 2-1/2 INCH FIRE HOSE VALVE AT 3 TO 4 FEET ABOVE FINISHED FLOOR.
7. TYPICAL PIPE OFFSET AT CEILING AND UP THOUGH FLOOR TO UPPER LEVEL.
8. TYPICAL EGRESS CLEARANCE (44-INCH MIN.) HOSE VALVE TO BE INSTALLED AWAY FROM CLEARANCE AREA.
9. TYPICAL RISER MAIN SHUT-OFF BUTTERFLY VALVE WITH TAMPER SWITCH AT CEILING.
10. TO STANDPIPE LOOP.
11. ELECTRICAL DISTRIBUTION ROOMS - NO SPRINKLER PROVIDED PER FCNYS SECTION 903.3.1.1.1. AUTOMATIC FIRE DETECTION REQUIRED IN ACCORDANCE WITH SECTION 907.2.
12. DROP DOWN SPRINKLER MAIN FOR SYSTEM BELOW GRATED EQUIPMENT PLATFORM. PROVIDE ISOLATION CONTROL VALVES AND AUXILIARY DRAINS.
13. TIE-IN TO EXISTING STANDPIPE LOOP TO SUPPLY NEW STANDPIPE IN STAIRS 13 AND 14.

DESIGN DENSITY LEGEND

	NO SPRINKLERS REQUIRED. SEE KEYNOTE 17.
	0.10 gpm/sq ft / 1,500 sq ft - LIGHT HAZARD
	OWNER SPECIFIED: 0.20 gpm/sq ft / 3,000 sq ft
	MIN. NFPA: 0.20 gpm/sq ft / 1,500 sq ft - ORDINARY HAZARD GROUP II
	OWNER SPECIFIED: 0.30 gpm/sq ft / ENTIRE AREA - SEE KEYNOTE 13
	MIN. NFPA: 0.30 gpm/sq ft / 3,250 sq ft - OH GRP II - DRY SYSTEM
	OWNER SPECIFIED: 0.25 gpm/sq ft / ENTIRE AREA (LESS THAN 3,000 SQ.FT.)
	MIN. NFPA: 0.25 gpm/sq ft / 2,500 sq ft - EXTRA HAZARD GROUP I

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Sheet Title

FAB FIRE PROTECTION SPRINKLER DESIGN DENSITY LEVEL 2

Sheet No.

FB-F 102

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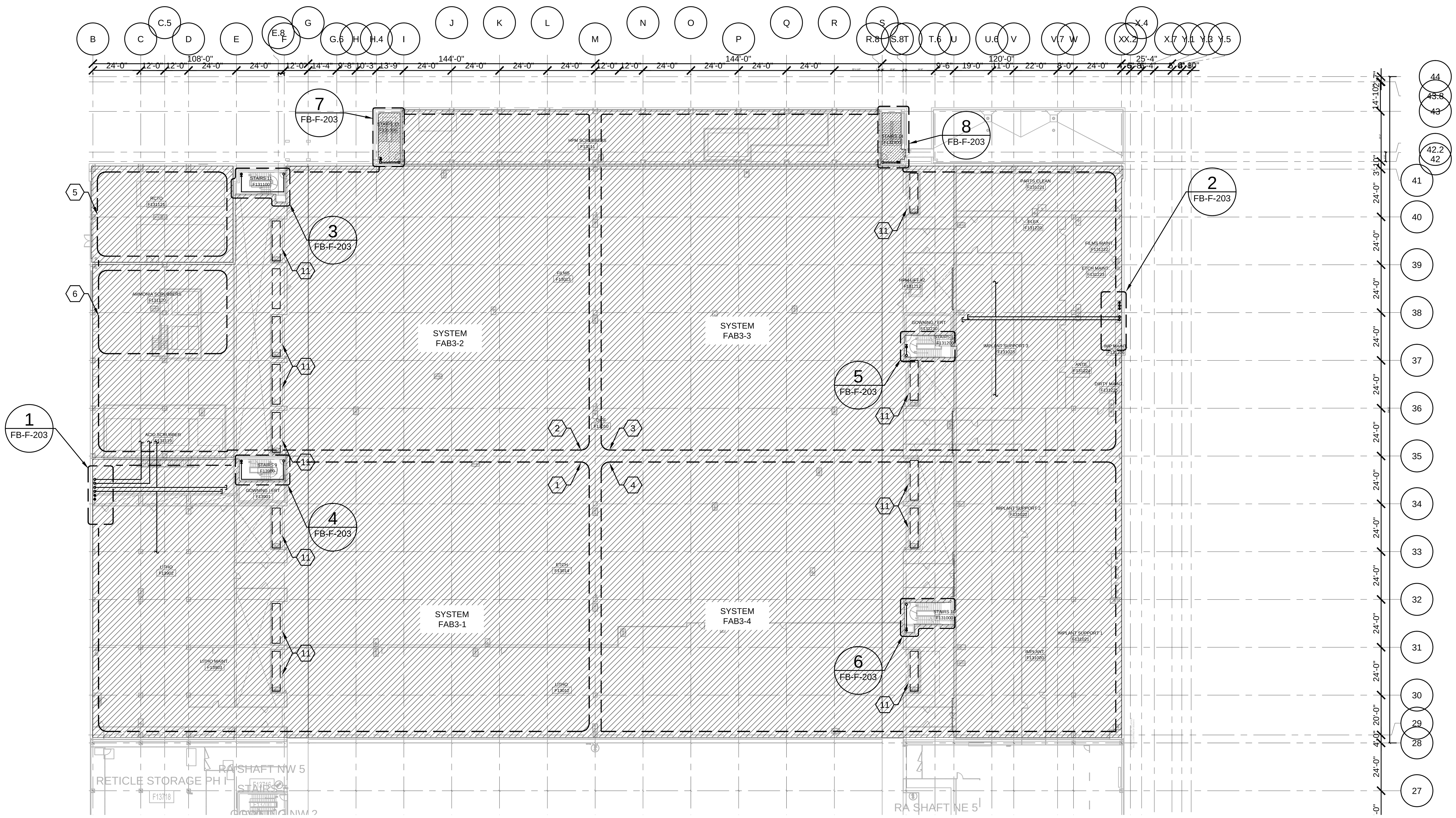
SYMBOL LEGEND

HYDRAULIC CALCULATION REFERENCE POINT



KEYED NOTES:

1. SPRINKLER ZONE 1 (FAB 3-1), LEVEL 3 AND FUTURE CLEAN ROOM.
2. SPRINKLER ZONE 2 (FAB 3-2), LEVEL 3 AND FUTURE CLEAN ROOM.
3. SPRINKLER ZONE 3 (FAB 3-3), LEVEL 3 AND FUTURE CLEAN ROOM.
4. SPRINKLER ZONE 4 (FAB 3-4), LEVEL 3 AND FUTURE CLEAN ROOM.
5. EXISTING SYSTEM TO BE REWORKED TO BE SUPPLIED BY ADJACENT ZONE 3-2 WET SYSTEM.
6. SUB-SYSTEM TO SCRUBBERS.
7. TYPICAL 2-1/2 INCH FIRE HOSE VALVE AT 3 TO 4 FEET ABOVE FINISHED FLOOR.
8. PIPE OFFSET AT CEILING AND CROSS STAIR TO OPPOSITE SIDE OF STAIR.
9. TYPICAL PIPE OFFSET AT CEILING AND UP THROUGH FLOOR TO UPPER LEVEL.
10. TYPICAL EGRESS CLEARANCE (44-INCH IN.) HOSE VALVE TO BE INSTALLED AWAY FROM CLEARANCE AREA.
11. PROVIDE SPRINKLERS TO INSIDE THE FOUP STOCKERS ABOVE THE CLEANROOM CEILING.
12. SPRINKLER PROTECTION FOR FUME EXHAUST SCRUBBERS REFER TO MECHANICAL DRAWINGS FOR EXACT LOCATION. SEPARATE RISER CONTROL VALVE AT RISER ROOM. SPRINKLERS ON OUTLETS ONLY (VERTICAL SCRUBBERS).
13. PROVIDE 2 HIGH FLOW SPRINKLERS PER STOCKER. FOR EXACT LOCATION REFER TO AMHS DRAWINGS.
14. SPRINKLER PROTECTION TO INTERSTITIAL SPACE FROM SYSTEM FAB3-3
15. SPRINKLER PROTECTION TO INTERSTITIAL SPACE FROM SYSTEM FAB3-5
16. SPRINKLER PROTECTION TO INTERSTITIAL SPACE FROM SYSTEM FAB3-6
17. SPRINKLER PROTECTION TO INTERSTITIAL SPACE FROM SYSTEM FAB3-7
18. SPRINKLER PROTECTION TO INTERSTITIAL SPACE FROM SYSTEM FAB3-8

DESIGN DENSITY LEGEND

- 0.10 gpm/sq ft / 1,500 sq ft - LIGHT HAZARD
- OWNER SPECIFIED: 0.20 gpm/sq ft / 3,000 sq ft
- MIN. NFPA: 0.20 gpm/sq ft / 1,500 sq ft - ORDINARY HAZARD GROUP II

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Sheet Title

FAB
FIRE PROTECTION
SPRINKLER
DESIGN DENSITY
LEVEL 3

Sheet No.

FB-F
103

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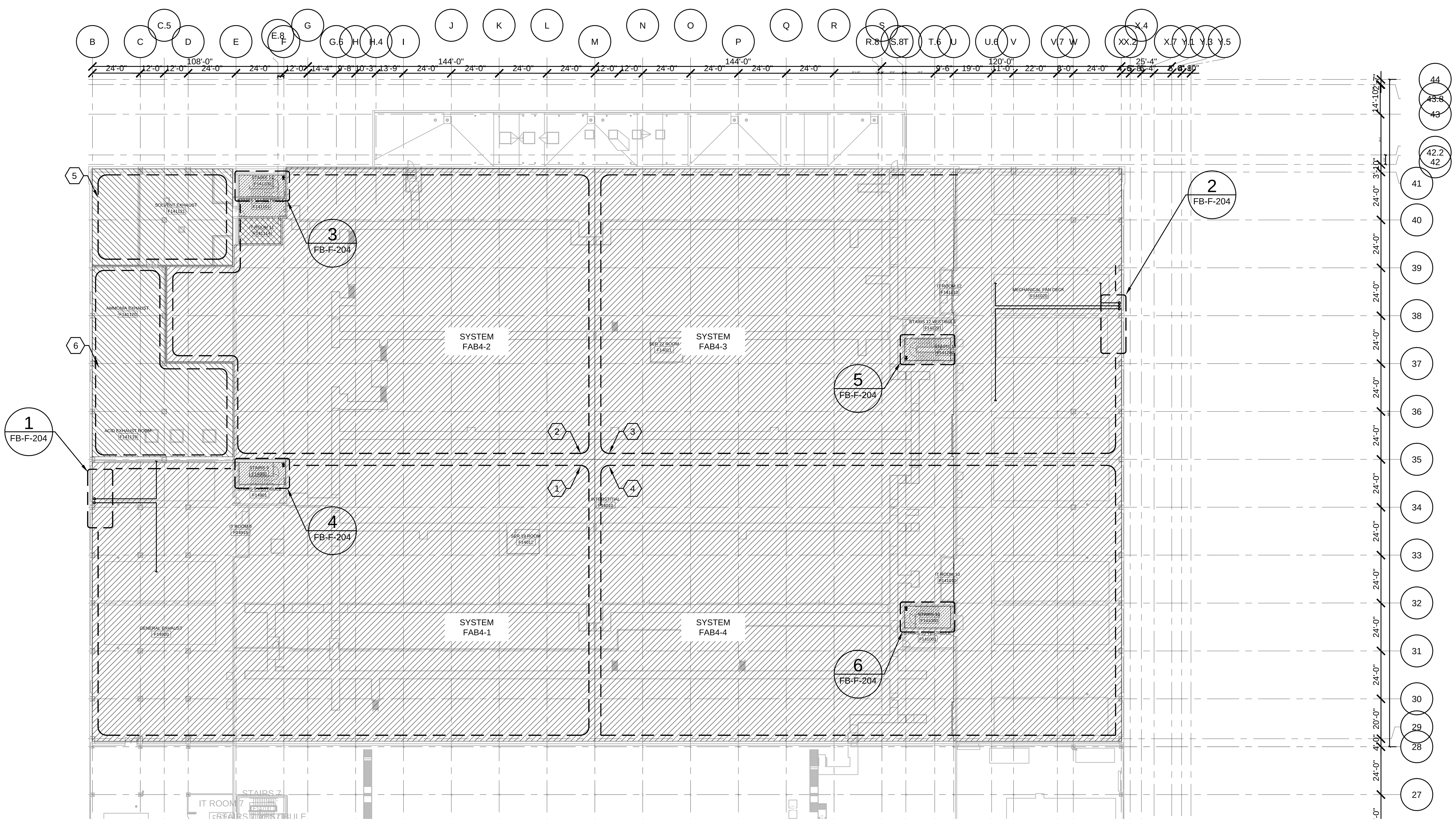

SYMBOL LEGEND

HYDRAULIC CALCULATION REFERENCE POINT

KEYED NOTES:

1. SPRINKLER ZONE 1 (FAB 4-1), LEVEL 4.
2. SPRINKLER ZONE 2 (FAB 4-2), LEVEL 4.
3. SPRINKLER ZONE 3 (FAB 4-3), LEVEL 4.
4. SPRINKLER ZONE 4 (FAB 4-4), LEVEL 4 .
5. EXISTING SYSTEM TO BE REWORKED TO BE SUPPLIED BY ADJACENT ZONE 4-2 WET SYSTEM.
6. SPRINKLER PROTECTION FOR FUME EXHAUST SCRUBBERS. SEPARATE SPRINKLER CONTROL ASSEMBLY VALVE AT RISER ROOM.
7. TYPICAL 2-1/2 INCH FIRE HOSE VALVE AT 3 TO 4 FEET ABOVE FINISHED FLOOR.
8. TYPICAL EGRESS CLEARANCE (44-INCH MIN.) HOSE VALVE TO BE INSTALLED AWAY FROM CLEARANCE AREA.

DESIGN DENSITY LEGEND

	0.10 gpm/sq ft / 1,500 sq ft - LIGHT HAZARD
	OWNER SPECIFIED: 0.20 gpm/sq ft / 3,000 sq ft MIN. NFPA: 0.20 gpm/sq ft / 1,500 sq ft - ORDINARY HAZARD GROUP II
	OWNER SPECIFIED: 0.30 gpm/sq ft / 3,000 sq ft MIN. NFPA: 0.30 gpm/sq ft / 2,500 sq ft - EXTRA HAZARD GROUP I

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Sheet Title

FAB
FIRE PROTECTION
SPRINKLER
DESIGN DENSITY
LEVEL 4

Sheet No.

FB-F
104

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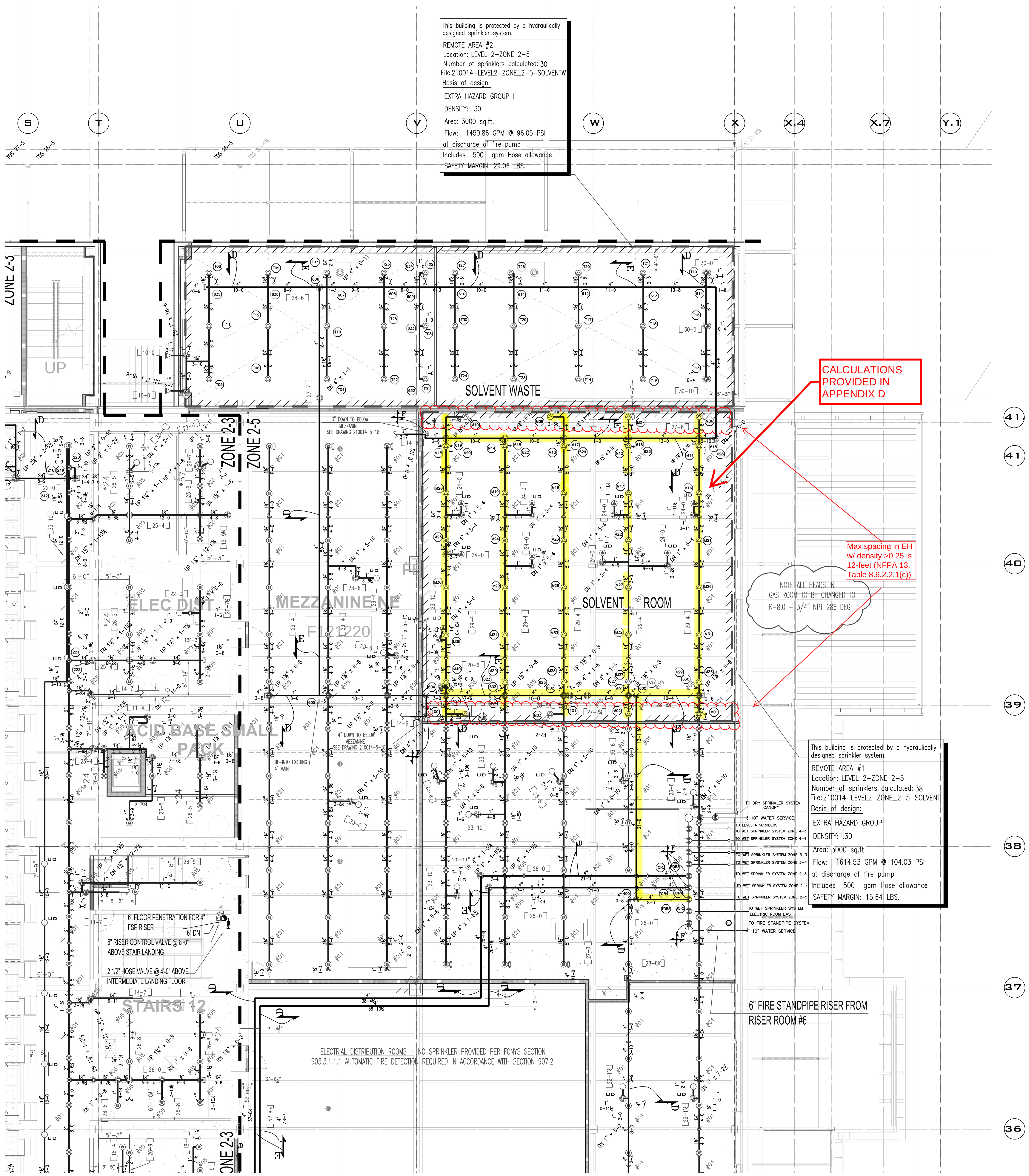
Appendix D – Fire Protection Piping Plan – Level 1

SYMBOL LEGEND

HYDRAULIC CALCULATION REFERENCE POINT



This building is protected by a hydraulically designed sprinkler system.

REMOTE AREA #2
Location: LEVEL 2–ZONE 2–5
Number of sprinklers calculated: 30
File:210014–LEVEL2–ZONE_2–5–SOLVENTW
Basis of design:

EXTRA HAZARD GROUP I
DENSITY: .30
Area: 3000 sq.ft.
Flow: 1450.86 GPM @ 96.05 PSI
at discharge of fire pump
Includes 500 gpm Hose allowance
SAFETY MARGIN: 29.06 LBS.

This building is protected by a hydraulically designed sprinkler system.

REMOTE AREA #1
Location: LEVEL 2–ZONE 2–5
Number of sprinklers calculated: 38
File:210014–LEVEL2–ZONE_2–5–SOLVENT
Basis of design:

EXTRA HAZARD GROUP I
DENSITY: .30
Area: 3000 sq.ft.
Flow: 1614.53 GPM @ 104.03 PSI
at discharge of fire pump
Includes 500 gpm Hose allowance
SAFETY MARGIN: 15.64 LBS.

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

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GENERAL NOTES

1 – ALL GROOVED PIPE TO BE BLACK STEEL SCHEDULE. 10, THREADED PIPE TO BE BLACK STEEL SCHEDULE 40.

2 – THREADED FITTINGS TO BE BLACK CAST IRON, GROOVED TYPE. FITTINGS TO BE VICTAULIC. OUTLETS OF OF GROOVED PIPING TO BE WELDED OUTLET TYPE.

3 – HANGERS TO BE ADJUSTABLE SWIVEL TYPE, LOCATED AND SPACED IN ACCORDANCE WITH NFPA 13

4 – SPRINKLER HEADS TO BE VICTAULIC QUICK RESPONSE TYPE AS INDICATED ON SRI FIRE SPRINKLER, LLC SPRINKLER DRAWING HEAD LEGEND.

5 – = FLUSHING CONNECTION

6 – POWER, CONTROL & ALARM WIRING BY OTHERS

7 – ALL WALL AND FLOOR PENETRATIONS TO BE PROVIDED WITH FIRE RATED FIRESTOPPING AS REQUIRED.

