FIRE PROTECTION ENGINEERING

IN

PROPERTY RISK MANAGEMENT

Presented to: NSPE

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OVERVIEW

- Section 1 – Welcome:
  - Overview
  - Learning Objectives
- Section 2 – Introduction to Property Risk Management
  - Enterprise Risk Management
  - Frameworks
- Section 3 – Introduction to Fire Protection Engineering
  - Early Building and Fire Laws
  - Development of Building and Fire Codes

OVERVIEW

- Codes & Fire Protection Engineering
- The Science of Fire Protection
  - What is Fire Protection Engineering?
  - What is the Science of Fire?
  - What is Fire Dynamics?
  - The "Whole Building" Design Concept & the Fire Protection Equation
  - Hazards Outline
- Section 4 – Example; Hazard Identification, Assessment and Treatment
- Section 5 - Summary

LEARNING OBJECTIVES

- Learn about Enterprise Risk Management, Property Risk Management and Risk Frameworks.
- Gain Insight to the Connections between the Insurance Industry, Fire Protection Engineering, and Codes through the history and development of Building and Fire Codes and how tragedies from fire losses helped to shape their development.
- Learn the science of fire, the basic principles of Fire Protection Engineering, “Whole Building” Design concept and the FP Equation.
- Understand the role of the Fire Protection Engineering in Property Risk Management and the value it brings in the built environment.

ENTERPRISE RISK MANAGEMENT

- Property Risk Management is a part of a holistic Enterprise Risk Management (ERM) Framework. Today's modern approach focuses on both positive and negative outcomes.
- ERM is used by an Organization's Stakeholders to determine their Risk Objectives so Investors have a level of confidence that reasonable Risk taking will lead to economic growth.
- ERM Objectives consider:
  - Balance Risk & Reward
  - Support Decision Making
  - Acceptable Risk Appetite
  - Emphasis Certain Goals

Risk Optimization: *The Risk/return balance that achieves the maximum return of the level of Risk an Organization is willing to accept.* (ARM)

RISK: *Is Uncertainty about outcomes, either positive (+), or negative (-). (ARM)*

ENTERPRISE RISK MANAGEMENT

- ERM Goals include:
  - Tolerable Uncertainty
  - Legal & Regulatory Compliance
  - Survival
  - Continuity of Operations
  - Earnings Stability
  - Profitability
  - Growth
  - Social Responsibility
  - Economy of Operations

ENTERPRISE RISK MANAGEMENT

- To implement a successful Management Program an Organization must adopt a Framework that best matches their Mission, Values, Corporate Structure and Objectives.
  - Four "Components" of the Framework Model
    1. Lead and Establish Accountability
    2. Align and Integrate
    3. Allocate Resources
    4. Communicate and Report
  - Five "Steps" of the Framework Process
    1. Scan the Environment
    2. Identify the Risks
    3. Analyze the Risks
    4. Treat the Risks
    5. Monitor & Review

ENTERPRISE RISK MANAGEMENT

- Applying the ERM Framework and Process to a Hazard Risk

Application = Components + Process

Components	Process
1. Lead and Establish Accountability	1. Scan the Environment
2. Align and Integrate	2. Identify Risks }
3. Allocate Resources	3. Analyze Risks }
4. Communicate and Report	4. Treat Risks }
	5. Monitor & Review

Hazard Risk: *Risk from accidental Loss, with the possibility (likelihood) of Loss or No-Loss.* (ARM)

Hazard: *Is a Characteristic of a thing, a situation, a person, or the law that increases Loss Frequency and/or Loss Severity*. (ARM)

Hazard: *A condition or physical situation with the potential for harm*. (SFPE)

FRAMEWORKS

- ERM Framework Supports Decision Making

Six Basic Risk Management Measures

1. Exposure
2. Volatility
3. Likelihood
4. Time Horizon
5. Consequences
6. Correlation

(Exposure →)

* Frequency (Prevention) (Hazard)
- Almost Nil
- Slight
- Moderate
- Definite

* Severity (Reduction) (Hazard)
- Slight
- Significant
- Sever

(Consequences →)

* Low-Likelihood, Low-Consequence (little Mgmt.)
* High-Likelihood, Low-Consequence (normal Mgmt.)
* Risk with Major Consequences (serious Mgmt.)

