Fire and Life Safety Evaluation

Micro-Mechanics
465 Woodview Avenue,
Morgan Hill, CA 95037

Michael Beam

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Micro-Mechanics

- 1 story Manufacturing Building
- Total Square Footage: 41301 s.f.
 - Office Space: 8,239 s.f.
 - Non-Public Industrial Occupancy: 32,214 s.f.
 - Non-Public Finishing Department 848 s.f.
- Earliest set of plans dated 1993
 - Sprinkler System Installation
- Micro-Mechanics specializes in manufacturing high precision tools, parts and assemblies for the semiconductor, medical, and aerospace industries
 - Automated 24/7 processes
- Minimal storage of material

Applicable Codes and References

- International Building Code (IBC 2013)
 - California Building Code (CBC 2013)
- NFPA 101 – Life Safety Code (2015 Edition)
- NFPA 13 – Automatic Sprinkler Systems (2013 Edition)
- NFPA 72 National Fire Alarm and Signaling Code (2013 Edition)
- NFPA Fire Protection Handbook (20th Edition)
- SFPE Handbook of FPE (4th Edition)
- Structural Design for Fire Safety – Andrew H. Buchanan

Occupancy Classification

Industrial Occupancy

- NFPA 101
 - Section 6.1.12.1* Definition – Industrial Occupancy. An occupancy in which products are manufactured or in which processing, assembling, mixing, packaging, finishing, decorating, or repair operations are conducted.
- CBC
 - Factory Industrial Group F-1: moderate hazard

Secondary Occupancies

- Office Areas

Hazard Classification

- NFPA 101 section 6.2.2
 - Ordinary Hazard Contents
- Majority of space occupied by machinery
- Water-based coolants
- Minimal scrap material stored in bins and isolated
 - Aluminum
 - Stainless Steel
 - Brass
- Minimal shipping and receiving

Maintenance of Manufacturing Area

- Majority of processes produce recyclable size chips and scraps
 - Bin storage emptied twice a week
- Finishing Rooms
 - Only process that can produce dust/powdered metals
 - Uses wet sanding process to prevent airborne particles
 - Deep clean and change of filters weekly
- Regulation of Combustible Metals
 - NFPA 484 (Chapter 12 – Aluminum)
 - Table 1.1.11 Applicability Thresholds
 - 5lbs for Industrial Occupancy
 - Section 12.2.2 Fire Protection

Prevention/Fire Protection for Aluminum Dust

- **Prevention**

- Avoid contact with water
 - If a wet process is used the collection systems should be vented
 - Material from wet type collectors should be mixed with inert material (5:1)
- Maintain clean work environment to prevent airborne particles
- Ground equipment to prevent static electricity

- **Fire Protection**

- Ring fire with inert material or class D extinguishing powder
- Class A, B, and C extinguishers and Halogen extinguishing agents shall not be used.
- Manual application of water should be a last resort.
- Automatic Sprinkler Protection should only be used when approved by the local AHJ.

Description of Building Structure and Construction

Table 721 of CBC

- Exterior Walls

- Load Bearing
- Solid Concrete (5" thick)

- Primary Structure

- 5" x 5" steel columns
- 5 1/8" x 34 1/2" to 5 1/8" x 36" glulam beams
- 28" I-joists

- Roof Assembly

- 1/2" plywood
- 2" x 6" wood stiffeners spanning purlins at 2'-0 on center

- Interior Walls

- Non-load Bearing
- Not full height rated walls
- 2" x 6" wood studs at 16" on center
- 5/8" gypsum board on each side
- R-11 sound insulation between studs

MATERIAL	ITEM NUMBER	CONSTRUCTION	MINIMUM FINISHED THICKNESS FACE-TO-FACE ^b (inches)			
			4 hours	3 hours	2 hours	1 hour
4. Solid concrete ^{h, i}	4-1.1	Siliceous aggregate concrete.	7.0	6.2	5.0	3.5
		Carbonate aggregate concrete.	6.6	5.7	4.6	3.2
		Sand-lightweight concrete.	5.4	4.6	3.8	2.7
		Lightweight concrete.	5.1	4.4	3.6	2.5