8 – A TEMPERATURE OF 40 DEGREE FARENHEIT SHALL BE MAINTAINED AT ALL TIMES (BY OTHERS)

= LATERAL SWAY BRACE
= LONGITUDINAL SWAY BRACE
= 4 WAY RISER BRACE
= BRANCH LINE RESTRAINT
= 1 HOUR FIRE WALL
= 2 HOUR FIRE WALL

SPRINKLER LEGEND

Symbol	DESCRIPTION	SIN#	ORIFICE	K–FACTOR	FINISH	TEMP	QUANTITY
	VICTAULIC UPRIGHT, QUICK RESPONSE	V2704	1/2"	5.6	BRASS	155°	30
	VICTAULIC UPRIGHT, QUICK RESPONSE, ON 1" SPRIG	V2704	1/2"	5.6	BRASS	155°	497
	VICTAULIC UPRIGHT, QUICK RESPONSE, BELOW DUCT	V2704	1/2"	5.6	BRASS	155°	0
	VICTAULIC UPRIGHT, QUICK RESPONSE, ON SPRIG, BELOW DUCT	V2704	1/2"	5.6	BRASS	155°	0
	VICTAULIC RECESSED PENDENT, QUICK RESPONSE	V2708	1/2"	5.6	CHROME	155°	21
UD	VICTAULIC UPRIGHT, QUICK RESPONSE "UNDER DUCT"	V2704	1/2"	5.6	BRASS	155°	26
UD	VICTAULIC UPRIGHT, STANDARD RESPONSE "UNDER DUCT"	V3401	17/32	8.0	BRASS	286°	23
	VICTAULIC UPRIGHT, STANDARD RESPONSE ON SPRIG	V3401	17/32	8.0	BRASS	286°	91
						TOTAL	688

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Drawn By:	J. EPSTEIN

Sheet Title

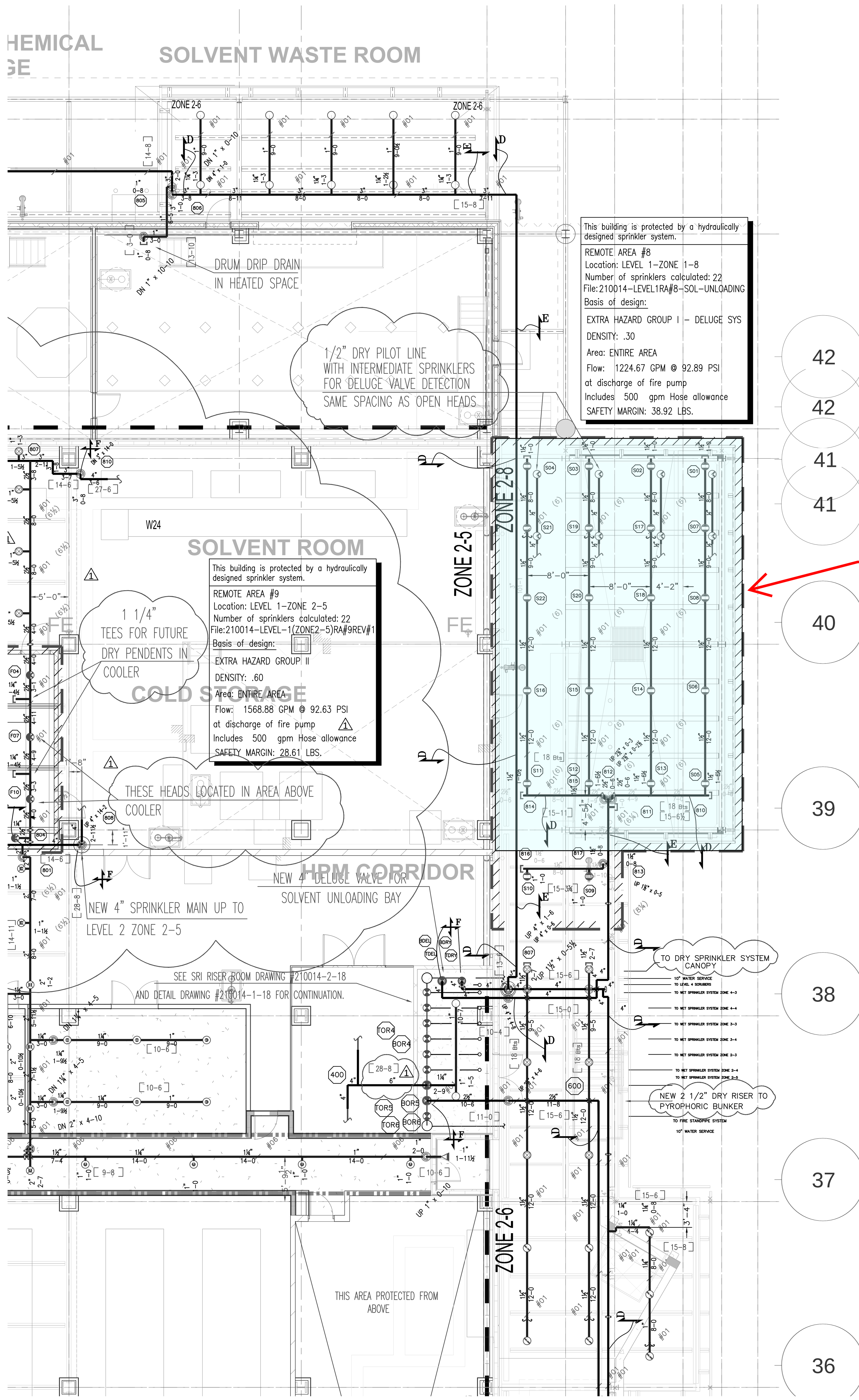
FAB
FIRE PROTECTION
SPRINKLER SYSTEM
PIPING PLAN
ZONE 1-3

Sheet No.

FB-F
101-3

SYMBOL LEGEND

HYDRAULIC CALCULATION REFERENCE POINT



CALCULATIONS PROVIDED IN APPENDIX E.

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

SPRINKLER LEGEND

Symbol	DESCRIPTION	SIN#	ORIFICE	K-FACTOR	FINISH	TEMP	QUANTITY
○	VICTAULIC UPRIGHT, QUICK RESPONSE	V2704	1/2"	5.6	BRASS	155°	178
⊗	VICTAULIC UPRIGHT, QUICK RESPONSE, ON 1" SPRIG	V2704	1/2"	5.6	BRASS	155°	53
⊠	VICTAULIC UPRIGHT, STD RESPONSE ON SPRIG	V2704	17/32	8.0	BRASS	286°	6
⃠	VICTAULIC UPRIGHT, STD RESPONSE	V2704	17/32	8.0	BRASS	286°	11
⊙	VICTAULIC RECESSED PENDENT, QUICK RESPONSE	V2708	1/2"	5.6	CHROME	155°	23
◁	VICTAULIC DRY HORIZONTAL SIDEWALL	V3609	1/2"	5.6	CHROME	155°	1
⊖	VICTAULIC UPRIGHT, OPEN - DELUGE SYSTEM	V3401	17/32	8.0	BRASS	OPEN	22
	VICTAULIC UPRIGHT, STANDARD RESP. DETECTION - DELUGE SYSTEM	V2703	1/2	5.60	BRASS	200°	22
	VICTAULIC UPRIGHT, STANDARD RESPONSE	V3403	5/8	11.2	BRASS	286°	21
						TOTAL	337

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ARCHITECT / ENGINEER OF RECORD

Consultant

Project Title

ACME SEMICONDUCTOR MODULE 1 EXPANSION

PROGRESS PRINT
NOT FOR CONSTRUCTION

No	Date	Revision	By
1	03/15/16	FPE SS23	JE

Date: 03/15/16
Proj.#: 12345
Checked By: J. EPSTEIN
Drawn By: J. EPSTEIN

Sheet Title
FAB FIRE PROTECTION SPRINKLER SYSTEM PIPING PLAN ZONE 1-3D

Sheet No.
FB-F 101-3D

Appendix E – Solvent Storage Room HASS Calculations

FPE S523
Winter 2016
Jacob Epstein

HYDRAULIC CALCULATIONS FOR
FPE S523 Project Report

DRAWING NUMBER: FB-F101-3 DATE: MAR 15, 2016

-DESIGN DATA-

REMOTE AREA NAME: SOLVENT STORAGE REMOTE AREA LOCATION:

OCCUPANCY CLASSIFICATION: EX. HAZ. I (CLASS IB FLAMMABLE BULK STORAGE)
DENSITY: 0.30 gpm/sq. ft.
AREA OF APPLICATION: 3,000 sq. ft. (NOMINAL)

COVERAGE PER SPRINKLER: 100 sq. ft. (MAX)
TYPE OF SPRINKLERS CALCULATED: k-8.0 SSU (SR) (286°F)
NUMBER OF SPRINKLERS CALCULATED: 38

SPRINKLER DEMAND: 1198.4 gpm
HOSE-STREAM DEMAND: 500.0 gpm
TOTAL WATER REQUIRED (INCLUDING HOSE): 1698.4 gpm
FLOW AND PRESSURE (AT BASE OF RISER): &SFLO:BOR& gpm @ &NPRS:BOR& psi

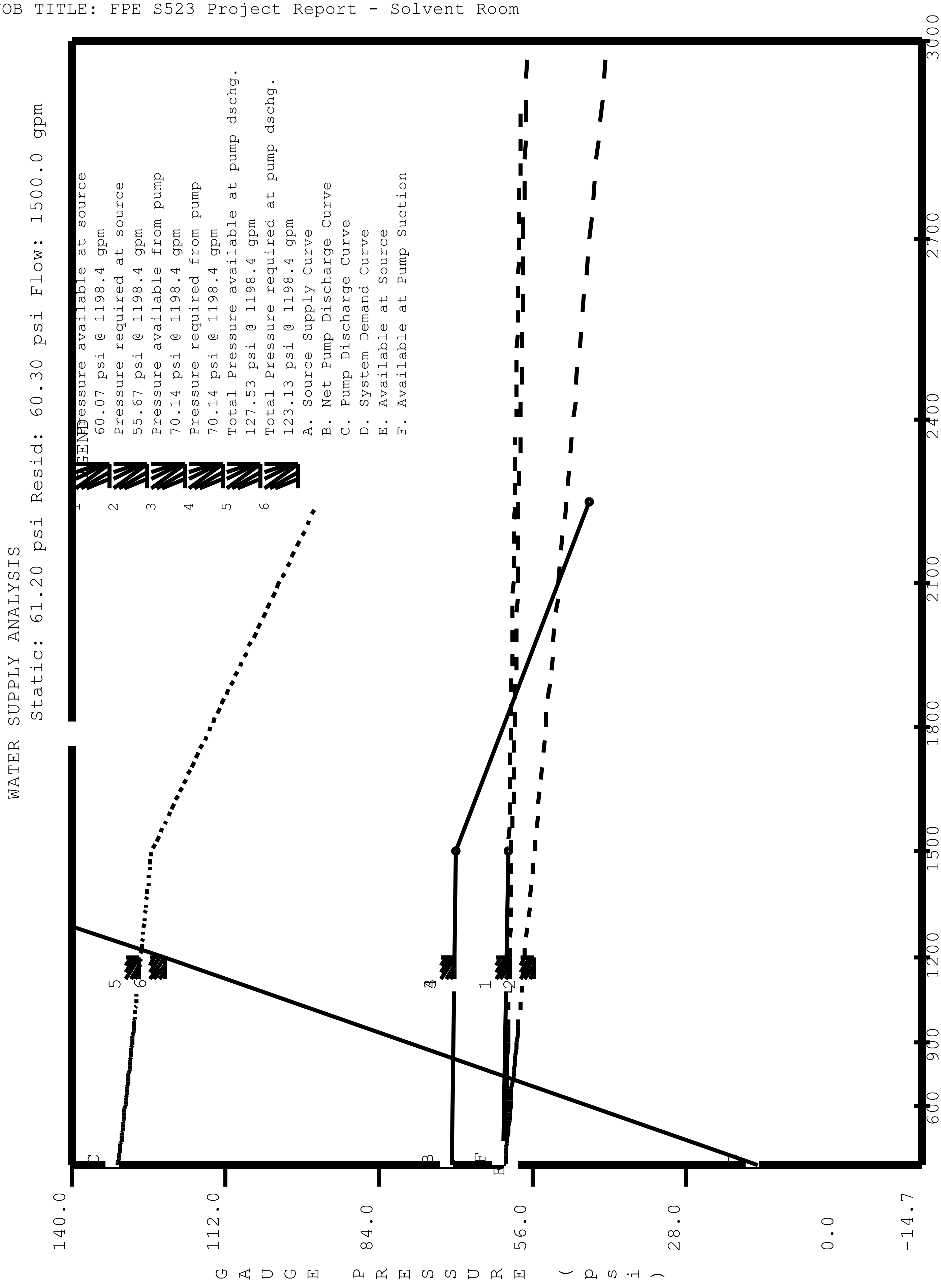
TYPE OF SYSTEM: WET, GRID
*VOLUME OF DRY OR PREACTION SYSTEM: N/A
*DETAILS:
WATER SUPPLY
Source: ELEV. TANK Test Date: 1/20/16 Test By: ABC
Location: HYDRANT UPSTREAM OF FIRE PUMP
Static: 68.0 psi Residual: 67.0 psi Flow: 1,500 gpm
Source Elevation Relative to Finished Floor Level: 0 ft.

INSTALLING CONTRACTOR
Name:
Address:
Phone: Certification number:

NAME OF DESIGNER: JACOB EPSTEIN, P.E.
AUTHORITY HAVING JURISDICTION: F. MOWRER

NOTES:
Calculations performed by HASS under license # 2704032913 ,
granted by HRS SYSTEMS, INC.
(Notes continue after pipe calculations results.)

DATE: 3/15/2016LES\HRS SYSTEMS\HASS\HASS DATA\FPE S523 PROJECT REPORT.SDF
JOB TITLE: FPE S523 Project Report - Solvent Room



NFPA WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI)	@ FLOW (GPM)	AVAIL. PRESS. (PSI)	@ TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
SRC	61.2	60.3	1500.0	60.1	1698.4	55.7

Required pressure is 4.4 psi (7%) less than available pressure.

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	1698.4 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	500.0 GPM
OTHER HOSE STREAM ALLOWANCES	0.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	1198.4 GPM

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
M1	29.3	K= 8.00	47.2	55.0	
M2	29.3	K= 8.00	31.7	45.1	
M3	29.3	K= 8.00	28.5	42.7	
M5	29.3	K= 8.00	27.7	42.1	
M6	29.3	K= 8.00	10.2	25.6	
M7	29.3	K= 8.00	10.0	25.3	
M8	29.3	K= 8.00	9.9	25.2	
M10	29.3	K= 8.00	9.5	24.6	
M11	29.3	K= 8.00	11.2	26.8	
M12	29.3	K= 8.00	10.4	25.8	
M13	29.3	K= 8.00	10.3	25.6	
M14	29.3	K= 8.00	10.5	25.9	
M15	29.3	K= 8.00	10.2	25.6	
M16	29.3	K= 8.00	12.4	28.2	
M17	29.3	K= 8.00	10.8	26.3	
M18	29.3	K= 8.00	10.6	26.0	
M19	29.3	K= 8.00	10.9	26.4	
M20	29.3	K= 8.00	10.5	26.0	
M21	29.3	K= 8.00	14.6	30.6	
M22	29.3	K= 8.00	11.8	27.5	
M23	29.3	K= 8.00	11.4	27.0	
M24	29.3	K= 8.00	11.9	27.6	
M25	29.3	K= 8.00	11.4	27.0	
M26	29.3	K= 8.00	18.1	34.0	
M27	29.3	K= 8.00	13.7	29.7	
M28	29.3	K= 8.00	13.1	28.9	
M29	29.3	K= 8.00	13.8	29.8	
M30	29.3	K= 8.00	13.0	28.8	
M31	29.3	K= 8.00	23.4	38.7	
M32	29.3	K= 8.00	16.9	32.9	
M33	29.3	K= 8.00	15.8	31.8	
M34	29.3	K= 8.00	17.0	33.0	

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
M35	29.3	K= 8.00	15.7	31.7	
M36	29.3	K= 8.00	31.3	44.7	
M37	29.3	K= 8.00	21.7	37.3	
M38	29.3	K= 8.00	20.2	35.9	
M39	29.3	K= 8.00	21.8	37.4	
M40	29.3	K= 8.00	20.0	35.8	
101	29.3	- - - -	29.2	- - -	
100	29.3	- - - -	28.9	- - -	
400	29.3	- - - -	67.2	- - -	
601	29.3	- - - -	46.5	- - -	
602	29.3	- - - -	42.5	- - -	
603	29.3	- - - -	42.1	- - -	
604	29.3	- - - -	42.0	- - -	
615	29.3	- - - -	10.5	- - -	
616	29.3	- - - -	10.3	- - -	
617	29.3	- - - -	10.2	- - -	
618	29.3	- - - -	10.4	- - -	
619	29.3	- - - -	10.2	- - -	
620	27.5	- - - -	11.1	- - -	
621	28.7	- - - -	29.9	- - -	
622	27.5	- - - -	11.1	- - -	
623	28.7	- - - -	32.9	- - -	
624	27.5	- - - -	11.1	- - -	
625	28.7	- - - -	30.2	- - -	
626	27.5	- - - -	11.1	- - -	
627	28.7	- - - -	32.8	- - -	
628	27.5	- - - -	11.1	- - -	
629	29.3	- - - -	48.3	- - -	
630	28.7	- - - -	48.6	- - -	
631	29.3	- - - -	50.8	- - -	
TOR	28.7	- - - -	72.0	- - -	
BOR	4.0	- - - -	114.5	- - -	
AF17	-5.0	- - - -	118.9	- - -	
UG17	-5.0	- - - -	119.4	- - -	
UG11	-5.0	- - - -	120.3	- - -	
UG2	-5.0	- - - -	121.1	- - -	
UG3	-5.0	- - - -	122.5	- - -	
UG4	-5.0	- - - -	122.6	- - -	
FAF4	-5.0	- - - -	123.1	- - -	
FAFO	-5.0	- - - -	53.0	- - -	
SRC	-5.0	SOURCE	55.7	1198.4	

NFPA PIPE DATA

Pipe Tag		K-fac	Add Fl	Add Fl To		Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 1		8.00	55.0	Disch			2.92	120	1.4	
630	28.7	48.6	0.0		B1.500	T:10.0	10.00		-0.3	
M1	29.3	47.2	55.0		1.682		12.92	0.085	1.1	
Pipe: 2		8.00	44.7	Disch			2.08	120	17.3	
630	28.7	48.6	206.4	M31	B1.500	T:10.0	10.00		-0.3	
M36	29.3	31.3	251.2		1.682		12.08	1.408	17.0	
Pipe: 3		8.00	38.7	Disch			8.00	120	7.8	
M36	29.3	31.3	167.7	M26	B1.500	----	0.00		0.0	
M31	29.3	23.4	206.4		1.682		8.00	0.980	7.8	
Pipe: 4		8.00	34.0	Disch			8.00	120	5.3	
M31	29.3	23.4	133.6	M21	B1.500	----	0.00		0.0	
M26	29.3	18.1	167.7		1.682		8.00	0.667	5.3	
Pipe: 5		8.00	30.6	Disch			8.00	120	3.5	
M26	29.3	18.1	103.0	M16	B1.500	----	0.00		0.0	
M21	29.3	14.6	133.6		1.682		8.00	0.438	3.5	
Pipe: 6		8.00	28.2	Disch			8.00	120	2.2	
M21	29.3	14.6	74.8	M11	B1.500	----	0.00		0.0	
M16	29.3	12.4	103.0		1.682		8.00	0.271	2.2	
Pipe: 7		8.00	26.8	Disch			8.00	120	1.2	
M16	29.3	12.4	48.0	615	B1.500	----	0.00		0.0	
M11	29.3	11.2	74.8		1.682		8.00	0.150	1.2	
Pipe: 8		0.0	22.4	628			1.33	120	0.7	
M11	29.3	11.2	25.6	M6	B1.500	T:10.0	10.00		0.0	
615	29.3	10.5	48.0		1.682		11.33	0.066	0.7	
Pipe: 9		8.00	25.6	Disch			3.67	120	0.3	
615	29.3	10.5	0.0		B1.500	T:10.0	10.00		0.0	
M6	29.3	10.2	25.6		1.682		13.67	0.021	0.3	
Pipe: RN1		0.0	0.0				0.67	120	0.3	
630	28.7	48.6	0.0		B1.500	T:10.0	10.00		-0.3	
629	29.3	48.3	0.0		1.682		10.67	0.000	0.0	
Pipe: RN2		0.0	0.0				1.83	120	0.6	
615	29.3	10.5	22.4	626	B1.500	T:10.0	10.00		0.8	
628	27.5	11.1	22.4		1.682		11.83	0.016	0.2	
Pipe: 10		8.00	45.1	Disch			2.92	120	1.0	
627	28.7	32.8	0.0		B1.500	T:10.0	10.00		-0.3	
M2	29.3	31.7	45.1		1.682		12.92	0.059	0.8	