Retention or Transfer

Low-Frequency / Low-Severity Losses (usually Retained) (Hazard)

High-Frequency / Low-Severity Losses (often Retained) (Hazard)

Low-Frequency / High-Severity Losses (usually transferred) (Hazard)

High-Frequency / Hight-Severity Losses (usually Avoided) (Hazard)

FRAMEWORKS

RISK IDENTIFICATION - A Risk Quadrant Creates a Framework for Risk Identification

Pure Risk: *Involves Loss or No-Loss; the chance of financial Loss without the chance of financial gain.* Treatment focuses on managing negative outcomes.

Uncertainty related to Financial Loss due to damage or destruction to Property.
The VALUE of Fire Protection Engineering is found here.

ENTERPRISE RISK MANAGEMENT	
RISK	
HAZARD (pure) Liability Personnel Property Fire Flood Tornado	OPERATIONAL (pure) Organizations: Processes Systems Controls People External Events
FINANCIAL (speculative) Market Risk Credit Risk Price Risk	STRATEGIC (speculative) Economic Environ. Demographics Political Risk

THE FOUR QUADRANTS OF RISK

Risk: *Uncertainty about outcomes, either positive (+) or negative (-).* (ARM)

Risk: *The potential for realization of unwanted adverse consequences, considering scenarios and their associate frequencies or probabilities and associated consequences.* (SFPE)

FRAMEWORKS

RISK IDENTIFICATION

- Five Team Approaches to Finding Risks

1. Facilitated Workshops
2. Delphi Technique
3. Scenario Analysis ← Identifies Risks and projects their potential consequences.
4. HAZOP
5. SWOT

Performing a Hazard Analysis is one way of identifying Loss Exposures.

Hazard Analysis: *Reveals potential Losses* (Loss Exposures*) by identifying conditions* (characteristics*) that increase expected Loss frequency and/or Loss severity.* (ARM)

Loss Exposure: *A situation that presents the possibility of a Loss, even if the exposure is not identified, and even if the Loss never occurs*. (ARM)

FRAMEWORKS

RISK ANALYSIS – Provides information for:

- Understanding the Risks
- Sources of Risks
- Consequences of Risks
- Treatment of Risks

RISK ASSESSMENT – Defines the way an Organization measures and manages Risk. (ARM)

Fire Risk Assessment: *A defined process for estimation and evaluation of Fire Risk that addresses Fire scenario clusters with associated probabilities and consequences using one or more acceptability thresholds.* (SFPE)

FRAMEWORKS

RISK ANALYSIS

QUALITATIVE Ratings (significant of consequences)

Low (slight)

Medium (moderate)

High (severe)

QUANTITATIVE Values (levels of Risk)

1-2 (low)

3-4 (low to moderate)

5-6 (Moderate)

7-8 (moderate to high)

9-10 (high)

Qualitative Assessment: *Measures a Risk by the significance of its consequences, using ratings, with clear written definitions of those ratings.* (ARM)

Quantitative Analysis: *Assigns specific numerical values to Risk consequences and their probabilities to derive numeric indications of the levels of Risk.* (ARM)

FRAMEWORKS

RISK TREATMENT – Involves making decisions based on outcomes of Risk Identification and Analysis.

- The Five "Categories" of Risk Management Techniques

  1. Avoidance (foregoing activities that create the Loss Exposure)

  2. Modification

     a. Loss Prevention (actions that reduce the frequency (Hazard) of loss)

     b. Loss Reduction (activities that reduce the severity (Hazard) of loss).

  3. Transfer (share the Risk; Insurance is the primary method)

  4. Retention (the Firms keeps all or part of the financial consequences)

  5. Exploitation (events with positive outcomes using techniques that maximize expected gains)

FRAMEWORKS

RISK TREATMENT

Loss Exposure Significance

Five **Treatments** (based on each Frequency/Severity Combination)

* Frequency (**Prevention**) (Hazard)
- Almost Nil
- Slight
- Moderate
- Definite

* Severity (**Reduction**) (Hazard) (MPL)
- Slight
- Significant
- Sever

1. Avoid
2. Retain
3. Transfer
4. Prevent
5. Control (Reduction) or (Prevention)

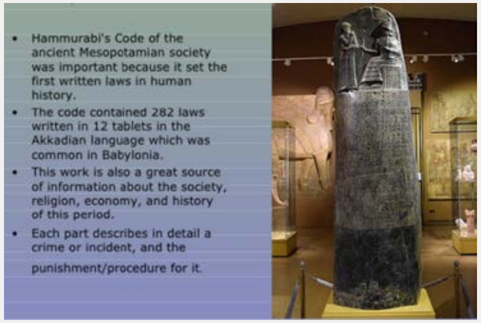
Frequency: *Measures the number of Losses within a specified period. (ARM)*

Frequency: *The number of times an event occurs within a specified time interval.* (SFPE)

Severity: *Measures the amount of a Loss in dollars.* (ARM)

Loss Control: *Reduces the estimated Frequency and/or Severity* (Exposure) *of Accidental Losses* (Hazard Risk).