Rating Requirements

Table 721 of CBC

MATERIAL	ITEM NUMBER	CONSTRUCTION	MINIMUM FINISHED THICKNESS FACE-TO-FACE ^b (inches)			
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		Carbonate aggregate concrete.	6.6	5.7	4.6	3.2
		Sand-lightweight concrete.	5.4	4.6	3.8	2.7
		Lightweight concrete.	5.1	4.4	3.6	2.5

Table 601 of CBC

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A ^d	B	A ^d	B	HT	A ^d	B
Primary structural frame ^g (see Section 202)	3 ^a	2 ^a	1	0	1	0	HT	1	0
Bearing walls									
Exterior ^{f, g}	3	2	1	0	2	2	2	1	0
Interior	3 ^a	2 ^a	1	0	1	0	1/HT	1	0
Nonbearing walls and partitions	See Table 602								
Exterior									
Nonbearing walls and partitions									
Interior ^c	0	0	0	0	0	0	See Section 602.4.6	0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	1 ^{1/2} ^b	1 ^{b,c}	1 ^{b,c}	0 ^c	1 ^{b,c}	0	HT	1 ^{b,c}	0

Building Height & Area Limitations

Table 503 of CBC

GROUP		TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
	HEIGHT (feet)	UL	160	65	55	65	55	65	50	40
		STORIES(S) AREA (A)								
A-1	S A	UL UL	5 UL	3 15,500	2 8,500	3 14,000	2 8,500	3 15,000	2 11,500	1 5,500
A-2	S A	UL UL	11 UL	3 15,500	2 9,500	3 14,000	2 9,500	3 15,000	2 11,500	1 6,000
A-3	S A	UL UL	11 UL	3 15,500	2 9,500	3 14,000	2 9,500	3 15,000	2 11,500	1 6,000
A-4	S A	UL UL	11 UL	3 15,500	2 9,500	3 14,000	2 9,500	3 15,000	2 11,500	1 6,000
A-5	S A	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL
B	S A	UL UL	11 UL	5 37,500	3 23,000	5 28,500	3 19,000	5 36,000	3 18,000	2 9,000
E	S A	UL UL	5 UL	3 26,500	2 14,500	3 23,500	2 14,500	3 25,500	1 18,500	1 9,500
F-1	S A	UL UL	11 UL	4 25,000	2 15,500	3 19,000	2 12,000	4 33,500	2 14,000	1 8,500

Building Area Modifications

$$A_a = \{A_t + [A_t \times I_f] + [A_t \times I_s]\} \quad (5-1)$$

where

A_a = allowable building area per story (ft^2)

A_t = tabular building area per story in accordance with Table 503 (ft^2)

I_f = area increase factor due to frontage as calculated in accordance with Section 506.2

I_s = area increase factor due to sprinkler protection as calculated in accordance with Section 506.3

$$I_f = \left[\frac{F}{P} - 0.25\right] \frac{W}{30} \quad (5-2) \quad \text{Section 506 of CBC}$$

where

F = building perimeter that fronts on a public way or open space having 20 feet open minimum width (ft)

P = perimeter of entire building (ft)

W = width of public way or open space in accordance with Section 506.2.1

$$A_a = \{12,000 \text{ } ft^2 + [12,000 \text{ } ft^2 \times 0.75] + [12,000 \text{ } ft^2 \times 3]\}$$

$$A_a = 57,000 \text{ } ft^2$$

Allowable Building Area

- Building Area Modifications:
 - 57,000 sq. ft.
- Section 507.3 of CBC
 - 1 story
 - Group F Occupancy
 - Fire Sprinklers throughout
 - Unlimited building area

Egress Analysis

- Annotation
 - Usage
 - Room Numbers
 - Door Numbers
 - Occupant Load Factor
 - Area
- No dead end corridors
- Table A.7.6 of NFPA 101 requires a 100 foot limit for Common Paths of travel