Pipe Tag		K-fac	Add Fl	Add Fl To		Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 11		8.00	37.3	Disch			2.08	120	11.1	
627	28.7	32.8	158.9	M32	B1.500	T:10.0	10.00		-0.3	
M37	29.3	21.7	196.2		1.682		12.08	0.892	10.8	
Pipe: 12		8.00	32.9	Disch			8.00	120	4.8	
M37	29.3	21.7	126.1	M27	B1.500	----	0.00		0.0	
M32	29.3	16.9	158.9		1.682		8.00	0.604	4.8	
Pipe: 13		8.00	29.7	Disch			8.00	120	3.1	
M32	29.3	16.9	96.4	M22	B1.500	----	0.00		0.0	
M27	29.3	13.7	126.1		1.682		8.00	0.393	3.1	
Pipe: 14		8.00	27.5	Disch			8.00	120	1.9	
M27	29.3	13.7	68.9	M17	B1.500	----	0.00		0.0	
M22	29.3	11.8	96.4		1.682		8.00	0.240	1.9	
Pipe: 15		8.00	26.3	Disch			8.00	120	1.0	
M22	29.3	11.8	42.6	M12	B1.500	----	0.00		0.0	
M17	29.3	10.8	68.9		1.682		8.00	0.129	1.0	
Pipe: 16		8.00	25.8	Disch			8.00	120	0.4	
M17	29.3	10.8	16.8	616	B1.500	----	0.00		0.0	
M12	29.3	10.4	42.6		1.682		8.00	0.053	0.4	
Pipe: 17		0.0	0.0				1.33	120	0.1	
M12	29.3	10.4	16.8		B1.500	T:10.0	10.00		0.0	
616	29.3	10.3	16.8		1.682		11.33	0.009	0.1	
Pipe: 18		8.00	25.3	Disch			3.67	120	0.3	
616	29.3	10.3	0.0		B1.500	T:10.0	10.00		0.0	
M7	29.3	10.0	25.3		1.682		13.67	0.020	0.3	
Pipe: RN3		0.0	196.2	M37			0.67	120	13.7	
601	29.3	46.5	45.1	M2	B1.500	T:10.0	10.00		0.3	
627	28.7	32.8	241.3		1.682		10.67	1.308	14.0	
Pipe: RN4		0.0	0.0				1.83	120	0.8	
626	27.5	11.1	8.5		B1.500	T:10.0	10.00		-0.8	
616	29.3	10.3	8.5		1.682		11.83	0.003	0.0	
Pipe: 28		8.00	42.7	Disch			2.33	120	0.7	
101	29.3	29.2	0.0		B1.500	T:10.0	10.00		0.0	
M3	29.3	28.5	42.7		1.682		12.33	0.053	0.7	
Pipe: 19		0.0	0.0				2.92	120	1.0	
625	28.7	30.2	42.7		B1.500	T:10.0	10.00		-0.3	
101	29.3	29.2	42.7		1.682		12.92	0.053	0.7	
Pipe: 20		8.00	35.9	Disch			2.08	120	10.0	
625	28.7	30.2	149.7	M33	B1.500	T:10.0	10.00		-0.3	
M38	29.3	20.2	185.6		1.682		12.08	0.805	9.7	

Pipe Tag / Frm Node / To Node	El (ft) / El (ft)	K-fac / PT / PT	Add Fl (q) / Tot.(Q)	Add Fl To Node/ Disch	Nom ID / Act ID	Fit: Eq.Ln. (ft.)	L / F / T	C / Pf/ft.	(Pt) / (Pe) / (Pf)	Notes
Pipe: 21		8.00	31.8	Disch			8.00	120	4.3	
M38	29.3	20.2	117.9	M28	B1.500	----	0.00		0.0	
M33	29.3	15.8	149.7		1.682		8.00	0.541	4.3	
Pipe: 22		8.00	28.9	Disch			8.00	120	2.8	
M33	29.3	15.8	89.0	M23	B1.500	----	0.00		0.0	
M28	29.3	13.1	117.9		1.682		8.00	0.347	2.8	
Pipe: 23		8.00	27.0	Disch			8.00	120	1.7	
M28	29.3	13.1	61.9	M18	B1.500	----	0.00		0.0	
M23	29.3	11.4	89.0		1.682		8.00	0.206	1.7	
Pipe: 24		8.00	26.0	Disch			8.00	120	0.8	
M23	29.3	11.4	35.9	M13	B1.500	----	0.00		0.0	
M18	29.3	10.6	61.9		1.682		8.00	0.106	0.8	
Pipe: 25		8.00	25.6	Disch			8.00	120	0.3	
M18	29.3	10.6	10.3	617	B1.500	----	0.00		0.0	
M13	29.3	10.3	35.9		1.682		8.00	0.039	0.3	
Pipe: 26		0.0	0.0				1.33	120	0.0	
M13	29.3	10.3	10.3		B1.500	T:10.0	10.00		0.0	
617	29.3	10.2	10.3		1.682		11.33	0.004	0.0	
Pipe: 27		8.00	25.2	Disch			3.67	120	0.3	
617	29.3	10.2	0.0		B1.500	T:10.0	10.00		0.0	
M8	29.3	9.9	25.2		1.682		13.67	0.020	0.3	
Pipe: RN5		0.0	185.6	M38			0.67	120	12.3	
602	29.3	42.5	42.7	101	B1.500	T:10.0	10.00		0.3	
625	28.7	30.2	228.4		1.682		10.67	1.181	12.6	
Pipe: RN6		0.0	0.0				1.83	120	0.9	
624	27.5	11.1	14.9		B1.500	T:10.0	10.00		-0.8	
617	29.3	10.2	14.9		1.682		11.83	0.008	0.1	
Pipe: 29		8.00	37.4	Disch			2.08	120	11.1	
623	28.7	32.9	158.8	M34	B1.500	T:10.0	10.00		-0.3	
M39	29.3	21.8	196.2		1.682		12.08	0.892	10.8	
Pipe: 30		8.00	33.0	Disch			8.00	120	4.8	
M39	29.3	21.8	125.9	M29	B1.500	----	0.00		0.0	
M34	29.3	17.0	158.8		1.682		8.00	0.603	4.8	
Pipe: 31		8.00	29.8	Disch			8.00	120	3.1	
M34	29.3	17.0	96.1	M24	B1.500	----	0.00		0.0	
M29	29.3	13.8	125.9		1.682		8.00	0.392	3.1	
Pipe: 32		8.00	27.6	Disch			8.00	120	1.9	
M29	29.3	13.8	68.5	M19	B1.500	----	0.00		0.0	
M24	29.3	11.9	96.1		1.682		8.00	0.238	1.9	

Pipe Tag		K-fac	Add Fl	Add Fl To		Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 33		8.00	26.4	Disch			8.00	120	1.0	
M24	29.3	11.9	42.0	M14	B1.500	----	0.00		0.0	
M19	29.3	10.9	68.5		1.682		8.00	0.127	1.0	
Pipe: 34		8.00	25.9	Disch			8.00	120	0.4	
M19	29.3	10.9	16.1	618	B1.500	----	0.00		0.0	
M14	29.3	10.5	42.0		1.682		8.00	0.052	0.4	
Pipe: 35		0.0	0.0				1.33	120	0.1	
M14	29.3	10.5	16.1	622	B1.500	T:10.0	10.00		0.0	
618	29.3	10.4	16.1		1.682		11.33	0.009	0.1	
Pipe: RN7		0.0	0.0				0.67	120	9.2	
603	29.3	42.1	196.2	M39	B1.500	T:10.0	10.00		0.3	
623	28.7	32.9	196.2		1.682		10.67	0.892	9.5	
Pipe: RN8		0.0	15.2	620			1.83	120	0.7	
618	29.3	10.4	1.0	624	B1.500	T:10.0	10.00		0.8	
622	27.5	11.1	16.1		1.682		11.83	0.009	0.1	
Pipe: 36		8.00	42.1	Disch			3.25	120	1.3	
100	29.3	28.9	0.0		1.250	T: 6.0	6.00		0.0	
M5	29.3	27.7	42.1		1.380		9.25	0.135	1.3	
Pipe: 37		0.0	0.0				2.92	120	1.0	
621	28.7	29.9	42.1		B1.500	T:10.0	10.00		-0.3	
100	29.3	28.9	42.1		1.682		12.92	0.052	0.7	
Pipe: 38		8.00	35.8	Disch			2.08	120	9.9	
621	28.7	29.9	148.5	M35	B1.500	T:10.0	10.00		-0.3	
M40	29.3	20.0	184.3		1.682		12.08	0.794	9.6	
		8.00	31.7	Disch						
Pipe: 39			0.0				8.00	120	4.3	
M40	29.3	20.0	116.8	M30	B1.500	----	0.00		0.0	
M35	29.3	15.7	148.5		1.682		8.00	0.533	4.3	
Pipe: 40		8.00	28.8	Disch			8.00	120	2.7	
M35	29.3	15.7	88.0	M25	B1.500	----	0.00		0.0	
M30	29.3	13.0	116.8		1.682		8.00	0.342	2.7	
Pipe: 41		8.00	27.0	Disch			8.00	120	1.6	
M30	29.3	13.0	61.0	M20	B1.500	----	0.00		0.0	
M25	29.3	11.4	88.0		1.682		8.00	0.202	1.6	
Pipe: 42		8.00	26.0	Disch			8.00	120	0.8	
M25	29.3	11.4	35.0	M15	B1.500	----	0.00		0.0	
M20	29.3	10.5	61.0		1.682		8.00	0.103	0.8	
Pipe: 43		8.00	25.6	Disch			8.00	120	0.3	
M20	29.3	10.5	9.4	619	B1.500	----	0.00		0.0	
M15	29.3	10.2	35.0		1.682		8.00	0.037	0.3	

Pipe Tag Frm Node To Node	El (ft) El (ft)	K-fac PT PT	Add Fl (q) Tot.(Q)	Add Fl To Node/ Disch	Nom ID Act ID	Fit: Eq.Ln. (ft.)	L F T	C Pf/ft.	(Pt) (Pe) (Pf)	Notes
Pipe: 44		0.0	0.0				1.33	120	0.0	
M15	29.3	10.2	9.4		B1.500	T:10.0	10.00		0.0	
619	29.3	10.2	9.4		1.682		11.33	0.003	0.0	
Pipe: 45		8.00	24.6	Disch			7.00	120	0.8	
619	29.3	10.2	0.0		1.250	T: 6.0	8.00		0.0	
M10	29.3	9.5	24.6		1.380	L: 2.0	15.00	0.050	0.8	
Pipe: RN9		0.0	184.3	M40			0.67	120	12.1	
604	29.3	42.0	42.1	100	B1.500	T:10.0	10.00		0.3	
621	28.7	29.9	226.4		1.682		10.67	1.162	12.4	
Pipe: RN10		0.0	0.0				1.83	120	0.9	
620	27.5	11.1	15.2		B1.500	T:10.0	10.00		-0.8	
619	29.3	10.2	15.2		1.682		11.83	0.008	0.1	
Pipe: CM1		0.0	251.2	M36			10.33	120	2.2	
631	29.3	50.8	55.0	M1	B3.000	T:20.0	20.00		0.3	
630	28.7	48.6	306.1		3.260		30.33	0.081	2.5	
Pipe: CM2		0.0	650.9	602			1.00	120	4.3	
631	29.3	50.8	241.3	627	B4.000	T:26.0	26.00		0.0	
601	29.3	46.5	892.2		4.260		27.00	0.159	4.3	
Pipe: CM3		0.0	422.6	603			12.67	120	4.0	
601	29.3	46.5	228.4	625	B4.000	4L:32.0	32.00		0.0	
602	29.3	42.5	650.9		4.260		44.67	0.089	4.0	
Pipe: CM4		0.0	226.4	604			10.00	120	0.4	
602	29.3	42.5	196.2	623	B4.000	----	0.00		0.0	
603	29.3	42.1	422.6		4.260		10.00	0.040	0.4	
Pipe: CM5		0.0	0.0				10.00	120	0.1	
603	29.3	42.1	226.4	621	B4.000	----	0.00		0.0	
604	29.3	42.0	226.4		4.260		10.00	0.013	0.1	
Pipe: CM6		0.0	14.0	624			12.00	120	0.0	
628	27.5	11.1	8.5	616	B4.000	----	0.00		0.0	
626	27.5	11.1	22.4		4.260		12.00	0.000	0.0	
Pipe: CM7		0.0	14.9	617			11.00	120	0.0	
626	27.5	11.1	-1.0	622	B4.000	----	0.00		0.0	
624	27.5	11.1	14.0		4.260		11.00	0.000	0.0	
Pipe: CM8		0.0	14.9	617			10.00	120	0.0	
622	27.5	11.1	-14.0	626	B4.000	----	0.00		0.0	
624	27.5	11.1	1.0		4.260		10.00	0.000	0.0	
Pipe: CM9		0.0	0.0				10.00	120	0.0	
622	27.5	11.1	15.2	619	B4.000	----	0.00		0.0	
620	27.5	11.1	15.2		4.260		10.00	0.000	0.0	

Pipe Tag / Frm Node / To Node	El (ft) / El (ft)	K-fac / PT / PT	Add Fl / (q) / Tot.(Q)	Add Fl To / Node/ / Disch	Nom ID / Act ID	Fit: / Eq.Ln. / (ft.)	L / F / T	C / / Pf/ft.	(Pt) / (Pe) / (Pf)	Notes
Pipe: BM1		0.0	892.2	601			34.00	120	16.5	
400	29.3	67.2	306.1	630	B4.000	T:26.0	26.00		0.0	
631	29.3	50.8	1198.4		4.260		60.00	0.275	16.5	
Pipe: BM2		0.0	0.0				8.25	120	4.8	
TOR	28.7	72.0	1198.4	631	B4.000	L: 8.0	8.00		-0.3	
400	29.3	67.2	1198.4		4.260		16.25	0.275	4.5	
Pipe: BM3		0.0	0.0			T2LCB	28.83	120	42.5	
BOR	4.0	114.5	1198.4	400	B4.000		87.00		-10.7	
TOR	28.7	72.0	1198.4		4.260		115.83	0.275	31.8	
Pipe: BM4		0.0	0.0				18.00	120	4.4	
AF17	-5.0	118.9	1198.4	TOR	B8.000	L:15.0	29.00		-3.9	
BOR	4.0	114.5	1198.4		8.249	B:14.0	47.00	0.011	0.5	
Pipe: BM5		0.0	0.0			T:80.0	83.00	140	0.5	
UG17	-5.0	119.4	1198.4	BOR	D10.00	L:26.0	114.00		0.0	
AF17	-5.0	118.9	1198.4		10.400	G: 8.0	197.00	0.003	0.5	
Pipe: UG1		0.0	0.0				653.00	140	0.8	
UG11	-5.0	120.3	1198.4	AF17	D12.00	3L:90.0	110.00		0.0	
UG17	-5.0	119.4	1198.4		12.460	2G:20.0	763.00	0.001	0.8	
Pipe: UG2		0.0	0.0				420.00	140	0.8	
UG2	-5.0	121.1	1198.4	UG17	D12.00	T:98.0	278.00		0.0	
UG11	-5.0	120.3	1198.4		12.460	6L180.0	698.00	0.001	0.8	
Pipe: UG3		0.0	0.0			T:98.0	1025.00	140	1.4	
UG3	-5.0	122.5	1198.4	UG11	D12.00	4L120.0	248.00		0.0	
UG2	-5.0	121.1	1198.4		12.460	3G:30.0	1273.00	0.001	1.4	
Pipe: UG4		0.0	0.0				5.00	140	0.1	
UG4	-5.0	122.6	1198.4	UG2	D12.00	T:98.0	108.00		0.0	
UG3	-5.0	122.5	1198.4		12.460	G:10.0	113.00	0.001	0.1	
Pipe: UG5		0.0	0.0				90.00	120	0.5	
FAF4	-5.0	123.1	1198.4	UG3	10.000	2L:32.0	37.00		0.0	
UG4	-5.0	122.6	1198.4		10.020	G: 5.0	127.00	0.004	0.5	
Pipe: UG6		0.0	0.0		Fire Pump	Rating	Avail.	Req'd.		
FAFO	-5.0	53.0	1198.4	UG4	gpm:	1500.0	1198.4	1198.4		
FAF4	-5.0	123.1	1198.4		psi:	70.0	70.0	70.0		
Pipe: UG7		Source	1198.3	FAF4			1000.00	140	2.7	
SRC	-5.0	55.7	0.1		D10.00	----	0.00		0.0	
FAFO	-5.0	53.0	1198.4		10.400		1000.00	0.003	2.7	

NOTES (HASS):

(1) Calculations were performed by the HASS 8.5 computer program
under license no. 2704032913 granted by
HRS Systems, Inc.
208 Southside Square
Petersburg, TN 37144
(931) 659-9760

(2) The system has been calculated to provide an average imbalance at each node of 0.001 gpm and a maximum imbalance at any node of 0.010 gpm.

(3) Total pressure at each node is used in balancing the system. Maximum water velocity is 36.3 ft/sec at pipe 2.

(4) The Minimum pump suction pressure under maximum calculated demand is 52.99 (psi)

(5) Items listed in bold print on the cover sheet

are automatically transferred from the calculation report.

(6) Available pressure at source node SRC under full flow conditions is 60.04 psi compared to the minimum required pressure of 20.00 psi.

(7) PIPE FITTINGS TABLE

Pipe Table Name: STANDARD.PIP

PAGE: A MATERIAL: S40 HWC: 120

Diameter (in)	E Ell	T Tee	L LngEll	C ChkVlv	B BfyVlv	G GatVlv	A AlmChk	D DPVlv	N NPTee
	Equivalent Fitting Lengths in Feet								
1.380	3.00	6.00	2.00	7.00	6.00	1.00	10.00	10.00	6.00
10.020	22.00	50.00	16.00	55.00	19.00	5.00	37.00	37.00	50.00

PAGE: B MATERIAL: THNWL HWC: 120

Diameter (in)	E Ell	T Tee	L LngEll	C ChkVlv	B BfyVlv	G GatVlv	A AlmChk	D DPVlv	N NPTee
	Equivalent Fitting Lengths in Feet								
1.682	5.00	10.00	3.00	11.00	8.00	1.00	12.00	12.00	10.00
3.260	10.00	20.00	7.00	22.00	14.00	1.00	18.00	18.00	20.00
4.260	13.00	26.00	8.00	29.00	16.00	3.00	26.00	26.00	26.00
8.249	21.00	41.00	15.00	53.00	14.00	5.00	37.00	37.00	41.00

Appendix F – Solvent Offload Canopy Hand Calculations

HYDRAULIC CALCULATIONS

CONTRACT NAME FPE 5523 PROJECT REPORT – EPSTEIN

NOZZLE IDENT. AND LOCATION	FLOW IN GPM	PIPE SIZE	PIPE FITTINGS AND DEVICES	EQUIV. PIPE LENGTH	FRICTION LOSS PSI/FT	PRESSURE SUMMARY	NORMAL PRESSURE	NOTES $P_f = \frac{4.52\, Q^{1.85}}{c^{1.85}\, d^{4.87}}$
	q 25.2		–	L 8.0	C=120	Pt 9.92	Pt	$P_f = (6.4\times10^{-4}) \frac{Q^{1.85}}{d^{4.87}}$
501		1.610	–	F –	K=8.0	Pe –	Pv	12×7 COVG AREA ON
	Q –		–	T 8.0	0.025	Pf 0.197	Pn	BL-1 0.30(84) = 25.2 GPM
	q 25.45		–	L 9.0		Pt 10.12	Pt	$\frac{50.65^{1.85}}{10.17} = 139.980$
507		1.610	–	F –		Pe –	Pv	
	Q 50.65		–	T 9.0	0.090	Pf 0.81	Pn	
	q 26.44		–	L 12.0		Pt 10.93	Pt	
508		1.610	–	F –	0.195	Pe	Pv	
	Q 77.1		–	T 12.0		Pf 2.34	Pn	
	q 29.14		–	L 12.0		Pt 13.27	Pt	
506		1.610	–	F –	0.353	Pe	Pv	
	Q 106.2		–	T 12.0		Pf 4.23	Pn	
	q 33.5		–	L 1.54		Pt 17.5	Pt	$139.7 = K\sqrt{23.1}$
505		1.610	T=8	F 8.0	0.585	Pe –	Pv	BL-1 K = 29.1
	Q 139.7			T 9.54		Pf 5.58	Pn	
	q –		–	L 7.0		Pt 23.1	Pt	9302.79
810		2.469	–	F –	0.073	Pe –	Pv	
	Q 139.7		–	T 7.0		Pf 0.511	Pn	
	q 141.4			L 4.75		Pt 23.61	Pt	$Q_{BL2} = 29.1\sqrt{23.61}$
811		2.469	T=12	F 12.0	0.266	Pe –	Pv	
	Q 281.1			T 16.75		Pf 4.46	Pn	81.57887
	q 139.7		–	L 8.0		Pt 23.1	Pt	
814		2.469	–	F –	0.073	Pe	Pv	
	Q –		–	T 8.0		Pf 0.584	Pn	
	q 141.62			L 1.75		Pt 23.7	Pt	
815		2.469	T=8	F 8.0		Pe	Pv	
	Q 281.3			T 9.75		Pf	Pn	
	q –			L 0.75		Pt 23.7	Pt	
812		2.469	L=4	F 4.0	0.96	Pe 0.325	Pv	
	Q 562.4			T 4.75		Pf 4.56	Pn	
	q –		4L=16	L 48.83		Pt 28.6	Pt	
TDEL		4.026		F 16.0	0.088	Pe –	Pv	$\frac{562.4^{1.85}}{882.54} = 138.63$
	Q 562.4			T 64.83		Pf 5.75	Pn	
						Pt 34.4		

American Fire Sprinkler Association
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www.firesprinkler.org