EARLY BUILDING AND FIRE LAWS



- The First Documented Building Code

  (law & enforcement)

  - The Code of Hammurabi ~ c. 1,754 BC.
    - *If a builder has built a house for a man and his work is not strong, and if the house he has built falls in and kills the householder, that builder shall be slain.*
    - *If the child of the householder be killed, the child of that builder shall be slain.*
    - *If the slave of the householder be killed, he shall give slave for slave to the householder.*
    - *If goods have been destroyed, he shall replace all that has been destroyed.*
    - *If a builder has built a house for a man, and his work is not done properly and a wall shifts, then that builder shall make that wall good with his own silver.*

EARLY BUILDING AND FIRE LAWS

- The earliest recorded building laws were concerned with the prevention of collapse.
  - Hammurabi Code
  - Under the reigns Julius and Augustus Caesar, Rome became the site of a large number of hastily constructed apartment buildings – may of which were erected to considerable heights. Due to structural failure and collapse, laws were passed that limited the heights of buildings.
- Later in history there evolved many building regulations for preventing fire and restricting its spread.
  - London 14th Century -
    - An ordinance was issued requiring that chimneys be built of tile, stone, or plaster; the ordinance prohibited the use of wood for this purpose.

EARLY BUILDING AND FIRE LAWS

- New York City -
  - Among the first ordinances was a similar provision as London's.

- Boston -
  - Followed London's and New York City's lead, but also…
  - Required that dwellings be constructed of brick or stone and roofed with slate or tile to restrict the spread of fire from building to building, and…
  - Those homeowners who did not comply, or who had chimney fires, were fined ten shillings! (law & enforcement)

THUS, was the first Fire Code in America established and enforced!!!

(it's no coincidence that NFPA HQ is minutes from Boston)

DEVELOPMENT OF BUILDING & FIRE CODES

DEVELOPMENT OF THE MODEL BUILDING CODES

- The National Board of Fire Underwriters (NBFU), organized in July 1866

  [**Later became the American Insurance Association**, and now the American Insurance Services Group (AISG)]

  - The NBFU was formed by the "**for profit**" insurance companies.
    - Nearly every U.S. city burned between 1820 and 1915, and threatened the existence of the insurance industry.
    - Thus, the Insurance Industry began Fire research to understand the concepts of Fire and how to mitigate Fire frequency and severity through "Engineering" practices.

  5 NOTABLE EXAMPLES

DEVELOPMENT OF BUILDING & FIRE CODES

- Example 1:

1871 – Chicago Fire

Chicago, IL

- 17,430 buildings destroyed.
- **250** people killed.
- $168M Loss.
- 56 insurance companies bankrupted.

DEVELOPMENT OF BUILDING & FIRE CODES

- Example 2:

1903 – Iroquois Theatre Fire

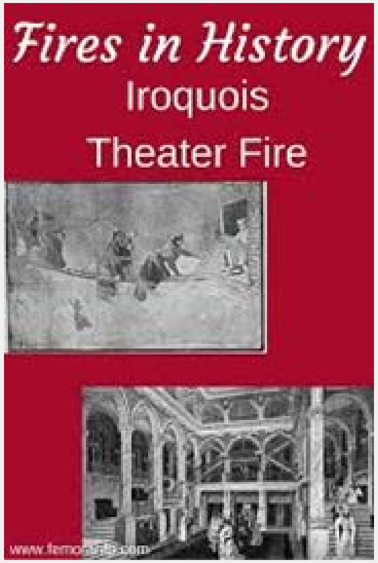
Chicago, IL

(stage curtain fire)

- **602** people killed due to:
  - Exits covered by curtains
  - No exit signs
  - Locked exits

Reaction: →

- New Laws enacted:
  - Visible lighted exit signs
  - Fire resistance curtains
  - Prohibited locked exits
  - Door swing in direction of travel



Hot Stage Light Ignited Velvet Curtain; Flammable Oil Paint Backdrops.

Worst Theatre and Single Building Fire in American History.