Space Designations	Color Codes
Assembly	Blue
Breakroom	Light Pink
Business	Red
Industrial Floor	Orange
Shop	Purple
Storage	Green
Electrical Rooms	Pink
Restrooms	Cyan
Lobby/Exit Corridor	Yellow

Occupant Load/Egress Capacity

$$\text{Occupant Load} = \frac{\text{Net Area}}{\text{Occupant Load Factor}}$$

$$\text{Egress Capacity} = \frac{\text{Door Width}}{\text{Capacity Factor}}$$

Manufacturing Floor

Room	Room #	Area (sqft)	Occupant Load Factor	Occupant Load
Assembly	13	984	50	20
Storage	14	976	50	20
Shop	15	616	50	13
Storage	16	224	500	1
Shop	17	532	100	6
Office	18	168	100	2
Restroom	19	194	100	2
Restroom	20	194	100	2
Finishing Room	21	832	50	17
Electrical Room	22	108	500	1
Manufacturing Floor	24	30661	100	307
Total				391

Door	Width	Capacity Factor	Exit Capacity
29	36	0.2	180
30	36	0.2	180
33	36	0.2	180
49	36	0.2	180
50	36	0.2	180
51	36	0.2	180
52	36	0.2	180
Total			1260

Fundamental Movement Calculations

Flow Calculations when considering population density:

Office Area

$$W_e = 36in. - 2 \times 6in. = 24in.$$

$$F_{s(Office)} = (1 - 2.86 \times \frac{91persons}{2622ft^2}) \times 275 \times \frac{91persons}{2622ft^2} = 8.60 \frac{persons}{ft \text{ effective width} \cdot min}$$

$$F_{c(Office)} = F_{s(Office)} W_e = 8.60 \frac{persons}{ft \text{ effective width} \cdot min} \times 24in. \times \frac{1ft.}{12in.} = 17.2 \frac{persons}{min}$$

$$t_{Office} = \frac{91persons}{3 \times 17.2 \frac{persons}{min}} = \boxed{1.76min}$$

Manufacturing Floor

$$W_e = 36in. - 2 \times 6in. = 24in.$$

$$F_{s(Manufacturing)} = (1 - 2.86 \times \frac{391persons}{30661ft^2}) \times 275 \times \frac{391persons}{30661ft^2} = 3.38 \frac{persons}{ft \text{ effective width} \cdot min}$$

$$F_{c(Manufacturing)} = F_{s(Manufacturing)} W_e = 3.38 \frac{persons}{ft \text{ effective width} \cdot min} \times 24in. \times \frac{1ft.}{12in.} = 6.76 \frac{persons}{min}$$

$$t_{Manufacturing} = \frac{391persons}{7 \times 6.76 \frac{persons}{min}} = \boxed{8.26min}$$

Fundamental Movement Calculations

Flow Calculations assuming everyone is moving at maximum exit speed:

$$F_c = 24 \frac{\text{persons}}{\text{min}} \times 24\text{in.} \times \frac{1\text{ft.}}{12\text{in.}} = 48 \frac{\text{persons}}{\text{min}}$$

SFPE Handbook – Table 3-13.5

Office Area

$$t_{Office,min} = \frac{91\text{persons}}{3 \times 48 \frac{\text{persons}}{\text{min}}} = \boxed{0.63\text{min}}$$

Manufacturing Floor

$$t_{Manufacturing,min} = \frac{391\text{persons}}{7 \times 48 \frac{\text{persons}}{\text{min}}} = \boxed{1.16\text{min}}$$

Pathfinder Simulation vs. Flow Calculations

Method	Evacuation Time
Manual (Density Based)	8.26 minutes
Manual (Max Flow Rate)	1.16 minutes
Model (Open Floor)	1.47 minutes
Model (With Machine Lines)	1.14 minutes

Fire Alarm System

- Protected Premises Fire Alarm System
 - Governed by NFPA 72 section 23
- Notifier SFP-400B fire alarm control panel (FACP)
 - Input
 - Smoke Detectors
 - Water Flow Switch
 - Tamper Switch