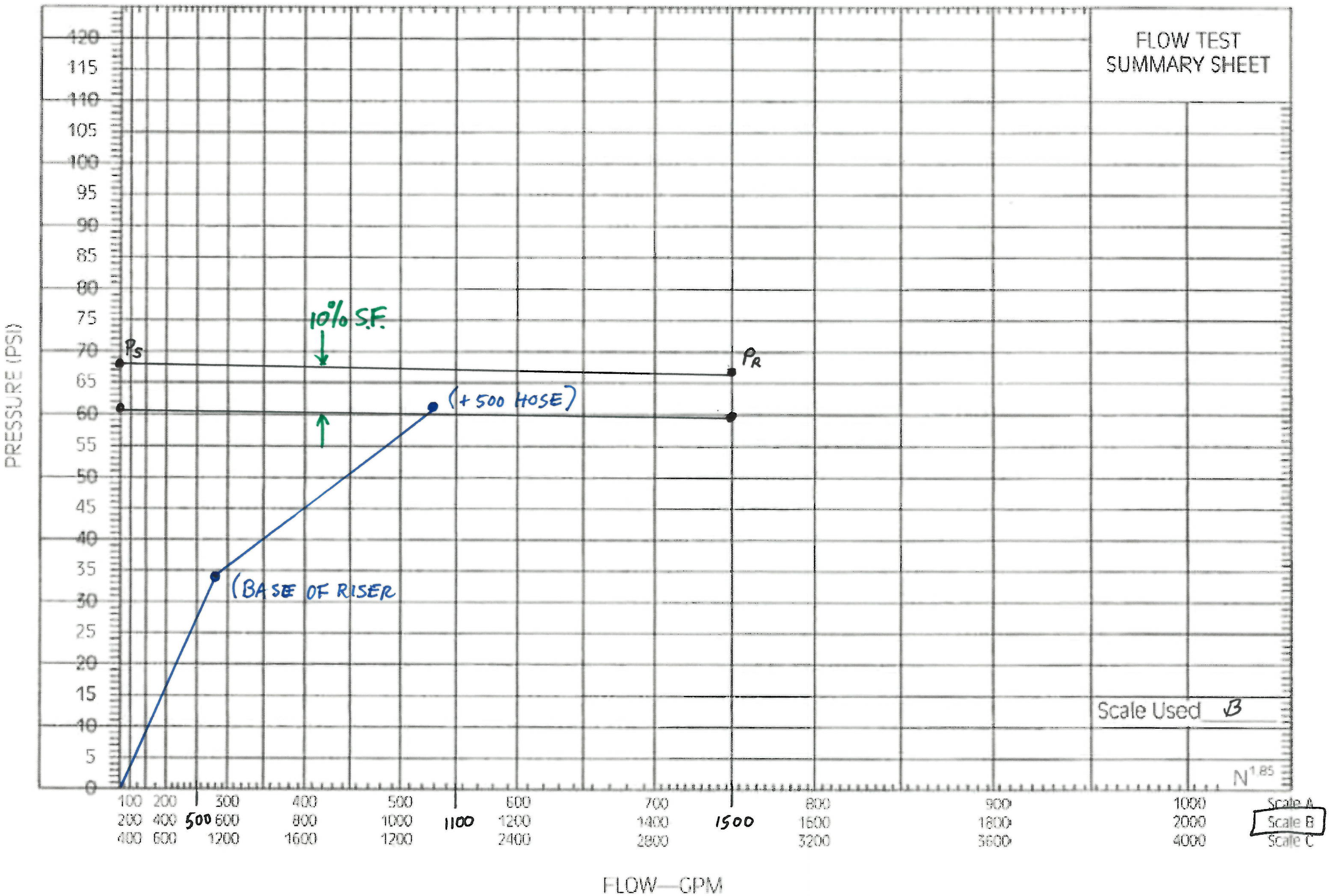
HYDRAULIC CALCULATIONS

CONTRACT NAME FPE 5523 PROJECT REPORT EPSTEIN

SHEET 2 OF 3

NOZZLE IDENT. AND LOCATION	FLOW IN GPM	PIPE SIZE	PIPE FITTINGS AND DEVICES	EQUIV. PIPE LENGTH	FRICTION LOSS PSI/FT	PRESSURE SUMMARY	NORMAL PRESSURE	NOTES
BDEL	q —	4.026	DELUGE VALVE	L 14.0	0.088	Pt 34.4	Pt	$\Delta P = Q^2/C_v^2 = 562.4^2/350^2$
			DV=21.0	F 12.0		Pe 6.062	Pv	$\Delta p = 9.214$
	Q 562.4		B=12	T 26.0		Pf 2.288	Pn	
AF17	q —	8.249	B=14.1	L 18.0	0.003	Pt 51.96	Pt	
			L=21.1	F 35.2		Pe 2.6	Pv	
	Q 562.4			T 53.2		Pf 0.14	Pn	$8.249^{4.87} = 29031.83$
UG17	q —	10.28	L=18.13	L 83.0	C=140 (DIP)	Pt 54.7	Pt	FTG FACTOR = 1.133
			G=5.66	F 80.43		Pe —	Pv	$140^{1.85} = \frac{4.52}{9339.8} = 4.8 \times 10^{-4}$
	Q 562.4		T=56.6	T 163.43	0.0006	Pf 0.113	Pn	$10.28^{4.87} = 84802.073$
UG11	(HOSE) q 500	11.65	6(45)=69	L 653.0	C=140	Pt 54.8	Pt	FTG FACTOR = 0.888
			T=53.3	F 146.5	0.00122	Pe —	Pv	
	Q 1062.4		E=24	T 799.5		Pf 0.976	Pn	$11.65^{4.87} = 155957.86$
UG2	q —	11.65	4(45)=46.2	L 420	C=140	Pt 55.78	Pt	
			T=53.3	F 115.5	0.00122	Pe —	Pv	
	Q 1062.4		3G=16	T 535.5		Pf 0.654	Pn	
UG3	q —	11.65	G=5.3	L 1025	C=140	Pt 56.4	Pt	
			T=53.3	F 58.6	0.00122	Pe —	Pv	
	Q 1062.4			T 1083.6		Pf 1.32	Pn	
UG4	q —	11.65	G=5.3	L 95.0	C=140	Pt 57.7	Pt	
			45=11.6	F 32.8	0.00122	Pe —	Pv	
	Q 1062.4		L=16	T 127.8		Pf 0.156	Pn	
FAF4	q —	10.02	T=50	L 20.0	C=120	Pt 57.86	Pt	6.4×10^{-4} (C=120)
			L=16 G=5	F 126.0	0.0034	Pe —	Pv	
	Q 1062.4		C=55	T 146.0		Pf 0.5	Pn	$10.02^{4.87} = 74855.86$
FAF0	q —	10.28	2E=49.8	L 1000.0	C=140	Pt 58.4	Pt	FTG FACTOR = 1.133
			2(45)=24.9	F 86.03	0.0022	Pe –	Pv	
	Q 1062.4		2G=11.3	T 1086.		Pf 2.44	Pn	
SRC	q —			L		Pt 60.84	Pt	
				F		Pe	Pv	
	Q 1062.4			T		Pf	Pn	
	q			L		Pt	Pt	
				F		Pe	Pv	
	Q			T		Pf	Pn	
						Pt		

CONTRACT NAME: FPE 5523 PROJECT REPORT EPSTEIN NO: SHEET 3 OF 3



Appendix G – Fire Alarm Design Drawings (abbreviated)

SYMBOL LEGEND

SYMBOL	DESCRIPTION
	CONDUIT DOWN
	CONDUIT UP
	CONDUIT, STUBBED AND CAPPED PROVIDE LOCATION MARKER PER DETAILS
1	AUDIBLE OR VISUAL EVACUATION (HORN/STROBE COMBO, SPEAKER/STROBE COMBO); ONE ASSEMBLY, WALL MOUNTED, EXP = EXPLOSION PROOF, A = AMBER
1	AUDIBLE EVACUATION (SPEAKER OR HORN), WALL MOUNTED, EXP = EXPLOSION PROOF, A = AMBER
1	VISUAL (LAMP, SIGNAL LIGHT, INDICATOR LAMP, STROBE), A = AMBER
A X	AUDIBLE OR VISUAL EVACUATION (SPEAKER/STROBE COMBO); ONE ASSEMBLY, CEILING MOUNTED, A = AMBER, X = OPTIONAL ATTRIBUTE
	VALVE WITH TAMPER DETECTOR/SWITCH
	FLOW DETECTOR/SWITCH
	LEVEL DETECTOR/SWITCH
	PRESSURE DETECTOR/SWITCH
	TAMPER DETECTOR
F	HEAT DETECTOR - F = FIXED TEMPERATURE R = RATE OF RISE R/C = RATE COMPENSATED R/F = COMBINATION
X	SMOKE DETECTOR - P=PHOTOELECTRIC, I=IONIZATION, BT=BEAM TRANSMITTER, BR=BEAM RECEIVER
	SMOKE DETECTOR IN DUCT
	FLAME DETECTOR - F=FLAME, UV=ULTRAVIOLET, IR=INFRARED, UV/IR=COMBINATION ULTRAVIOLET/INFRARED
	GAS DETECTORS
A	ACCESSIBLE EMERGENCY TELEPHONE STATION
2 P/ M	FIRE ALARM BOX/ MANUAL STATION - P=PULL STATION M=MONITOR MODULE
	WATER MOTOR ALARM (WATER MOTOR GONG)
	BELL
	DOOR HOLDER
EPO	ABORT SWITCH - EMERGENCY POWER OFF
ESR	ELEVATOR STATUS/ RECALL
EOL	END OF LINE DEVICE
BPS	BOOSTER POWER SUPPLY
FAC	FIRE ALARM COMMUNICATOR
FACP	FIRE ALARM PANEL
HPM RIO	HPM RIO CABINET
EWSD	EARLY WARNING SMOKE DETECTOR
R	OUTPUT RELAY
XXX	MODULE - AIM=ADDRESSABLE INPUT MODULE, AOM=ADDRESSABLE OUTPUT MODULE
HT	TEMPERATURE SWITCH - HT=HIGH TEMPERATURE, LT=LOW TEMPERATURE
	EARLY WARNING SMOKE DETECTION DETECTOR AND SAMPLE PIPE NETWORK
RTS	REMOTE ALARM INDICATING AND TEST SWITCH
	CONTROL PANEL OR TERMINAL CABINET, WALL MOUNTED (SHOWN SURFACE AND FLUSH MOUNTED)
XX"	CABLE TRAY, WIDTH AS INDICATED
UP	INDICATES CHANGE IN ELEVATION USING VERTICAL ADJUSTABLE SIDE PLATES OF CABLE TRAY
X"x X"	WIREWAY, SIZE AS INDICATED
X	KEYED NOTE
1 / XXX	DETAIL LOCATED ON SHEET XXX
A / XXX	SECTION LOCATED ON SHEET XXX
	SCOPE OF WORK BORDER

HATCH PATTERN DESIGNATION

EWSD COVERAGE AREA

ABBREVIATIONS

ABBREVIATIONS	DESCRIPTION
A	AMMETER, AMPERE
AC	ALTERNATING CURRENT
ACU	AIR CONDITIONING UNIT
ADA	AMERICANS WITH DISABILITIES ACT
AFF	ABOVE FINISHED FLOOR
AHU	AIR HANDLER UNIT
AMP	AMPLIFIER
AN	ANNUNCIATOR
AUX	AUXILLIARY
B	BELL
BAS	BREATHING AIR SYSTEM
BAT	BATTERY
BCDS	BULK CHEMICAL DISTRIBUTION SYSTEM
BKR	BREAKER
BLDG	BUILDING
BOC	BOTTOM OF CONDUIT
BOD	BOTTOM OF DUCT
BOT	BOTTOM OF TRAY
C	CONDUIT, COIL, CONTROL
CPS	CONTINUOUS POWER SYSTEM
CR	CONTROL RELAY
CRS	COATED RIGID STEEL CONDUIT
CSFD	COMBO SMOKE/FIRE DAMPER
D	DUCT
DB	DUCT BANK
DC	DIRECT CURRENT
DDC	DIRECT DIGITAL CONTROL
DIA	DIAMETER
DIV	DIVISION
DNC	DYNAMIC NEUTRALIZATION CHAMBER
EDR	EMERGENCY DOOR RELEASE
EGO	EMERGENCY GAS OFF
EM	EMERGENCY
EMO	EMERGENCY MANUAL OFF
EMT	ELECTRICAL METALLIC TUBING
ENT	ELECTRICAL NON-METALLIC TUBING
EOL	END OF LINE
EWSD	EARLY WARNING SMOKE DETECTION
EXP	EXPLOSION PROOF
F	FLUSH
(F)	FUTURE
FA	FIRE ALARM
FACP	FIRE ALARM CONTROL PANEL
FAP	FIRE ALARM PANEL
FDR	FEEDER
FDU	FIBER DISTRIBUTION UNIT
FLR	FLOOR
FMS	FACILITY MAINTENANCE SYSTEM
F/O	FIBER OPTIC
FS	FLOW SWITCH
FU	FUSE
GND	GROUND
GDP	GAS DETECTION PANEL
GDS	GAS DETECTION SYSTEM
GFI	GROUND FAULT INTERRUPTER
H	HORN
HH	HAND HOLE
HOA	HAND-OFF-AUTOMATIC
HPM	HAZARDOUS PRODUCTION MATERIALS
HVAC	HEATING, VENTILATING AND AIR CONDITIONING
I&C	INSTUMENTATION AND CONTROLS
IMC	INTEMEDIATE METALLIC CONDUIT
IS	INTRINSICALLY SAFE
I/O	INPUT/OUTPUT
J	JUMPER
JB	JUNCTION BOX
KVA	KILOVOLT-AMPERE
KW	KILOWATT
LAN	LOCAL AREA NETWORK
LLD	LIQUID LEAK DETECTION
LSS	LIFE SAFETY SYSTEMS
M	MONITOR
MCC	MOTOR CONTROL CENTER
MFR	MANUFACTURER
MH	MAN-HOLE
MISC	MISCELLANEOUS
MT,MTD	MOUNT, MOUNTED
(N)	NEW
N	NEUTRAL
NA	NON-AUTOMATIC
N/A	NOT APPLICABLE
NC	NORMALLY CLOSED
NEMA	NATIONAL ELECTRIC MANUFACTURERS ASSOCIATION
NIC	NOT IN CONTRACT
NO	NORMALLY OPEN
NTS	NOT TO SCALE
OL	OVERLOAD RELAY
OS&Y	OUTSIDE SCREW & YOKE VALVE
PL	PILOT LIGHT
PC	PHOTOCELL
PIN	PERSONAL IDENTIFICATION NUMBER
PIV	POST INDICATOR VALVE
PLC	PROGRAMMABLE LOGIC CONTROLLER
PNL	PANEL
PS	POWER SUPPLY
PVC	POLYVINYL CHLORIDE
PWR	POWER
Ø	PHASE
QTY	QUANTITY
R	RATE OF RISE
RCPT	RECEPTACLE
RF	RADIO FREQUENCY
RM	ROOM
RNC	RIGID NON-METALLIC CONDUIT
RQD	REQUIRED
RX	RECEIVER
S	SURFACE
SCC	SECURITY COMMAND CENTER
SFEP	SMOKE/FUME EXHAUST PANEL
SS	STAINLESS STEEL
SW	SWITCH
SV	SUPERVISORY POINT
T	THEROMSTAT
TB	TERMINAL BLOCK
TBD	TO BE DETERMINED
TDR	TIME DELAY RELAY
TJB	TERMINAL JUNCTION BOX
TS	TEST SWITCH
TSP	TWISTED SHIELED PAIR
(TYP)	TYPICAL
TX	TRANSMITTER
UF	UNDER FLOOR
UPS	UNINTERRUPTIBLE POWER SUPPLY
V	VOLTMETER, VOLT
VA	VOLT-AMPERE
VLF	VERTICAL LAMINAR FLOW UNIT
VMB	VALVE MANIFOLD BOX
VMP	VALVE MANIFOLD PANEL
VP	VAPOR PROOF
W	WATT, WIRE
WAN	WIDE AREA NETWORK
XFMR	TRANSFORMER

DEVICE/ EQUIPMENT ABBREVIATIONS

AHS	AIR HANDLER SHUTDOWN
AMH	AMHS/ TRANSLOGIC DOORS
BA	BREATHING AIR PANEL
BD	BEAM SMOKE DETECTOR
BGS	BREAK GLASS STATION
BPS	BOOSTER POWER SUPPLY
BU	AUDI RISER BACKUP
CM	CONTROL MONITOR
COM	COMPUTER ROOM
DAM	DAMPER CONTROL
DD	DUCT DETECTOR
DGP	DATA GATHERING PANEL
DH	DOOR HOLDER MODULE
EGO	EMERGENCY GAS OFF
EH	EVAC HORN
ELH	ELEVATOR HEATS
ELS	ELEVATOR SMOKES
EMO	EMERGENCY MACHINE OFF
ET	EMERGENCY TELEPHONE
ETI	E-PHONE INTERNAL MONITOR
EV	VOICE EVACUATION
EVC	EVACUATION TEST
EVI	EVAC. SYSTEM INTERNAL MONITOR
EW	EARLY WARNING DEVICES
EWC	VESDA COMPUTER
EWD	EARLY WARNING DETECTORS
EWSD	EARLY WARNING SMOKE DETECTION
EWP	EARLY WARNING POWER SUPPLIES
EYS	EYEWASH/SHOWER
FDC	FIRE DOOR CLOSER
FS	FLOW SWITCH
FSD	FIRE SMOKE DAMPER
GD	GAS DETECTION POINT
GSD	GAS CABINET SHUTDOWN
GSS	SPARE GAS CAB SHUTDOWN
HD	HEAT DETECTOR
HT	HEAT TRACE
IM	INTERNAL MONITORING POINT
KH	KITCHEN HOOD
KS	TEST SWITCH
LNC	LCN DOOR HOLDER
LD	LIQUID LEAK DETECTION POINT
LDS	LEAK DETECTION SPARE
LED	LIGHT EMITTING DIODE
MM	MONITOR MODULE
PNL	PANEL
PS	PULL STATION
PV	(PIV) POST INDICATING VALVE
RUD	ROLL-UP DOOR SMOKE DETECTORS
SD	SMOKE DETECTOR
SE	FIREMAN'S PANEL
SEN	SENSITIVITY
SP	SPARE POINT
ST	STROBE
STI	STOBE SYSTEM INTERNAL MONITOR
SW	SWITCH PANELS
SYP	SYSTEM POINT (USED BY THE SYSTEM)
TEM	TEMPERATURE MONITORING
TM	TANK MONITORING
TP	TOOL MISC. POINT
TS	TAMPER SWITCH
TSS	MODULE SHUT DOWN SPARE
UV	ULTRAVIOLET FLAME DETECTOR

VENDOR EQUIPMENT IDENTIFICATION

PANEL TAG

EXAMPLE OF:

FIRE ALARM PANEL LOCATED IN THE CUB LEVEL 2, SECTOR C. INITIATING PANEL ADDRESS IS '001'

FIRE ALARM PANEL TAG

FAP-C-2C-001 (4)

- SEQUENTIAL NUMBER
- PANEL ADDRESS
- LEVEL AND SECTOR
- BUILDING DESIGNATION CODE
- SYSTEM PANEL CODE

SYSTEM PANEL CODE

BDA	BI DIRECTIONAL AMPLIFIER
CAB	SECURITY/ CCTV CABINET
CAP	CCTV AUXILIARY POWER SUPPLY
CCP	CLOSED CIRCUIT PANEL
CGP	COLOR GRAPHICS PANEL
CSFD	COMBINATION SMOKE/ FIRE DAMPER
EDR	EMERGENCY DOOR RELEASE PANEL
EVP	VOICE EVACUATION PANEL
EWSD	EARLY WARNING SMOKE DETECTION
FAP	FIRE ALARM PANEL
FCP	FIREMAN'S CONTROL PANEL
FDC	FIRE CONTROL MODULE ENCLOSURE
FDM	FIRE MONITOR MODULE ENCLOSURE
FDU	FIBER DISTRIBUTION UNIT
FHS	FIRE EWSD
OSD	OFF SITE DIALER
PTR	SYSTEM PRINTER

BPS PANEL TAG

BPS-F-4C-001

- NUMBER OF BPS IN AREA
- BUILDING LEVEL (4), DRAWING SECTOR (C)
- BUILDING DESIGNATION CODE
- SYSTEM CHARACTER (BOOSTER POWER SUPPLY)

BLDG SECTOR
(REFER TO KEY PLAN FOR SECTORS)

NOTE: REFER TO "BUILDING LABEL" LEGEND IN THE "BUILDING DESIGNATIONS" SECTION ON THIS SHEET

EARLY WARNING SMOKE DETECTION TAG (4)

EARLY WARNING SMOKE DETECTION
POWER SUPPLY/ DETECTOR PANEL TAG

FEW - PS - 4C - 01

- NUMBER OF DEVICE OR POWER SUPPLY IN AREA
- BUILDING LEVEL (4), DRAWING SECTOR (C)
- VESDA DETECTOR POWER SUPPLY (ONLY ON POWER SUPPLY)
- SYSTEM CHARACTER (FIRE EARLY WARNING)

SYSTEM CHARACTER

FA	FIRE ALARM
G	GAS DETECTION
HP	HPM
TY	SECURITY/ ACCESS

CABLE LIST (3)

CABLE NO.	MAKE	MODEL	STYLE	AWG	TYPE	DESCRIPTION
1	WEST PENN	D990	1 TP	#16	UL FIRE CABLE - FPL	SIGNATURE LOOP CABLE
2	WEST PENN	1991	1 TSP	#16	UL FIRE CABLE - NFPL	AUDIO OUTPUT CABLE
3	WEST PENN	D997	4 STRAND	#18	UL FIRE CABLE - FPL	RS-232
4	WEST PENN	D990	1 TP	#16	UL FIRE CABLE - FPL	PEER TO PEER, AUDIO PRE-AMP
5	WEST PENN	AQ 225	1 TP	#16	DIRECT BURY RATED	PEER TO PEER, AUDIO PRE-AMP, PUSH-TO-TALK
6	SEICOR/CORNING		8 FIBER CABLE		AS REQUIRED	PEER TO PEER, AUDIO
7	WEST PEN	1984	6 COND	#18	UL FIRE CABLE - NPLF	HSSD CABLE

NOTE: CABLE LIST MAY NOT INCLUDE ALL WIRING REQUIRED BY INDIVIDUAL SYSTEMS. SEE INDIVIDUAL DRAWING SHEETS FOR DETAILS

FIRE ALARM / VOICE EVACUATION

CABLE TYPE	RUN IN CONDUIT	OK TO RUN IN CABLE TRAY	COMMENTS
PEER TO PEER	X	X	STYLE 7
SIGNATURE LOOP	X		
AUDIO RISER/ DIGITAL AUDIO	X		
70V AUDIO	X	X	
STROBES	X	X	
POINT WIRING	X		

BUILDING DESIGNATIONS

CODE:	BUILDING
C - :	CENTRAL UTILITY BUILDING
F - :	FAB
O - :	ADMIN
P - :	SPINE
S - :	SITE
G - :	GENERAL
H - :	HIGH VOLTAGE YARD
W - :	HPM WAREHOUSE

GENERAL NOTES:

A. FIRE ALARM SYSTEM SHALL BE INSTALLED IN ACCORDANCE WITH ALL APPLICABLE CODES AND STANDARDS. REFER TO FIRE ALARM SHEET "-FA-904, DETAIL #19 FOR DEVICE INSTALLATION GUIDELINES.

B. ALL WIRING TO BE INSTALLED ACCORDING TO THE LATEST ADOPTED REVISION OF THE NATIONAL ELECTRICAL CODE ARTICLE 760

C. THIS IS A STANDARD LEGEND SHEET. SOME SYMBOLS OR ABBREVIATIONS MAY APPEAR IN THIS SHEET AND NOT ON THE PROJECT DRAWINGS.

D. WHEN FIRE ALARM WIRING IS IN CONDUIT. ALL CONDUIT TO BE 3/4" UNLESS OTHERWISE NOTED. THE FOLLOWING SHALL BE MAINTAINED:
1. EMT IN CEILING SPACES
2. RIGID CONDUIT OR PVC IN SLABS WITH RIGID ELBOWS

IF FLEX CONDUIT IS USED THE FOLLOWING APPLIES:
1. FLEX CONDUIT RUNS SHALL NO EXCEED 72"
2. ONLY METAL FLEX SHALL BE USED

E. ALL STYLES OF CLASS "A" CIRCUITS USING PHYSICAL CONDUCTORS (e.g. METALLIC, OPTICAL FIBER) SHALL BE INSTALLED SUCH THAT THE OUTGOING AND RETURN CONDUCTORS, EXITING FROM AND RETURNING TO THE CONTROL UNIT, RESPECTIVELY, ARE ROUTED SEPARATELY. THE OUTGOING AND RETURN CIRCUIT CONDUCTORS SHALL NOT BE RUN IN THE SAME CABLE ASSEMBLY, ENCLOSURE OR RACEWAY. FOR ADDITIONAL INFORMATION AND EXCEPTIONS SEE NFPA 72.

F. WHEN INSTALLING SHIELDED CABLE THE FOLLOWING MUST BE OBSERVED:
1. CONTINUITY OF THE SHIELD MUST BE MAINTAINED THROUGHOUT THE ENTIRE LENGTH OF THE CABLE RUN.
2. THE CABLE SHIELD MUST BE ISOLATED FROM GROUND AND TERMINATED ONLY IN THE ASSOCIATED CONTROL PANEL AT THE TERMINAL INDICATED ON CONTROL PANEL DRAWINGS.

G. ALL WIRING MUST BE FREE OF GROUNDS, AND IN NO CASE LESS THAN (4) MEGOHM TO GROUND.

H. ONLY WIRING CONNECTED TO THE FIRE ALARM SYSTEM MAY BE RUN IN THE SAME CONDUIT/ RACEWAY.

L. REFER TO ELECTRICAL DRAWINGS FOR ELECTRICALLY CLASSIFIED AREAS. REFER TO ARCHITECTURAL CODE DRAWINGS AND SPECIFICATION SECTIONS FOR WALL RATINGS AND SEALING REQUIREMENTS.

M. THE CONTRACT DRAWINGS DEPICT GENERAL LOCATIONS OF LIFE SAFETY EQUIPMENT AND FIELD DEVICES. EXACT ROUTING OF CONDUITS/RACEWAYS TO BE DETERMINED IN THE FIELD BY THE INSTALLING CONTRACTOR TO SUIT CONDITIONS. ALL CHANGES SHALL BE CLEARLY INDICATED ON THE RECORD DRAWINGS.

N. SHOULD ANY CONDITION EXIST THAT DIFFER FROM WHAT IS INDICATED ON THESE DRAWINGS WHICH CAUSE MAJOR DEVIATIONS IN THE WORK SHOWN, THE CONTRACTOR SHALL CONTACT THE GENERAL CONTRACTOR IN A TIMELY MANNER SO AS NOT TO IMPACT THE CONSTRUCTION SCHEDULE.

O. DUCT DETECTORS MUST BE READILY ACCESSIBLE FOR SERVICING AND TESTING.

P. ELECTRICAL CONTRACTOR TO PROVIDE 120 VAC EMERGENCY POWER TO ALL FIRE ALARM PANELS.

Q. COMPLIANCE WITH CODES TO BE MAINTAINED AND VERIFIED.

R. CONTRACTOR SHALL REFER TO SPECIFICATION 283111, FOR ADDITIONAL REQUIREMENTS.

S. CONTRACTOR SHALL FIELD VERIFY AND COORDINATE ALL FIELD CONDITIONS THAT MAY AFFECT INSTALLATION OF LSS SYSTEM COMPONENTS, INCLUDING OTHER DISCIPLINE SCOPE OF WORK THAT MAY IMPACT LSS EQUIPMENT. CONTRACTOR SHALL BECOME FAMILIAR WITH FIELD CONDITIONS PRIOR TO COMMENCING WORK.

KEYED NOTES:

1. MOUNT DEVICE 80" AFF TO BOTTOM OF DEVICES AT LOCATIONS SHOWN ON PLANS UNLESS OTHERWISE NOTED. REFER TO FIRE ALARM DETAIL SHEET 904 FOR INSTALLATION GUIDELINES.
2. MOUNT DEVICE 48" AFF TO BOTTOM OF DEVICES AT LOCATIONS SHOWN ON PLANS UNLESS OTHERWISE NOTED. REFER TO FIRE ALARM DETAIL SHEET 904 FOR INSTALLATION GUIDELINES.
3. WIRE GAUGE AND TYPES LISTED ARE FOR REFERENCE PURPOSES, AND DO NOT RELIEVE SYSTEM SUBCONTRACTOR OF THE REQUIREMENT TO DETERMINE THE REQUIRED CABLE SIZE AND TYPE FOR EACH INDIVIDUAL CIRCUIT. SYSTEM WIRING SHALL BE SIZED SUCH THAT CIRCUIT IMPEDANCE, CAPACITANCE, SIGNAL LOSS AND VOLTAGE DROP CHARACTERISTICS ARE APPROPRIATE FOR INTENDED CIRCUIT USE.
4. SYSTEM PROGRAMMING SUBCONTRACTOR SHALL PROVIDE LIST OF FIELD DEVICE IDENTIFICATION TAGS.

REV.	DATE	DESCRIPTION	DRAWN	CHECKED
C	9/14/09	90% BASEBUILD REVIEW	BR	MB
B	7/13/09	60% BASEBUILD REVIEW	BR	MB
A	5/18/09	30% BASEBUILD REVIEW	BR	MB

KEY PLAN

ACME
Semiconductor

CLIENT

PROJECT

ARCHITECT / ENGINEER OF RECORD

SHEET TITLE

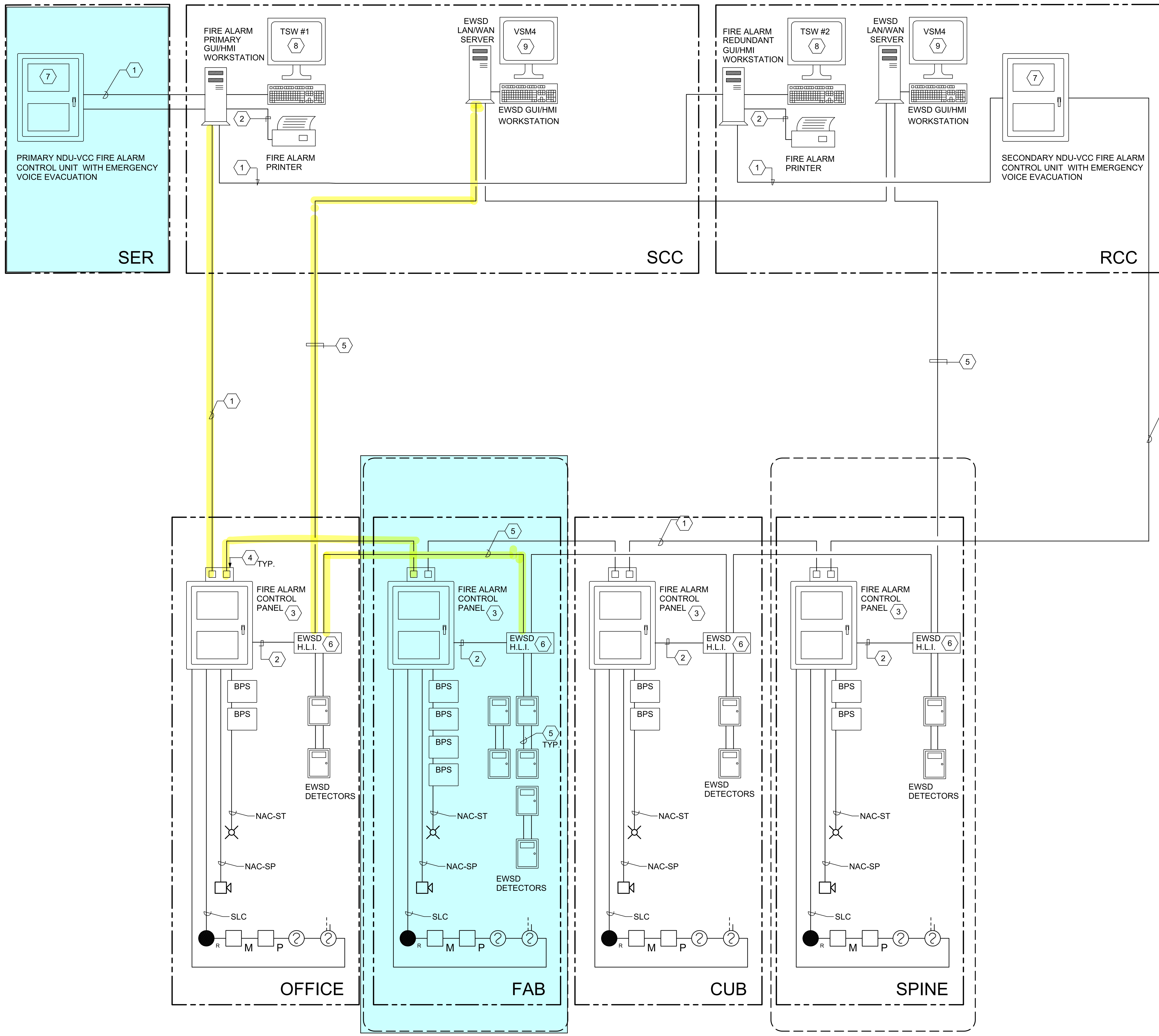
FAB - LIFE SAFETY SYSTEMS LEGEND, SYMBOLS, AND ABBREVIATIONS

	DATE	NAME
DRAWN	3/30/09	BR
CHECKED		MB
ISSUED/APPROVE	9/14/09	
SCALE/SHT. SIZE	NTS	F1 (30x42)
CTB FILE		MWZ_BW_V.ctb

PROJ. NO.

REV. C

SHEET NO. F-FA-001



SHEET NOTES:

A. FOR LEGENDS AND ABBREVIATIONS SEE DRAWING F-FA-001.

B. THIS PLAN DEPICTS THE GENERAL LOCATION OF FIELD DEVICES. COORDINATE FINAL LOCATIONS WITH OTHER TRADES AND CONSTRUCTION MANAGER.

C. THE FIRE ALARM SYSTEM WILL BE INSTALLED AND TESTED IN ACCORDANCE WITH NFPA-72, NEC, AND LOCAL CODES AND AMENDMENTS AS ADOPTED BY THE LOCAL AUTHORITY HAVING JURISDICTION.

D. THE EWSD TESTING WILL BE PERFORMED BY A CERTIFIED VENDOR. ALL FUTURE SAMPLE ORFICES WILL BE SIZED, DRILLED AND POSITIONED IN ACCORDANCE WITH THE MANUFACTURES SPECIFICATONS AND PIPE SAMPLING CALCULATIONS.

E. CONDUIT ROUTING TO FIELD DEVICES WILL BE DETERMINED AND SIZED BY THE SUBCONTRACTOR. THE SUBCONTRACTOR WILL COORDINATE CONDUIT ROUTING WITH OTHER TRADES.

F. FIELD DEVICE TAGS WILL BE LABELED WITH THE APPROPRIATE TAG NUMBER AS INDICATED ON THE LEGEND SHEET.

G. THE LIFE SAFETY INSTALLATION CONTRACTOR WILL PROVIDE AND INSTALL LSS EQUIPMENT, COMPONENT MODULES, RACEWAYS AND WIRING FOR A COMPLETE AND FUNCTION SYSTEM.

H. THE LIFE SAFETY SYSTEM INSTALLATION WILL INCLUDE EQUIPMENT MOUNTING, RACEWAY INSTALLATION, TERMINATION OF CABLING AND EQUIPMENT, CABLING, WIRING, AND RACEWAY LABELING.

KEYED NOTES:

1. FIRE ALARM SYSTEM NETWORK. 6 FIBER (2 - DATA IN, 2 - DATA OUT, 2 - AUDIO RISER) 50/125 MICRON.
2. RS232 WIRING, 20 FT. MAX.
3. FIRE ALARM CONTROL PANEL(S) LOCATED IN LSS ROOMS, TYPICAL.
4. FIRE ALARM SYSTEM NETWORK CONNECTION (T.O.) INSTALLED BY I.T. LOCATED WITHIN LSS ROOMS, TYPICAL.
5. VESDANET NETWORK COMMUNICATIONS LINK.
6. VESDA SYSTEM HIGH LEVEL INTERFACE (HLI). ONE HLI PER VESDANET.
7. PRIMARY/SECONDARY FIRE ALARM CONTROL PANEL WITH VOICE EVACUATION. SIMPLEX NDU-VCC OR EQUAL.
8. PRIMARY/SECONDARY FIRE ALARM GUI/HMI SIMPLEX TRUESITE OR EQUAL.
9. EWSD SYSTEM GUI/HMI VESDA VSM4 OR EQUAL.

REV.	DATE	DESCRIPTION	DRAWN	CHECKED
C	9/14/09	90% BASEBUILD REVIEW	BR	MB
B	7/13/09	60% BASEBUILD REVIEW	BR	MB
A	5/18/09	30% BASEBUILD REVIEW	BR	MB

KEY PLAN

ACME
Semiconductor

CLIENT

PROJECT

ARCHITECT / ENGINEER OF RECORD

SHEET TITLE

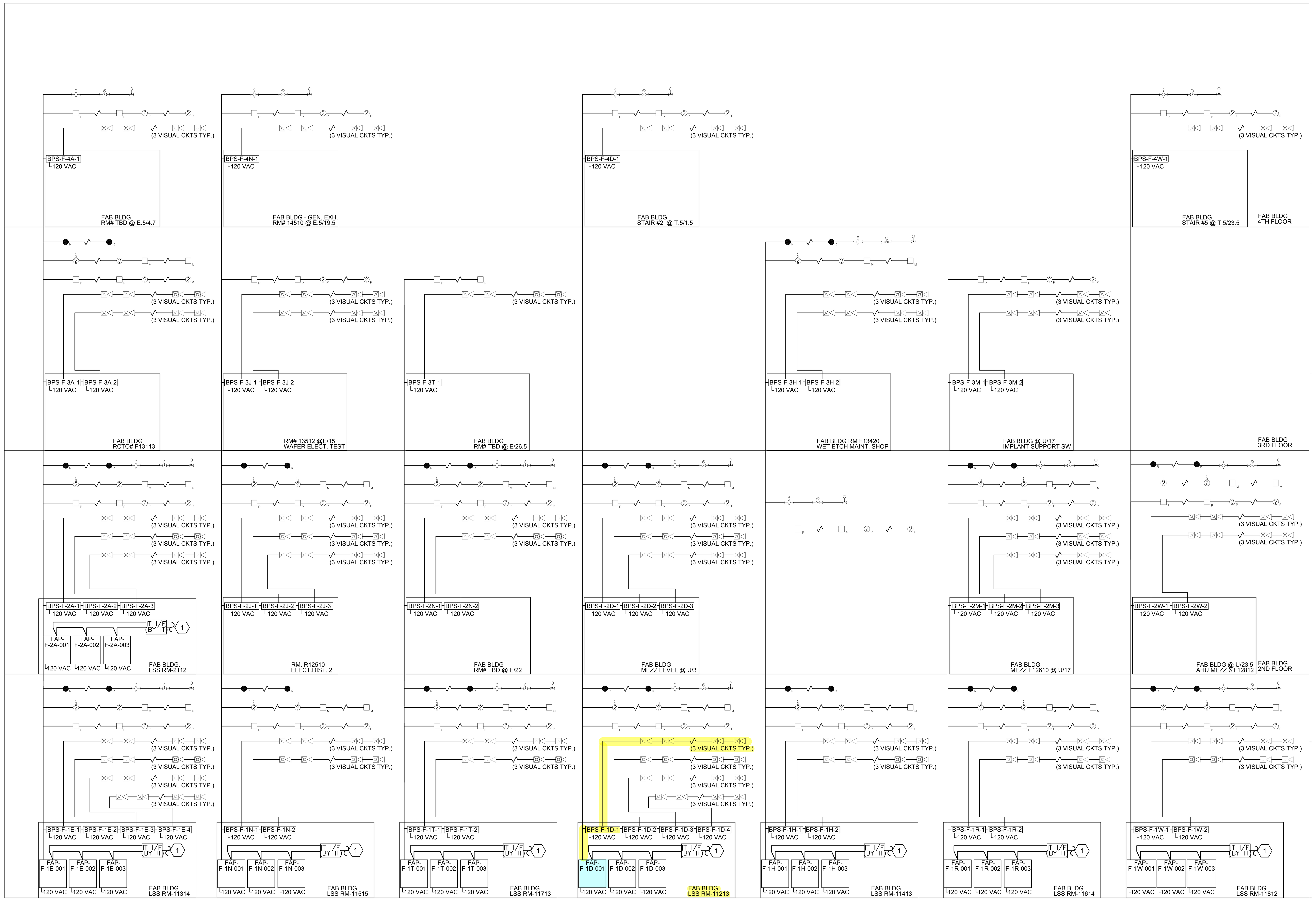
FAB - LIFE SAFETY SYSTEMS FIRE ALARM SYSTEM SINGLE LINE DIAGRAM

	DATE	NAME
DRAWN	4/3/09	BR
CHECKED		MB
ISSUED/APPROVE	9/14/09	
SCALE/SHT. SIZE	NTS	F1 (30x42)
CTB FILE		MWZ_BW_V.ctb

PROJ. NO.

REV. C

SHEET NO. F-FA-200



SHEET NOTES:

A. FOR LEGENDS AND ABBREVIATIONS SEE DRAWING F-FA-001.

B. THIS PLAN DEPICTS THE GENERAL LOCATION OF FIELD DEVICES. COORDINATE FINAL LOCATIONS WITH OTHER TRADES AND CONSTRUCTION MANAGER.

C. THE FIRE ALARM SYSTEM WILL BE INSTALLED AND TESTED IN ACCORDANCE WITH NFPA-72, NEC, AND LOCAL CODES AND AMENDMENTS AS ADOPTED BY THE LOCAL AUTHORITY HAVING JURISDICTION.

D. REFERENCE DRAWING F-FA-200 FIRE ALARM SINGLE LINE FOR EWSD BLOCK DIAGRAMS.

E. CONDUIT ROUTING TO FIELD DEVICES WILL BE DETERMINED AND SIZED BY THE SUBCONTRACTOR. THE SUBCONTRACTOR WILL COORDINATE CONDUIT ROUTING WITH OTHER TRADES.

F. FIELD DEVICE TAGS WILL BE LABELED WITH THE APPROPRIATE TAG NUMBER AS INDICATED ON THE LEGEND SHEET.

G. THE LIFE SAFETY INSTALLATION CONTRACTOR WILL PROVIDE AND INSTALL LSS EQUIPMENT, COMPONENT MODULES, RACEWAYS AND WIRING FOR A COMPLETE AND FUNCTION SYSTEM.

H. THE LIFE SAFETY SYSTEM INSTALLATION WILL INCLUDE EQUIPMENT MOUNTING, RACEWAY INSTALLATION, TERMINATION OF CABLING AND EQUIPMENT, CABLING, WIRING, AND RACEWAY LABELING.