Fire Alarm System Requirements

- NFPA 101 Section 40.3.4 outlines detection, alarm and communication requirements for Industrial Occupancies
 - Alarm System must be activated by one of the following:
 - Manual means in accordance with 9.6.2.1
 - Approved automatic fire detection system in accordance with 9.6.2.1 throughout the building, plus a minimum of one manual fire alarm box in accordance with 9.6.2.6
 - Approved, supervised automatic sprinkler system in accordance with 9.6.2.1 through the building, plus a minimum of one manual fire alarm box in accordance with 9.6.2.6
- CBC Section 907.2.4
 - Manual fire alarm box not required when equipped with a sprinkler system and occupant notification appliances activate upon sprinkler activation
 - Group F occupancies

Detection Devices

- Heat Detection
 - Reliable Solder Link Sprinkler
 - 212 degree, ½" orifice, brass upright
 - 165 degree, ½" orifice, chrome pendent
- Water Flow
 - 4" Vane Type Water Flow Switch
- Smoke Detection
 - Series 400 System Sensor
 - Ionization Type Detector

Upright

Pendent

Uniform Building Code (UBC)

- UBC was used at the time of construction
- Fire Alarm Plans
 - Smoke Detection System in lieu of 1 hour corridor per UBC 3305g exception #5
 - Office corridor is the only location for smoke detectors
- CBC now replaces UBC

Alarm Notification Appliances

- ADA horn/strobe
 - Manufacturer: Wheelock
 - Operating range: 18-31 VDC
 - Nominal Voltage: 24 VDC
 - Current Draw: 0.088 amps at 117 candela
- MIZ-24 Mini Horn
 - Manufacturer: Wheelock
 - Operating Voltage: 20-31 VDC
 - Rated sound pressure level (SPL): 90dBA at 10 feet
 - Current Draw: 0.024 Amps

Horn/Strobe Locations

◀ HORN/STROBE LOCATIONS

NFPA 101 Section 40.3.4.3.1:
Fire alarm system shall sound
an audible and visible signal in
a constantly attended location
for the purposes of initiating
emergency action

Power Requirements

	Standby Current Per Unit				Standby Current Per Unit	Alarm Current Per Unit				System Alarm Current
Description	(amps)		QTY		(amps)	(amps)		QTY		(amps)
FACP	0.096	x	1		0.096					
Detector	0.0001	x	7	=	0.0007	0.041	x	7	=	0.287
ADA Horn	-	x	2	=	none	0.088	x	2	=	0.176
Mini-Horn	-	x	2	=	none	0.024	x	2	=	0.048
	Total System Standby Current (amps)				0.0967	Total System Alarm Current (amps)				0.511

Battery Calculations for Office Area
Per NFPA 72 Section 10.6.7

Secondary Power Supply shall have sufficient capacity to operate for 24 hours under non alarm conditions and then an additional 5 minutes under alarm conditions

Micro-Mechanics System Supplied with 2 x 7 amp-hour batteries

Required Standby Time (hours)		Total System Standby Current (amps)		Required Standby Capacity (amp-hours)	Required Alarm Time (hours)		Total System Alarm Current (amps)		Required Alarm Current (amp-hours)
24	x	0.0967	=	2.3208	0.083333	x	0.511	=	0.042583

Required Standby Capacity (amp-hours)		Required Alarm Capacity (amp-hours)		Total Required Capacity (amp-hours)		Factor of Safety
2.32	+	0.0426	=	2.3626	x	1.2

Required Battery Capacity (amp-hours)
2.83512

Sprinkler System Description

- Wet System
- Gridded throughout entire building
- Upright sprinkler throughout building at ceiling level
- Pendent Sprinklers dropped to office areas and clean rooms

Underground Description

- 8" city main runs along front of building
- Property main fed by 8" x 6" reducer
- Flow passes through 6" Wilkins Backflow Assembly
- Tees off for FDC and 6" supply for building
- Underground piping is PVC
 - Except at connection points to the backflow, FDC, and building where the pipe is Ductile Iron