KEYED NOTES:

1. DISTRIBUTION OF NETWORK FIBER INTERCONNECTION THROUGHOUT SITE WILL BE ADMINISTERED BY THE TELECOMMUNICATION DISCIPLINE. REFER TO TELECOMMUNICATION *-T-201 SERIES DRAWINGS FOR THE FIBER NETWORK LAYOUT AND IDF ROOM LOCATIONS.

2. REFER TO ADMIN. BLDG PACKAGE SET FOR CONTINUTATION OF FIRE ALARM INTERCONNECTION.

REV.	DATE	DESCRIPTION	DRAWN	CHECKED
B	9/14/09	90% BASEBUILD REVIEW	BR	MB
A	7/13/09	60% BASEBUILD REVIEW	BR	MB

KEY PLAN

ACME
Semiconductor

CLIENT

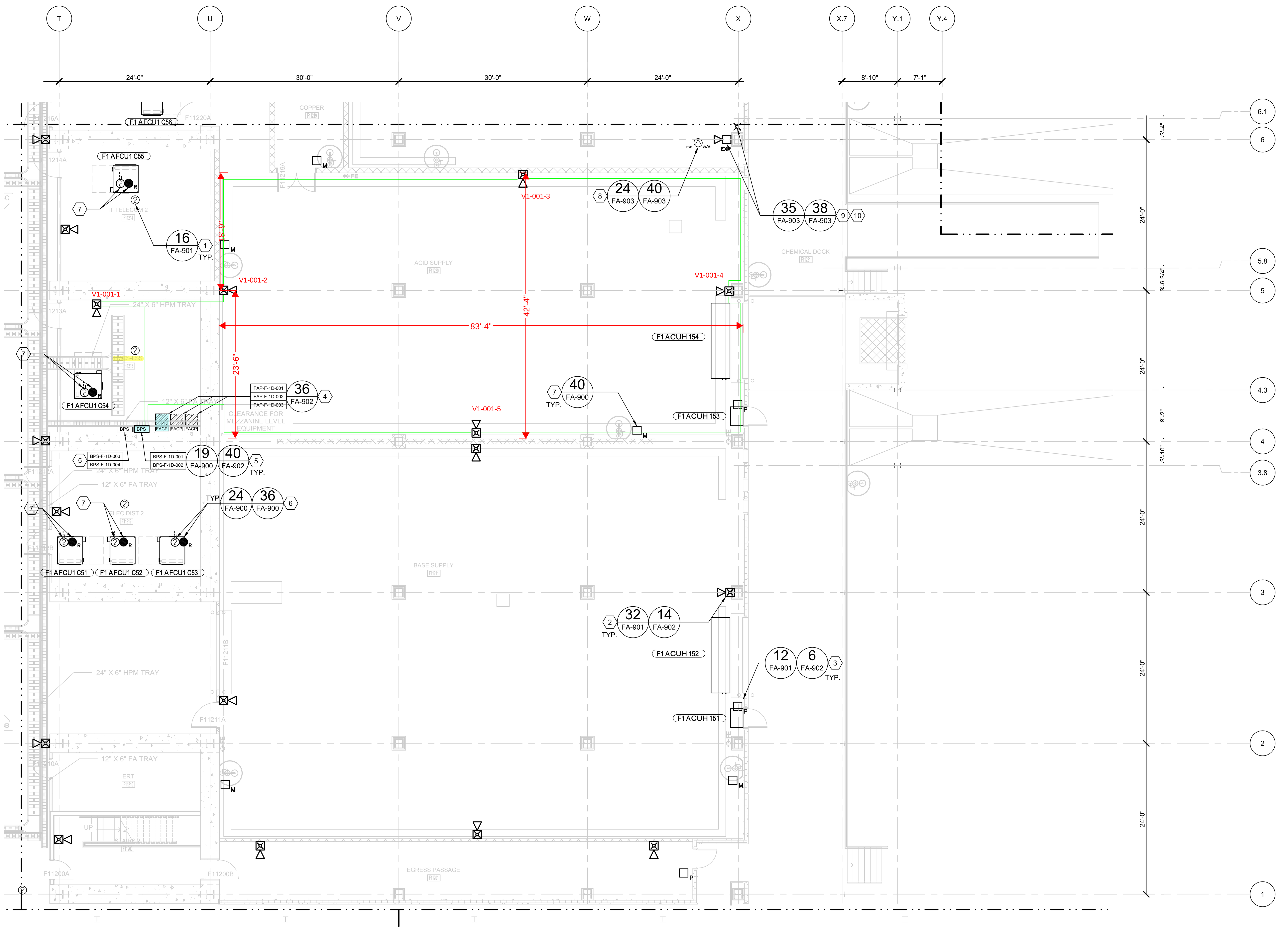
PROJECT

ARCHITECT / ENGINEER OF RECORD

SHEET TITLE

FAB - LIFE SAFETY SYSTEMS FIRE ALARM SYSTEM RISER DIAGRAM

	DATE	NAME	PROJ. NO.	REV.
DRAWN	4/22/09	AG		B
CHECKED		MB		
ISSUED/APPROVE	9/14/09		SHEET NO.	
SCALE/SHT. SIZE	NTS	F1 (30x42)	F-FA-201	
CTB FILE		MWZ_BW_V.ctb		



SHEET NOTES:

A. FOR LEGENDS AND ABBREVIATIONS SEE DRAWING FA-001.

B. THIS PLAN DEPICTS THE GENERAL LOCATION OF FIELD DEVICES. COORDINATE FINAL LOCATIONS WITH OTHER TRADES AND CONSTRUCTION MANAGER.

C. THE FIRE ALARM SYSTEM WILL BE INSTALLED AND TESTED IN ACCORDANCE WITH NFPA-72, NEC, AND LOCAL CODES AND AMENDMENTS AS ADOPTED BY THE LOCAL AUTHORITY HAVING JURISDICTION.

D. THE EWSD TESTING WILL BE PERFORMED BY A CERTIFIED VENDOR. ALL FUTURE SAMPLE ORIFICES WILL BE SIZED, DRILLED AND POSITIONED IN ACCORDANCE WITH THE MANUFACTURES SPECIFICATONS AND PIPE SAMPLING CALCULATIONS.

E. CONDUIT ROUTING TO FIELD DEVICES WILL BE DETERMINED AND SIZED BY THE SUBCONTRACTOR. THE SUBCONTRACTOR WILL COORDINATE CONDUIT ROUTING WITH OTHER TRADES.

F. FIELD DEVICE TAGS WILL BE LABELED WITH THE APPROPRIATE TAG NUMBER AS INDICATED ON THE LEGEND SHEET.

G. THE LIFE SAFETY INSTALLATION CONTRACTOR WILL PROVIDE AND INSTALL LSS EQUIPMENT, COMPONENT MODULES, RACEWAYS AND WIRING FOR A COMPLETE AND FUNCTIONAL SYSTEM.

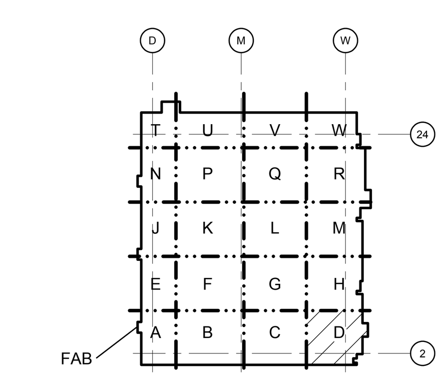
H. THE LIFE SAFETY SYSTEM INSTALLATION WILL INCLUDE EQUIPMENT MOUNTING, RACEWAY INSTALLATION, TERMINATION OF CABLING AND EQUIPMENT, CABLING, WIRING, AND RACEWAY LABELING.

KEYED NOTES:

1. PROVIDE AND INSTALL PHOTOELECTRIC SMOKE SENSOR AND MOUNTING BASE.
2. FURNISH AND INSTALL COMBINATION SPEAKER STROBE. ADJUST WATTAGE TAP ON SPEAKER TO PROVIDE AUDIBLE SIGNAL OF 15 Dba OVER THE AMBIENT SOUND LEVEL. STROBE CANDELA SHALL BE RATED FOR SQUARE FOOTAGE OF DEVCE COVERAGE AREA PER NFPA 72.
3. FURNISH AND INSTALL ADDRESSABLE DOUBLE ACTION MANUAL PULL STATION. MOUNT PULL STATION SO THAT THE OPERABLE PART SHALL NOT BE LESS THAT 3.5 FEET AND NOT MORE THAN 4.5 FEET ABOVE FLOOR LEVEL.
4. FURNISH AND INSTALL NETWORK FIRE ALARM CONTROL PANEL ALONG WITH ALL APPLICABLE CONDUIT AND CABLE. COORDINATE INSTALLATION AND ELECTRICAL POWER CONNECTIONS WITH ELECTRICAL CONTRACTORS. COORDINATE FIBER NETWORK INTERCONNECTION WITH TELECOM CONTRACTOR.
5. FURNISH AND INSTALL FIRE ALARM BOOSTER POWER SUPPLY FOR NOTIFICATION APPLIANCE CIRCUITS ALONG WITH ALL ASSOCIATED CONDUIT AND CABLE. COORDINATE INSTALLATION AND ELECTRICAL POWER CONNECTIONS WITH ELECTRICAL CONTRACTOR.
6. FURNISH AND INSTALL DUCT DETECTOR AND CONTROL RELAY ALONG WITH ALL ASSOCIATED CONDUIT AND CABLE AS REQUIRED FOR SMOKE DETECTION AND SHUTDOWN OF FAN COIL UNIT. COORDINATE MOUNTING LOCATIONS AND POINTS OF CONNECTION WITH MECHANICAL AND ELECTRICAL CONTRACTORS.
7. FURNISH AND INSTALL ADDRESSABLE MONITOR MODULE TO MONITOR EYEWASH/SHOWER STATUS. COORDINATE INSTALLATION AND CONNECTIONS WITH MECHANICAL CONTRACTOR.
8. FURNISH AND INSTALL EXPLOSION PROOF OPTICAL FIRE DETECTOR (UV/IR) RATED FOR A CLASS 1, DIVISION 2 ENVIRONMENT ALONG WITH ALL ASSOCIATED CONDUIT AND CABLE.
9. FURNISH AND INSTALL EXPLOSION PROOF STROBE RATED FOR A CLASS 1, DIVISION-2 ENVIRONMENT ALONG WITH ALL ASSOCIATED CONDUIT AND CABLE.
10. FURNISH AND INSTALL EXPLOSION PROOF HORN RATED FOR A CLASS 1, DIVISION 2 ENVIRONMENT ALONG WITH ALL ASSOCIATED CONDUIT AND CABLE.

REV.	DATE	DESCRIPTION	DRAWN	CHECKED
C	9/14/09	90% BASEBUILD REVIEW	BR	MB
B	7/13/09	60% BASEBUILD REVIEW	BR	MB
A	5/18/09	30% BASEBUILD REVIEW	BR	MB

KEY PLAN



ACME
Semiconductor

DWG NORTH

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

CLIENT

PROJECT

ARCHITECT / ENGINEER OF RECORD

SHEET TITLE

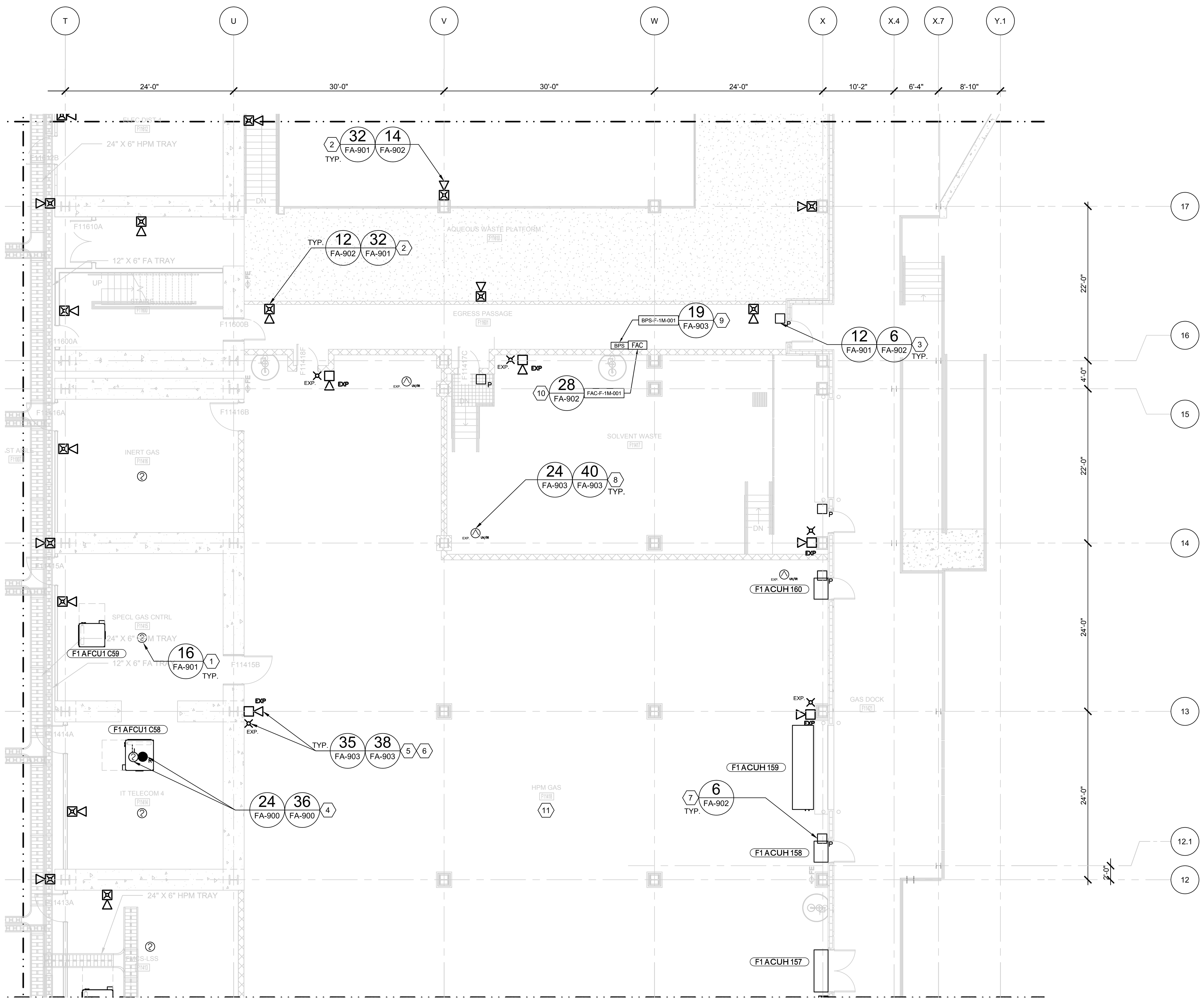
FAB - LIFE SAFETY SYSTEMS
FIRE ALARM INSTALLATION PLAN
LEVEL 1 SECTOR D

	DATE	NAME
DRAWN	3/30/09	BR
CHECKED		MB
ISSUED/APPROVE	9/14/09	
SCALE/SHT. SIZE	1/8" = 1'	F1 (30x42)
CTB FILE		MWZ_BW_V.ctb

PROJ. NO.

REV. C

SHEET NO. F-FA-301D



SHEET NOTES:

A. FOR LEGENDS AND ABBREVIATIONS SEE DRAWING FA-001.

B. THIS PLAN DEPICTS THE GENERAL LOCATION OF FIELD DEVICES. COORDINATE FINAL LOCATIONS WITH OTHER TRADES AND CONSTRUCTION MANAGER.

C. THE FIRE ALARM SYSTEM WILL BE INSTALLED AND TESTED IN ACCORDANCE WITH NFPA-72, NEC, AND LOCAL CODES AND AMENDMENTS AS ADOPTED BY THE LOCAL AUTHORITY HAVING JURISDICTION.

D. THE EWSD TESTING WILL BE PERFORMED BY A CERTIFIED VENDOR. ALL FUTURE SAMPLE ORIFICES WILL BE SIZED, DRILLED AND POSITIONED IN ACCORDANCE WITH THE MANUFACTURES SPECIFICATONS AND PIPE SAMPLING CALCULATIONS.

E. CONDUIT ROUTING TO FIELD DEVICES WILL BE DETERMINED AND SIZED BY THE SUBCONTRACTOR. THE SUBCONTRACTOR WILL COORDINATE CONDUIT ROUTING WITH OTHER TRADES.

F. FIELD DEVICE TAGS WILL BE LABELED WITH THE APPROPRIATE TAG NUMBER AS INDICATED ON THE LEGEND SHEET.

G. THE LIFE SAFETY INSTALLATION CONTRACTOR WILL PROVIDE AND INSTALL LSS EQUIPMENT, COMPONENT MODULES, RACEWAYS AND WIRING FOR A COMPLETE AND FUNCTIONAL SYSTEM.

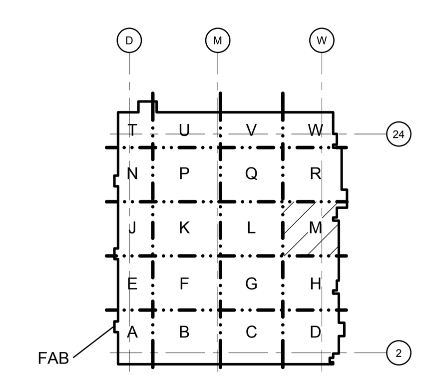
H. THE LIFE SAFETY SYSTEM INSTALLATION WILL INCLUDE EQUIPMENT MOUNTING, RACEWAY INSTALLATION, TERMINATION OF CABLING AND EQUIPMENT, CABLING, WIRING, AND RACEWAY LABELING.

KEYED NOTES:

1. PROVIDE AND INSTALL PHOTOELECTRIC SMOKE SENSOR AND MOUNTING BASE.
2. FURNISH AND INSTALL COMBINATION SPEAKER STROBE. ADJUST WATTAGE TAP ON SPEAKER TO PROVIDE AUDIBLE SIGNAL OF 15 Dba OVER THE AMBIENT SOUND LEVEL. STROBE CANDELA SHALL BE RATED FOR SQUARE FOOTAGE OF DEVICE COVERAGE AREA PER NFPA 72.
3. FURNISH AND INSTALL ADDRESSABLE DOUBLE ACTION MANUAL PULL STATION. MOUNT PULL STATION SO THAT THE OPERABLE PART SHALL NOT BE LESS THAN 3.5 FEET AND NOT MORE THAN 4.5 FEET ABOVE FLOOR LEVEL.
4. FURNISH AND INSTALL DUCT DETECTOR AND CONTROL RELAY ALONG WITH ALL ASSOCIATED CONDUIT AND CABLE AS REQUIRED FOR SMOKE DETECTION AND SHUTDOWN OF FAN COIL UNIT. COORDINATE MOUNTING LOCATIONS AND POINTS OF CONNECTION WITH MECHANICAL AND ELECTRICAL CONTRACTORS.
5. FURNISH AND INSTALL EXPLOSION PROOF STROBE RATED FOR A CLASS 1, DIVISION-2 ENVIRONMENT ALONG WITH ALL ASSOCIATED CONDUIT AND CABLE.
6. FURNISH AND INSTALL EXPLOSION PROOF HORN RATED FOR A CLASS 1, DIVISION 2 ENVIRONMENT ALONG WITH ALL ASSOCIATED CONDUIT AND CABLE.
7. FURNISH ANDINSTALL NON-ADDRESSABLE MANUAL PULL-STATION RATED FOR CLASS 1/DIVISION 2 HAZARDOUS ENVIRONMENT. FURNISH AND INSTALL CONDUIT AND CABLE BACK TO FIRE ALARM CABINET (FAC-F-1M-001) AS REQUIRED TO INTERCONNECT INITIATING DEVICE CIRCUIT TO MONITORING MODULE.
8. FURNISH AND INSTALL EXPLOSION PROOF OPTICAL FIRE DETECTOR (UV/IR) RATED FOR A CLASS 1, DIVISION 2 ENVIRONMENT ALONG WITH ALL ASSOCIATED CONDUIT AND CABLE.
9. FURNISH AND INSTALL FIRE ALARM BOOSTER POWER SUPPLY FOR NOTIFICATION APPLIANCE CIRCUITS ALONG WITH ALL ASSOCIATED CONDUIT AND CABLE. BPS-F-1M-001 CIRCUITS SHALL BE DEDICATED TO POWER ALL EXPLOSION PROOF AUDIBLE AND VISUAL DEVICES LOCATED WITHIN CLASS 1/DIV 2 ROOMS. COORDINATE INSTALLATION AND ELECTRICAL POWER CONNECTIONS WITH ELECTRICAL CONTRACTOR.
10. FURNISH AND INSTALL HOFFMAN (NEMA-4X RATED) ENCLOSURE TO HOUSE MONITORING MODULES ALLOCATED TO MONITOR THE UV/IR SENSORS AND SAFETY SHOWERS LOCATED IN CLASS 1/DIV 2 ROOMS. SIZE ENCLOSURE AS REQUIRED TO PROPERLY MOUNT MODULES ONTO BACK PANEL. FURNISH AND INSTALL ALL CONDUIT AND CABLE AS REQUIRED TO COMPLETE INTERCONNECTION OF DEVICES.
11. ALL EYEWASH/SAFETY SHOWERS WITHIN HPM GAS AND SOLVENTS WASTE ROOMS SHALL BE MONITORED VIA MONITORING MODULES LOCATED WITHIN FIRE ALARM CABINET OUTSIDE OF CLASS-1/DIVISION-2 HAZARDOUS AREA.