Hanging & Bracing

- 1 ¼" Branch Lines
 - Coach screw rod and ring to I-joist
- Cross mains
 - Beam clamps to I-joist at intermediate locations between beams
 - 3/8" U-hook with 2 x 3/8" lag screws to glulam beams
- Braces on mains use lag screws to the glulam beams and top chord of I-joist
 - Lag screws no longer allowed by California Fire Code (CFC) for bracing
- No branch line restraints required since hangers are less than 6" long

Sprinkler Design

Original Building Classification

Occupancy: Ordinary Hazard (Group III)
Max Coverage per Head: 130 sqft.
Area: 3000 ft²
Density: 0.18 gpm/ft²
Sprinkler: Standard Upright
Orifice: 1/2"
K-factor: 5.62
Temperature: 212°F
Number: 483
Hose Demand: + 500 gpm
Total System Demand: 1089.79 gpm @ 71.672 psi

New Building Classification

Occupancy: Ordinary Hazard (Group II)
Max Coverage per Head: 130 sqft.
Area: 3000 ft²
Density: 0.17 gpm/ft²
Sprinkler: Standard Upright
Orifice: 1/2"
K-factor: 5.62
Temperature: 212°F
Number: 483
Hose Demand: + 250 gpm for 60 minutes
Total System Demand: 823.86 gpm @ 71.559 psi

For SI units, 1 ft² = 0.092 m²; 1 gpm/ft² = 40.746 (L/min)/m².

Hydraulic Calculations

Water Supply

Current:

Static Pressure = 85 psi

Residual Pressure = 65 psi

Flow = 1360 gpm

Previous (for calculation comparison):

Static Pressure = 83 psi

Residual Pressure = 50 psi

Flow = 2566 gpm

Results

	Original	Model
System Pressure Demand:	71.672 psi	75.239 psi
System Flow Demand:	589.79 gpm	592.75 gpm
Total Demand:	1089.79 gpm	1092.75 gpm
Pressure Below Supply Curve:	≈5 psi	≈1 psi

Fire Scenarios

- Manufacturing Area Fire
 - During business hours fire is likely to be seen by occupants attending any machinery
 - Extinguishment
 - Evacuation
 - High ceilings and large area
 - Smoke layer will descend slowly
 - Occupants have more time to react
 - Less Critical
- Office Area Fire
 - Smaller space where smoke layer presents greater threat to occupants
 - Areas such as break room not always attended during business hours
 - Appliance left on unattended in break room
 - Malfunction causes the appliance to ignite and set fire to nearby wood tables and cabinets
 - Assume a slow t-squared fire growth until sprinkler activation (Figure 3.7.2 of FPH)
 - Peak Heat Release Rate of 2000kW (Table 5.6.3.1 of FPH)
 - Determine if tenability threshold is passed before sprinkler activation

FDS Sprinkler Activation

Smokeyview 6.1.12 - Oct 1 2014

■ >79 (kW/m³)

Frame: 199

Time: 199.0

mesh: 1

Soot Distribution at Sprinkler Activation

Tenability at Sprinkler Activation

Temperature

Thermal Tolerance for unprotected skin occurs around 120 degrees C (FPH)

FDS Slice Files at 6 feet above the floor

Tenability at Sprinkler Activation

Visibility

Smokeview 6.1.12 - Oct 1 2014

Slice
VIS_Soot
m

31.0
28.0
25.0
22.0
19.0
16.0
13.0
10.0
7.00
4.00
1.00

Suggested OD limits for
impairment of egress range from
0.5 1/m (2 meters of visibility) to
0.065 1/m (15 meters of visibility)

FDS Slice Files at 6 feet above the floor

Frame: 199

Time: 199.0

mesh: 1

Tenability after Egress Time

Temperature

Tenability after Egress Time

Visibility

Smokeview 6.1.12 - Oct 1 2014

Slice
VIS_Soot
m

Frame: 267

Time: 267.0

mesh: 1

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