REV.	DATE	DESCRIPTION	DRAWN	CHECKED
C	9/14/09	90% BASEBUILD REVIEW	BR	MB
B	7/13/09	60% BASEBUILD REVIEW	BR	MB
A	5/18/09	30% BASEBUILD REVIEW	BR	MB

KEY PLAN



ACME Semiconductor

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

DWG NORTH

CLIENT

PROJECT

ARCHITECT / ENGINEER OF RECORD

SHEET TITLE

FAB - LIFE SAFETY SYSTEMS FIRE ALARM INSTALLATION PLAN LEVEL 1 SECTOR M

	DATE	NAME	PROJ. NO.	REV.
DRAWN	3/30/09	BR		C
CHECKED		MB		
ISSUED/APPROVE	9/14/09		SHEET NO.	
SCALE/SHT. SIZE	1/8" = 1'	F1 (30x42)	F-FA-301M	
CTB FILE		MWZ_BW_V.ctb		

SHEET NOTES:

A. THIS FIRE ALARM SYSTEM FUNCTIONAL MATIX REFLECTS TYPICAL SYSTEM INPUT/ OUTPUT (I/O) FUNCTIONS ONLY TO BE USED AS A GUIDE FOR SYSTEM PROGRAMMING, THE FIRE ALARM SYSTEM INTEGRATOR/ CONTRACTOR SHALL COORDINATE SPECIFIC I/O REQUIREMENTS AS REQUIRED TO PROVIDE A COMPLETELY OPERATIONAL SYSTEM. REFER TO SPECIFICATION 283111 FOR ADDITIONAL REQUIREMENTS.

B. THIS FIRE ALARM SYSTEM SHALL OPERATE AS A PROPRIETARY SUPERVISING STATION SYSTEM, AN D SHALL COMPLY WITH THE REQUIREMENTS OF CHAPTER 8.3, NFPA 72 (2002).

C. THIS FIRE ALARM SYSTEM SHALL OPERATE AS A MANUALLY OPERATED EMERGENCY VOICE/ ALARM COMMUNICATIONS SYSTEM, AND SHALL COMPLY WITH THE REQUIREMENTS OF CHAPTER 6.9, NFPA 72 (2002).

SYSTEM OUTPUTS

SYSTEM INPUTS

		Control Unit Annunciation									Notification				Required Fire Safety Control												Supplementary						
		Actuate alarm visual signal at SCC/RCC	Actuate audible alarm signal at SCC/RCC	Actuate visual supervisory signal at SCC/RCC	Actuate audible supervisory signal at SCC/RCC	Actuate visual trouble signal at SCC/RCC	Actuate audible trouble signal at SCC/RCC	Display/print change of status at SCC/RCC	Actuate graphics system - display floor map	(RESERVED)	Transmit trouble signal to supervising station	Transmit fire alarm signal to supervising station	Transmit supervisory signal to supervising station	(RESERVED)	(RESERVED)	Release magnetically held smoke doors	(RESERVED)	(RESERVED)	Close smoke/fire dampers in rated walls	(RESERVED)	(RESERVED)	(RESERVED)	Unlock exits via Security/Access Control System	Actuate suppression system pre-discharge alarms	Initiate suppression system releasing sequence	(RESERVED)	(RESERVED)	(RESERVED)	Shutdown AHU	Elevator capture/recall/shunt trip per ANSI A17.1	(RESERVED)	(RESERVED)	
		A	B	C	D	E	F	G	H	T	J	K	E	M	M	N	Q	P	Q	R	S	T	E	V	W	X	X	Z	AA	BB	CC	DD	
1	Manual Fire Alarm Boxes - All Locations	●	●					●	●			●											●										1
2	Smoke Detectors - Pre-action System	●	●					●	●			●												●	●								2
3	Smoke Detectors - Elevator Shafts	●	●					●	●			●																		●			3
4	Smoke Detectors - Area Spot Type	●	●					●	●			●							●				●										4
5	Smoke Detectors - Elevator Lobby	●	●					●	●			●																		●			5
6	Smoke Detectors - At Fire Doors	●	●					●	●			●				●																	6
7	Smoke Detectors - Elevator Machine Rooms	●	●					●	●			●																		●			7
8	EWSD - 1st stage (Fire One)	●	●					●	●			●																					8
9	EWSD - 2nd stage (Fire Two)	●	●					●	●			●																					9
10	EWSD - 3rd stage (Fire Three)	●	●					●	●			●																					10
11	EWSD - Trouble/Off Normal					●	●	●	●		●																						11
12	Duct Smoke Detector	●	●					●	●			●							●										●				12
13	(RESERVED)																																13
14	Heat Detectors - Pre-action System	●	●					●	●			●												●	●								14
15	Heat Detectors - Area Spot Type	●	●					●	●			●											●										15
16	Heat Detectors - Elevator Machine Room	●	●					●	●			●																		●			16
17	Heat detectors - Elevator Shaft	●	●					●	●			●																		●			17
18	Elevator Shunt-trip Supervision			●	●																												
18	Waterflow Switch at Riser	●	●					●	●			●											●										18
19	Dry Pipe Sprinkler System Pressure Switch			●	●			●	●			●											●										19
20	Water Level Switch at Water Tank			●	●			●	●				●																				20
21	Water Temperature Switch at Water Tank			●	●			●	●				●																				21
22	Water Control Valve - P.I.V.			●	●			●	●				●																				22
23	Water Control Valve - OS&Y Tamper			●	●			●	●				●																				23
24	Fire Pump Running	●	●					●	●			●																					24
25	Fire Pump Power Failure/Phase Reversal			●	●			●	●				●																				25
26	Fire Alarm AC Power Failure/Abnormal Voltage					●	●				●																						26
27	Fire Alarm System Low Battery/Charge Fail					●	●				●																						27
28	Fire Alarm System - Open or Short Circuit					●	●				●																						28
29	Fire Alarm System - Ground Fault					●	●				●																						29
30	FAS - Device Tampering/Opening/Removing					●	●																										30
31	Fire Alarm System - Off Normal Switch Position					●	●																										31
32	Notification Appliance Circuit Short/Ground/Open					●	●				●																						32
		A	B	C	D	E	E	G	H	T	J	K	E	M	M	N	Q	P	Q	R	S	T	E	V	W	X	X	Z	AA	BB	CC	DD	

REV.	DATE	DESCRIPTION	DRAWN	CHECKED
B	9/14/09	90% BASEBUILD REVIEW	BR	MB
A	7/13/09	60% BASEBUILD REVIEW	BR	MB

KEY PLAN

ACME
Semiconductor

SHEET TITLE
FAB - LIFE SAFETY SYSTEMS
FIRE ALARM SYSTEM
INPUT/ OUTPUT MATRIX

	DATE	NAME	PROJ. NO.	REV.
DRAWN	6/8/09	BR		B
CHECKED		MB		
ISSUED/APPROVE	9/14/09		SHEET NO.	
SCALE/SHT. SIZE	NTS	F1 (30x42)	F-FA-800	
CTB FILE		MWZ_BW_V.ctb		

Appendix H – DETACT Input & Numerical Results

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

INPUT PARAMETERS			CALC. PARAMETERS	
Ceiling height (H)	8.9675	m	R/H	0.296
Radial distance (R)	2.65	m	dT(cj)/dT(pl)	0.676
Ambient temperature (To)	20	C	u(cj)/u(pl)	0.552
Actuation temperature (Td)	141.111	C	Rep. t2 coeff.	k
Response time index (RTI)	100	(m-s)1/2	Slow	0.003
Fire growth power (n)	2	-	Medium	0.012
Fire growth coefficient (k)	0.318	kW/s^n	Fast	0.047
Time step (dt)	5	s	Ultrafast	0.400

Calculation time (s)	HRR	Gas temp	Gas velocity	Det temp	dT/dt
0	0.0	20.0	0.00	20.00	0.0000
5	8.0	21.2	0.53	20.00	0.0086
10	31.8	23.0	0.84	20.04	0.0268
15	71.6	25.1	1.10	20.18	0.0516
20	127.2	27.5	1.34	20.43	0.0813
25	198.8	30.0	1.55	20.84	0.1147
30	286.2	32.8	1.75	21.41	0.1509
35	389.6	35.7	1.94	22.17	0.1890
40	508.8	38.8	2.12	23.11	0.2286
45	644.0	42.0	2.29	24.26	0.2688
50	795.0	45.3	2.46	25.60	0.3094
55	962.0	48.8	2.62	27.15	0.3499
60	1144.8	52.3	2.78	28.90	0.3900
65	1343.6	55.9	2.93	30.85	0.4295
70	1558.2	59.7	3.08	33.00	0.4680
75	1788.8	63.5	3.23	35.34	0.5055
80	2035.2	67.4	3.37	37.86	0.5418
85	2297.6	71.4	3.51	40.57	0.5769
90	2575.8	75.4	3.64	43.46	0.6106
95	2870.0	79.6	3.78	46.51	0.6429
100	3180.0	83.8	3.91	49.72	0.6738
105	3506.0	88.1	4.04	53.09	0.7034
110	3847.8	92.5	4.16	56.61	0.7315
115	4205.6	96.9	4.29	60.27	0.7583
120	4579.2	101.4	4.41	64.06	0.7838
125	4968.8	105.9	4.53	67.98	0.8080
130	5374.2	110.5	4.65	72.02	0.8310
135	5795.6	115.2	4.77	76.17	0.8528
140	6232.8	119.9	4.89	80.44	0.8735
145	6686.0	124.7	5.01	84.80	0.8932
150	7155.0	129.6	5.12	89.27	0.9119
155	7640.0	134.5	5.23	93.83	0.9296
160	8140.8	139.4	5.34	98.48	0.9465
165	8657.6	144.4	5.46	103.21	0.9625
170	9190.2	149.5	5.57	108.02	0.9778
175	9738.8	154.6	5.67	112.91	0.9924
180	10303.2	159.7	5.78	117.87	1.0063
185	10883.6	164.9	5.89	122.90	1.0196
190	11479.8	170.2	5.99	128.00	1.0323
195	12092.0	175.5	6.10	133.16	1.0445
200	12720.0	180.8	6.20	138.39	1.0562
205	13364.0	186.2	6.31	**143.67**	1.0675
210	14023.8	191.6	6.41	**149.01**	1.0783
215	14699.6	197.1	6.51	**154.40**	1.0888
220	15391.2	202.6	6.61	**159.84**	1.0989
225	16098.8	208.1	6.71	**165.34**	1.1087
230	16822.2	213.7	6.81	**170.88**	1.1182
235	17561.6	219.4	6.91	**176.47**	1.1274
240	18316.8	225.0	7.00	**182.11**	1.1364

Appendix I – NAC Calculation

AZ AFAA
NAC Voltage Drop Calculator
for Audio / Visual devices

This calculator provided voltage drop calculations in three formats (Point to Point, End of Line, and Load Centering).

Make sure that you know what method is accepted by, and the results do not exceed the limits set by the respective jurisdiction

Project Name	FPE S522 Proj Report				
Date		6/7/2016			
Circuit Number	Circuit V1				
Area Covered	Level 1 - BPS-F-1D-001 (Acid Supply)				
Nominal System Voltage			20		
Minimum Device Voltage			16		
Total Circuit Current		0.737		Wire	Ohm's
				Gauge	Per 1000
Distance from source to 1st device			29	16	4.89
Wire Gauge for balance of circuit				16	4.89
Enter current in amps.		Distance			
.150 = 150 ma		from	Voltage		
Device	Device	previous	At	Drop from	Percent
Number	Current	device	Device	source	Drop
Device 1	0.065	29	19.79	0.209	1.05%
Device 2	0.168	22	19.65	0.354	1.77%
Device 3	0.168	70	19.30	0.699	3.49%
Device 4	0.168	59	19.11	0.893	4.46%
Device 5	0.168	74	18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
END			18.99	1.014	5.07%
Totals	0.737	254	End of Line Voltage		**18.99**

Point to Point Method			**End of Line Method**			**Load Centering Method**		
CIRCUIT IS WITHIN LIMITS			**CIRCUIT IS WITHIN LIMITS**			**CIRCUIT IS WITHIN LIMITS**		
Totals		Voltage	Totals		Voltage	Totals		Voltage
Current	Distance	Drop	Current	Distance	Drop	Current	Distance	Drop
0.737	254	**1.01**	0.737	254	**1.831**	0.737	254	**0.915**
End of Line Voltage		**18.99**	End of Line Voltage		**18.17**	End of Line Voltage		**19.08**
Percent Drop		5.07%	Percent Drop		9.15%	Percent Drop		4.58%

End of Line and Load Centering Methods use only the wire guage for the first device to source

Standard Wire Resistance in Ohms per 1000 feet.

18=7.77 16=4.89 14=3.07 12=1.98 10=1.24

18-14 Awg = Solid Conductors 12-10 Awg = Stranded Conductors

Notes:

Wire resistance is doubled in the calculations for two wires (Positive and Negative)

The voltage calculated to the last device in any method must not be lower then

the manufactures listed minimum operating voltage (IE: rated operating voltage 20-32 VDC).

Device Manufacturer	Simplex	
		Current
Speaker/Strobes		@Rated
Model #	Candela	Voltage
4906-9153 Wall	15	0.040
4906-9153 Wall	30	0.063
4906-9153 Wall	75	0.124
4906-9153 Wall	110	0.168
4906-9157 Ceiling	110	0.211
4906-9157 Ceiling	15	0.050
4906-9157 Ceiling	30	0.083
4906-9157 Ceiling	75	0.155

Device Manufacturer	Gentex	
		Current
Strobe Only		@Rated
Model #	Candela	Voltage

Appendix J – Battery Calculation

Fire Alarm System Secondary Battery-set Calculation Worksheet

ITEM	DESCRIPTION	STANDBY CURRENT PER UNIT (AMPS)		QTY		TOTAL STANDBY CURRENT PER ITEM	ALARM CURRENT PER UNIT (AMPS)		QTY		TOTAL ALARM CURRENT PER ITEM
FACU	Fire Alarm Control Unit	0.1000	X	1	=	0.1000	0.2000	X	1	=	0.2000
SD	Smoke Detector	0.0010	X	0	=	0.0000	0.0500	X	5	=	0.2500
HD	Heat Detector	0.0000	X	0	=	0.0000	0.0000	X	5	=	0.0000
RLY	Relay (failsafe)	0.0500	X	3	=	0.1500	0.0000	X	3	=	0.0000
RLY	Relay (not failsafe)	0.0000	X	0	=	0.0000	0.0500	X	3	=	0.1500
SS	Speaker-Strobe	0.0000	X	36	=	0.0000	0.2400	X	30	=	7.2000
SP	Speaker	0.0000	X	47	=	0.0000	0.1474	X	15	=	2.2110
ANN	Annunciator	0.1000	X	0	=	0.0000	0.2000	X	0	=	0.0000
MS	Manual Station	0.0000	X	4	=	0.0000	0.0000	X	3	=	0.0000
WF	Waterflow Switch	0.0000	X	1	=	0.0000	0.0000	X	1	=	0.0000
TS	Tamper Switch	0.0000	X	1	=	0.0000	0.0000	X	1	=	0.0000
0	0	0.0000	X	0	=	0.0000	0.0000	X	0	=	0.0000
0	0	0.0000	X	0	=	0.0000	0.0000	X	0	=	0.0000
					TOTAL SYSTEM STANDBY CURRENT (AMPS)	0.2500				TOTAL SYSTEM ALARM CURRENT (AMPS)	10.0110

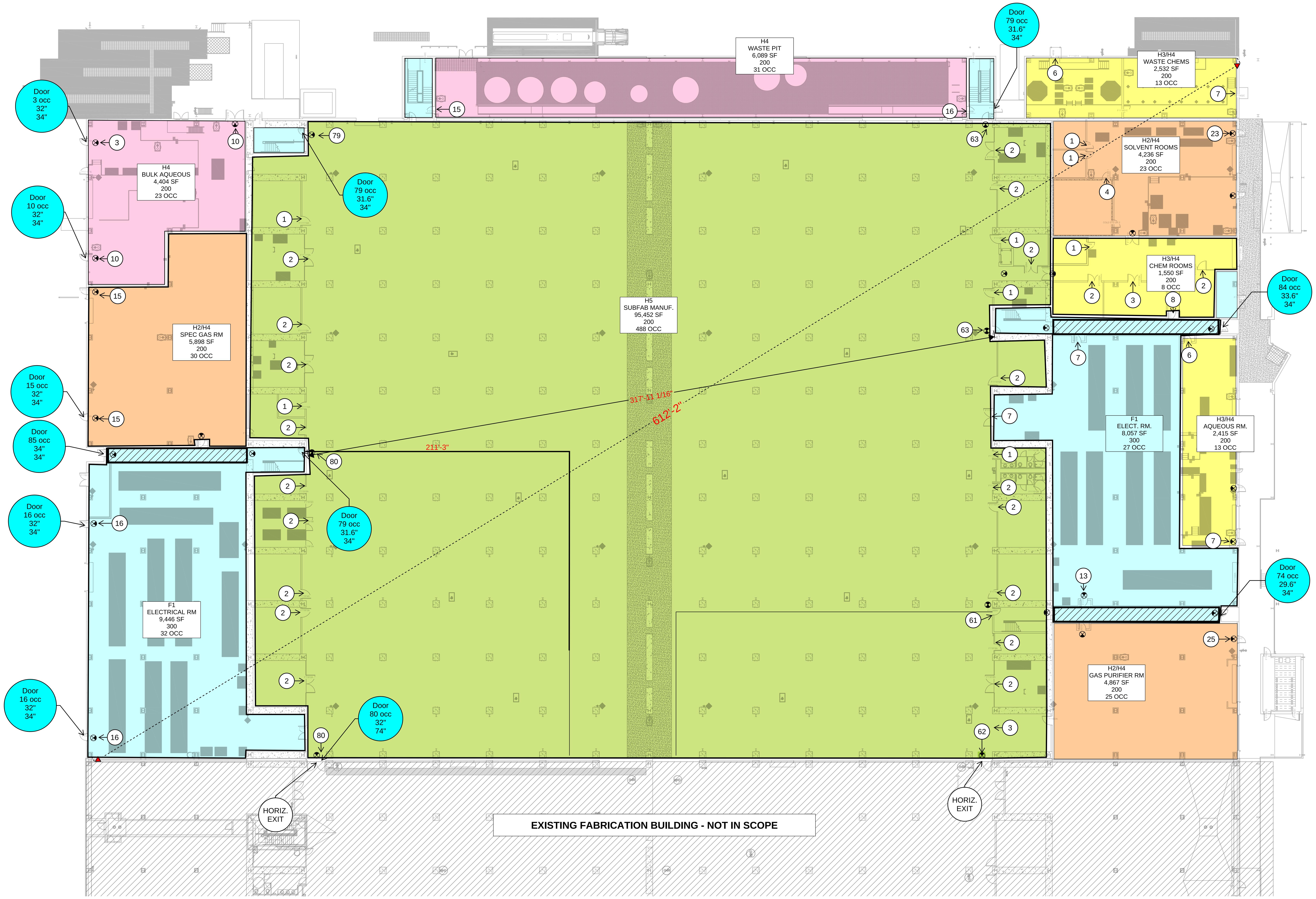
Prepared for:	REQUIRED STANDBY TIME (HRS) NFPA 72-2002 4.4.1.5.3.1		TOTAL SYSTEM STANDBY CURRENT (AMPS)		REQUIRED STANDBY CAPACITY (AMP-HOURS)	REQUIRED ALARM TIME (HOURS) NFPA 72-2002 4.4.1.5.3.1		TOTAL SYSTEM ALARM CURRENT (AMPS)		REQUIRED ALARM CAPACITY (AMP-HOURS)
	24	X	0.2500	=	6.0000	0.25	X	10.0110	=	2.5028

Prepared by:	REQUIRED STANDBY CAPACITY (AMP-HOURS)		REQUIRED ALARM CAPACITY (AMP-HOURS)		TOTAL CAPACITY (AMP-HOURS)	TOTAL CAPACITY (AMP-HOURS)		SAFETY FACTOR		ADJUSTED BATTERY CAPACITY (AMP-HOURS)
	6.00	+	2.5028	=	8.5028	8.5028	X	120%	=	10

Appendix K – Life Safety Plans

CONFIDENTIAL

In conformance with Education Law Article 145, Section 7209 and Article 147, section 7307; it is a violation of the law for any person, unless he is acting under the direction of a registered architect, professional engineer or land surveyor to alter an item in any way. If an item bearing the seal of an architect, engineer or land surveyor is altered, the altering architect, engineer or land surveyor shall affix to the item his seal and the notation "altered by" followed by his signature and the date of such alteration, and a specific description of the alteration.



KEYED NOTES:

1.

SYMBOL LEGEND

- TWO-HOUR FIRE-RESISTANCE RATED EGRESS PASSAGEWAY WITH 90-MINUTE OPENING PROTECTION
- TRAVEL DISTANCE TO EXIT (FEET)
- EXIT SIGN (HATCH INDICATES ORIENTATION)
- OCCUPANCY
- FUNCTION OF SPACE
- AREA (SQ. FT.)
- OCCUPANT LOAD FACTOR (PERSONS PER SQ. FT.)
- OCCUPANT LOAD (PERSONS)
- NUMBER OF OCCUPANTS USING EXIT / EXIT-ACCESS COMPONENT
- Door / 15 occ / 3" / 34":
  - EXIT / EXIT-ACCESS COMPONENT (E.G.,STAIR, DOOR)
  - NUMBER OF OCCUPANTS USING EXIT / EXIT-ACCESS COMPONENT
  - MINIMUM REQUIRED CLEAR WIDTH (INCHES)
  - PROVIDED CLEAR WIDTH (INCHES)

OCCUPANCY LEGEND

- F1 - MANUF.
- H2/H3/H4 - FLAM/OX/TOX/CORR
- H2/H4 - FLAMM/TOX/CORR
- H4 - TOX/CORR
- H5 - SEMICONDUCTOR FAB

DWG NORTH

ACME Semiconductor

ACME
Semiconductor
Anytown, USA

ARCHITECT / ENGINEER OF RECORD

Consultant

Project Title

ACME SEMICONDUCTOR MODULE 1 EXPANSION

CONFIDENTIAL

PROGRESS PRINT
NOT FOR CONSTRUCTION

No	Date	Revision	By
1	12/08/15	FPE DS21	JE

Date: 12/08/15
Proj.# 12345
Checked By: J. EPSTEIN
Drawn By: J. EPSTEIN

Sheet Title

FAB LIFE SAFETY PLANS LEVEL 1

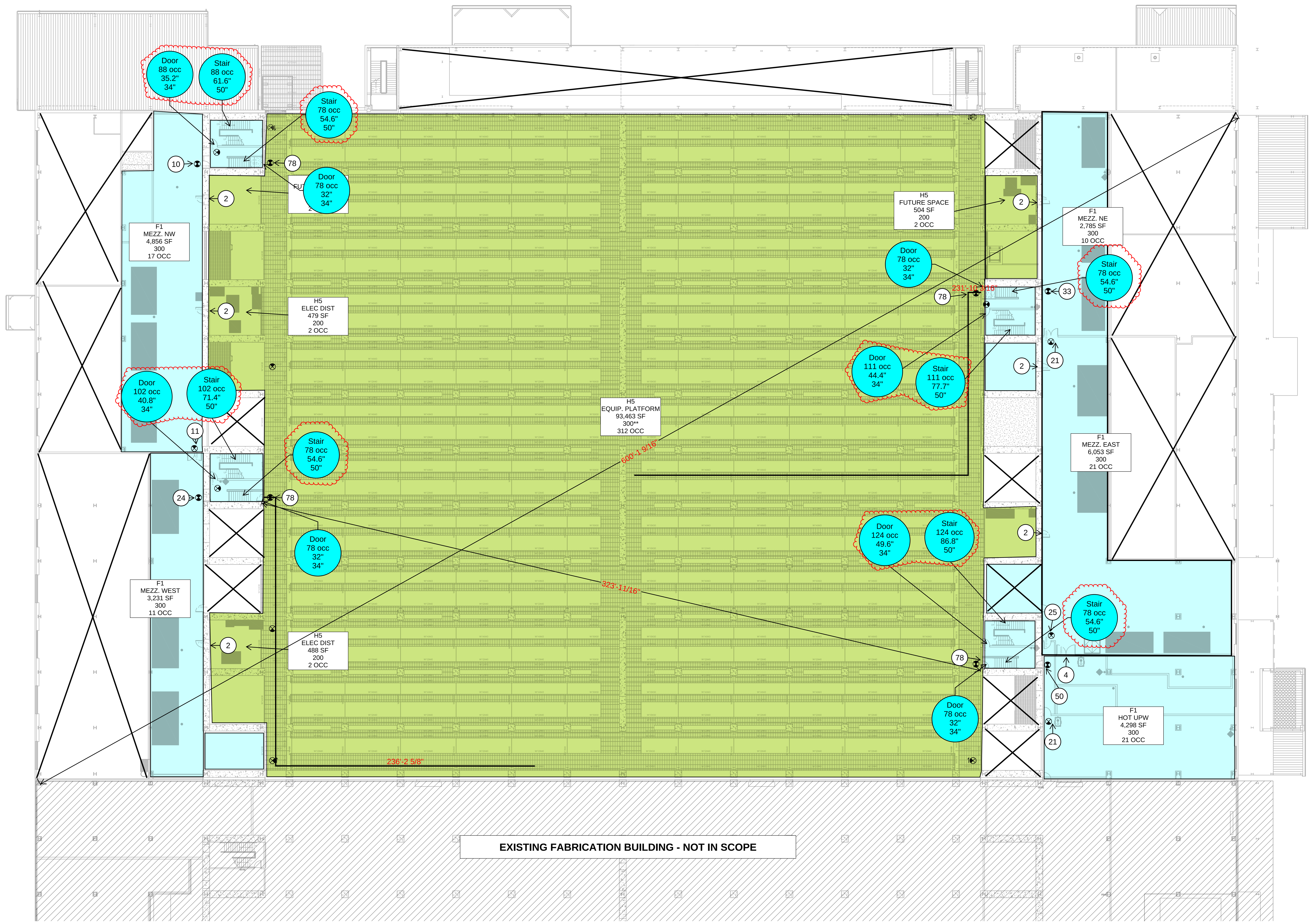
Sheet No.

FB-G 101

CONFIDENTIAL

KEYED NOTES:

1.



SYMBOL LEGEND

- TWO-HOUR FIRE-RESISTANCE RATED EGRESS PASSAGEWAY WITH 90-MINUTE OPENING PROTECTION
- TRAVEL DISTANCE TO EXIT (FEET)
- EXIT SIGN (HATCH INDICATES ORIENTATION)
- OCCUPANCY
- FUNCTION OF SPACE
- AREA (SQ. FT.)
- OCCUPANT LOAD FACTOR (PERSONS PER SQ. FT.)
- OCCUPANT LOAD (PERSONS)
- NUMBER OF OCCUPANTS USING EXIT / EXIT-ACCESS COMPONENT
- Door / 15 occ / 3" / 34":
  - EXIT / EXIT-ACCESS COMPONENT (E.G.,STAIR, DOOR)
  - NUMBER OF OCCUPANTS USING EXIT / EXIT-ACCESS COMPONENT
  - MINIMUM REQUIRED CLEAR WIDTH (INCHES)
  - PROVIDED CLEAR WIDTH (INCHES)

OCCUPANCY LEGEND

- F1 - MANUF.
- H2/H3/H4 - FLAM/OX/TOX/CORR
- H2/H4 - FLAMM/TOX/CORR
- H4 - TOX/CORR
- H5 - SEMICONDUCTOR FAB

8' 4' 0 8' 16'
SCALE: 1/8" = 1'-0"

DWG NORTH

ACME
Semiconductor

ACME
Semiconductor
Anytown, USA

ARCHITECT / ENGINEER OF RECORD

Consultant

Project Title

ACME SEMICONDUCTOR MODULE 1 EXPANSION

PROGRESS PRINT
NOT FOR CONSTRUCTION

No	Date	Revision	By
0	12/08/15	FPE S521	JE

Date: 12/08/15
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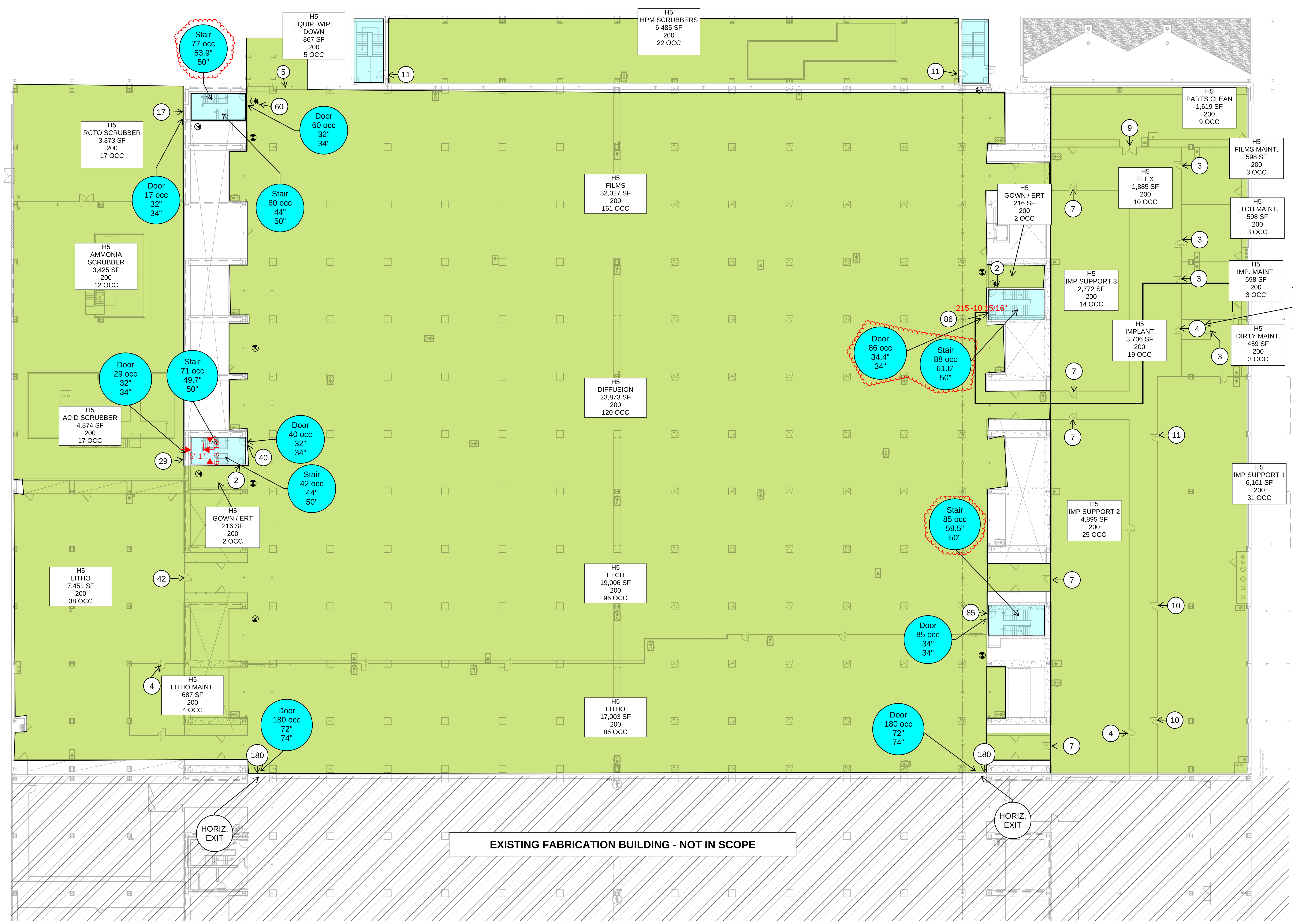
Drawn By: J. EPSTEIN

Sheet Title
FAB
LIFE SAFETY
PLANS
LEVEL 2

Sheet No.
FB-G
102

KEYED NOTES:

1.



SYMBOL LEGEND

- TWO-HOUR FIRE-RESISTANCE RATED EGRESS PASSAGEWAY WITH 90-MINUTE OPENING PROTECTION
- TRAVEL DISTANCE TO EXIT (FEET)
- EXIT SIGN (HATCH INDICATES ORIENTATION)
- OCCUPANCY
- FUNCTION OF SPACE
- AREA (SQ. FT.)
- OCCUPANT LOAD FACTOR (PERSONS PER SQ. FT.)
- OCCUPANT LOAD (PERSONS)
- NUMBER OF OCCUPANTS USING EXIT / EXIT-ACCESS COMPONENT
- Door 15 occ 3" 34":
  - EXIT / EXIT-ACCESS COMPONENT (E.G.,STAIR, DOOR)
  - NUMBER OF OCCUPANTS USING EXIT / EXIT-ACCESS COMPONENT
  - MINIMUM REQUIRED CLEAR WIDTH (INCHES)
  - PROVIDED CLEAR WIDTH (INCHES)

OCCUPANCY LEGEND

- F1 - MANUF.
- H2/H3/H4 - FLAM/OX/TOX/CORR
- H2/H4 - FLAMM/TOX/CORR
- H4 - TOX/CORR
- H5 - SEMICONDUCTOR FAB

8' 4' 0 8' 16'
SCALE: 1/8" = 1'-0"

DWG NORTH

ACME Semiconductor

ACME Semiconductor Anytown, USA

ARCHITECT / ENGINEER OF RECORD

Consultant

Project Title

ACME SEMICONDUCTOR MODULE 1 EXPANSION

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Sheet Title

FAB LIFE SAFETY PLANS LEVEL 3

Sheet No.

FB-G 103

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In conformance with Education Law Article 145, Section 7209 and Article 147, section 7307; it is a violation of the law for any person, unless he is acting under the direction of a registered architect, professional engineer or land surveyor to alter an item in any way. If an item bearing the seal of an architect, engineer or land surveyor is altered, the altering architect, engineer or land surveyor shall affix to the item his seal and the notation "altered by" followed by his signature and the date of such alteration, and a specific description of the alteration.

KEYED NOTES:

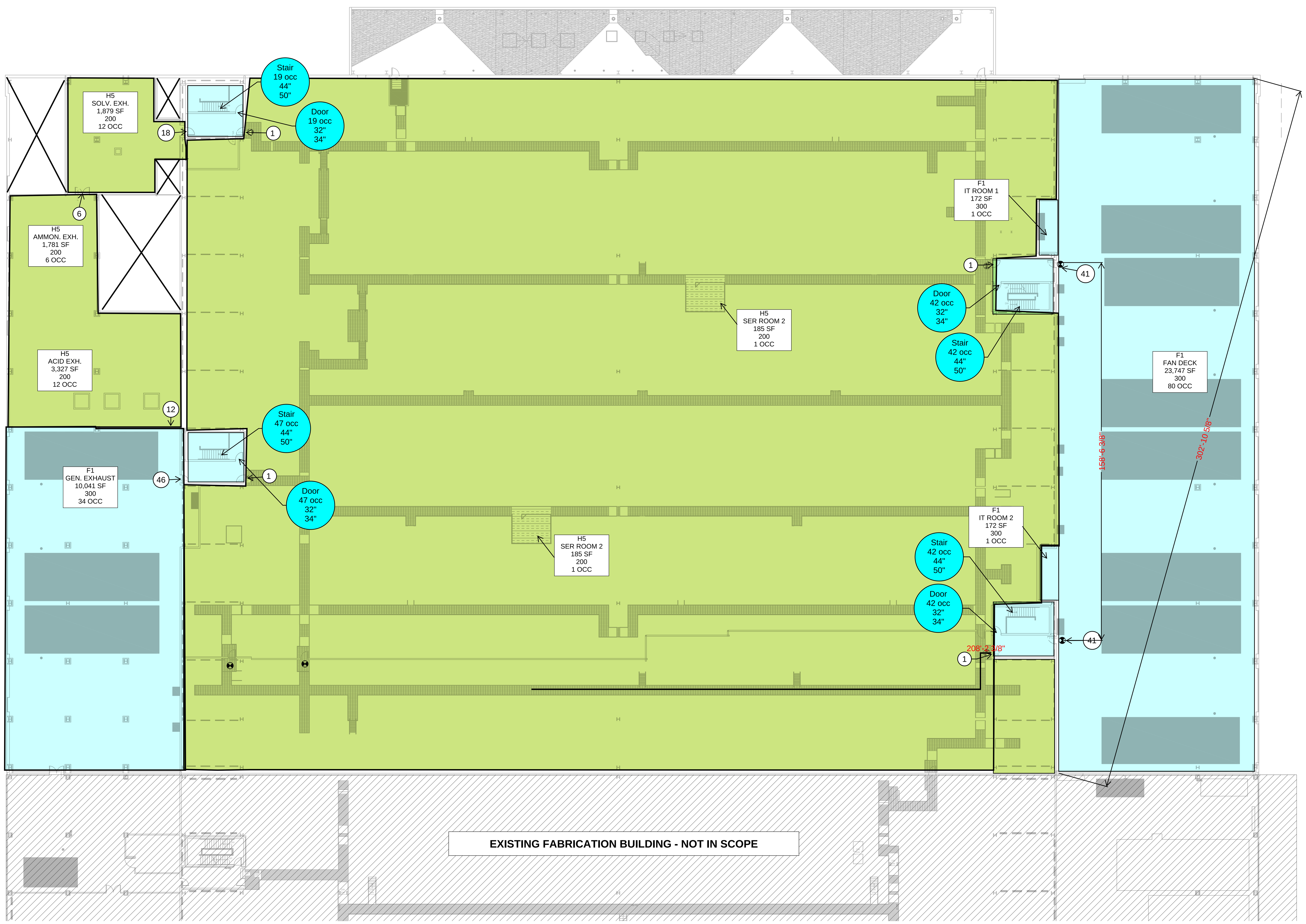
1.

SYMBOL LEGEND

- TWO-HOUR FIRE-RESISTANCE RATED EGRESS PASSAGEWAY WITH 90-MINUTE OPENING PROTECTION
- TRAVEL DISTANCE TO EXIT (FEET)
- EXIT SIGN (HATCH INDICATES ORIENTATION)
- OCCUPANCY
- FUNCTION OF SPACE
- AREA (SQ. FT.)
- OCCUPANT LOAD FACTOR (PERSONS PER SQ. FT.)
- OCCUPANT LOAD (PERSONS)
- NUMBER OF OCCUPANTS USING EXIT / EXIT-ACCESS COMPONENT
- Door 15 occ 3" 34": EXIT / EXIT-ACCESS COMPONENT (E.G.,STAIR, DOOR); NUMBER OF OCCUPANTS USING EXIT / EXIT-ACCESS COMPONENT; MINIMUM REQUIRED CLEAR WIDTH (INCHES); PROVIDED CLEAR WIDTH (INCHES)

OCCUPANCY LEGEND

- F1 - MANUF.
- H2/H3/H4 - FLAM/OX/TOX/CORR
- H2/H4 - FLAMM/TOX/CORR
- H4 - TOX/CORR
- H5 - SEMICONDUCTOR FAB



8' 4' 0 8' 16'
SCALE: 1/8" = 1'-0"

DWG NORTH

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FAB LIFE SAFETY PLANS LEVEL 4

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FB-G 104

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Appendix L – DNS SU-3100 Materials of Construction

SU-3100 Single Wafer Cleaning System

Combustible Materials Name	Plastic Abbr.	mass kg	T_{ig}* (°C)	k (W/mK)	ρ (kg/m³)	c_p (kJ/kgK)	ΔHc (MJ/kg)	MLR (kg/m²s)
Polyamide 6,6	NYLON	0.2	456	0.23	1140	1.57	28.2	0.003
Polychlorotrifluoroethylene	PCTFE	2.5	580	0.23	1670	0.92	6.5	
Polyetheretherketone	PEEK	1	570	0.2	1310	1.7	21.3	0.0033
Poly(ether urethane)	PEUR	8.8	356	0.19	1100	1.76	24	0.0059
Poly(tetrafluorethylene-perfluorether)	PFA	88.8	578	0.25	2150	1	2.2	
Polyphenylenesulfide	PPS	12	575	0.29	1300	1.02	23.5	0.0036
Polytetrafluorethylene	PTFE	174	630	0.25	2150	1.05	4.6	
Polyvinylchloride	PVC	11	395	0.19	1415	0.98	9.3	
Polyvinylchloride (FM4910)	PVC(FM)	545.3	395	0.19	1415	0.98	9.3	
Polyvinylidenefluoride	PVDF	1.2	643	0.13	1760	1.12	3.8	
Weighted Averages			465.9	0.21	1639.8	1.01	7.94	0.0040
	Total Mass	844.8						

*PFA number reported is the peak mass loss temperature

Appendix M – FDS Grid Resolution Analysis

One of the most significant factors influencing the computation time is the size of the computational grid. Since it is possible to over-resolve or under-resolve a space by specifying grids that are too fine or too course, it is important to determine an appropriate grid size that would optimize accuracy and time.

Multiple numerical meshes were utilized to compute the solution. Each mesh consisted of uniform rectilinear cells of a characteristic size intended to resolve the smallest turbulent eddies of significance to the final solution.

As a first approximation for the necessary grid cell size to accomplish proper resolution of the turbulent flow, it is generally recommended that the cell size in close proximity to the fire be defined by the following equation:

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

Where:

$\dot{Q}$ = Total heat release rate of the fire
ρ_∞ = Density of ambient air
c_p = Specific heat of ambient air
T_∞ = Temperature of ambient air
g = Gravitational acceleration

$$D^* = \left(\frac{\dot{Q}}{1{,}100}\right)^{2/5}$$

The recommended grid size is between ten percent and twenty percent of the calculated D*. Grid sizes in close proximity to the fire should be no larger than one-fifth the size of D*.

As the fire size is made up of several discrete fires, the cumulative effect of one wet bench is used to conservatively size the grid cells. For one wet bench with a HRR of approximately 2,500 kW (this fire size is discussed in the Design Fire Scenario section), the maximum grid cell size that could be used to accurately analyze this fire is calculated as D* = 1.39 meters. The corresponding grid size range is as follows:

(20 percent) of D* = 0.28 m (11.0 in)
(10 percent) of D* = 0.14 m (5.5 in)

Calculating twenty percent of the size of D* would dictate the grid size be no larger than 0.28 m (11.0 in). In the analysis, a slightly finer mesh of 0.25 m could be used (about 18 percent of D*) for ease of model set up. A mesh size of 0.25 m will be considered appropriate for this model.