DEVELOPMENT OF BUILDING & FIRE CODES

- Example 3:

1908 – Rhodes Opera House

Boyertown, PA

(stage fire)

- **170** people killed due to:
  - Insufficient number of Exits
  - Blocked exits
  - Locked exits

Reaction:

- New Laws enacted:
  - Adequate number of exits
  - Fire escapes
  - Prohibited locked exits
  - Prohibited blocked exits

Kerosene Lamp on Stage Knocked Over Igniting Combustibles.

DEVELOPMENT OF BUILDING & FIRE CODES

- Example 4:

1908 – Lakeview Grammar School

Collinwood, OH

(fire ignition unknown)

- **176** people killed due to:
  - Insufficient number of Exits (2)
  - Open stairs
  - Door swing in wrong direction
  - Obstructed exit access

Reaction:

- New Laws enacted:
  - Adequate number of exits
  - Unobstructed means of egress
  - Door swing in direction of travel

173 Children, 2 Teacher and 1 Responder killed.

DEVELOPMENT OF BUILDING & FIRE CODES

- Example 5:

1911 – Triangle Shirtwaist Factory

New York City, NY

(fabric fire)

- **146** people killed due to:
  - All exits locked
  - Insufficient number of fire escapes (1)

    (jumping to their deaths)

Reaction: →

- New Laws enacted:
  - Prohibited locking of exit doors
  - Door swing in direction of travel

Located on the 8th, 9th & 10th Floors of the Asch Building in Lower Manhattan.

Deadliest Industrial Disaster in the History of the City (until WTC attack), and One of the Deadliest in US History.

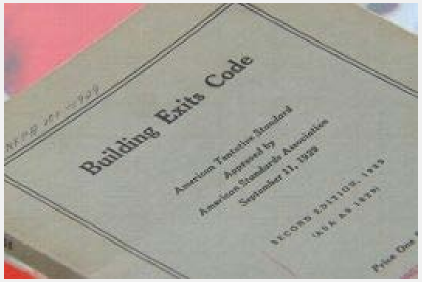
DEVELOPMENT OF BUILDING & FIRE CODES

- In 1892, a new technology call “electricity” led to a marked increase in fires. As a result the NBFU (AISG) formed the Underwriter’s International Electrical Association.
  - Developed the National Board Electrical Code, known today as the National Electric Code (NEC).
  - By 1901, the code was being enforced by 125 municipal governments.
  - In 1911, the NBFU (AISG) transferred responsibility to the National Fire Protection Association (NFPA).

DEVELOPMENT OF BUILDING & FIRE CODES

1913 - These examples are largely responsible for the appointment of the **NFPA Committee on Safety to Life**.

1927 – NFPA Committee on Safety to Life published its first edition of the **NFPA Building Exits Code** (eventually, the "*Life Safety Code*").



DEVELOPMENT OF BUILDING & FIRE CODES

- In 1905, the National Board of Fire Underwriters (AISG) published the first **"model code"** that could be utilized by communities to regulate construction – the "**Recommended Building Code**" [later the **"National Building Code"** (NBC)]. This was a first and very useful attempt to show the way to uniformity.
  - The NBC was totally controlled by the Association of Insurance Underwriters.
  - Their mission was to ensure profits through the protection of property.
  - No outside groups allow to participate in its development.
  - For 22 years it was the only code of its kind in the U.S.
  - Until the advent of the NBC, each municipality that wanted to regulate construction and use of buildings wrote its own code. The codes were often based more on the demands of special interests groups and emotions than technical merit or scientific analysis.

DEVELOPMENT OF BUILDING & FIRE CODES

- In 1927, the International Conference of Building Officials (ICBO) published the second "model code" – the **"Uniform Building Code"** (UBC).
  - The UBC was the first code developed by "Building Officials" – Significant!
  - Developed due to lack of uniformity in existing city and state codes.
  - The Building Officials also saw the need to expand life-safety provisions of the code.
- In 1946, the Southern Building Code Congress (SBCCI) published the third "model code" – the **"Southern Standard Building Code"** (SSBC).
  - Developed to reflect the needs of the southern U.S.
  - The SBCCI had a Board of Directors composed of "Code Officials" elected by its membership – Significant!

DEVELOPMENT OF BUILDING & FIRE CODES

- In 1950, the Building Officials and Code Administrators International (BOCA) published a fourth "model code" – the **"Basic Building Code**".
  - Developed by public officials and elected by membership – Significant!
  - When the American Insurance Association (formerly NBFU) discontinued publishing their **National Building Code** (first "model code") in 1980, BOCA acquired the rights to the name – leaving only the three model codes.
    - The 1984 edition used the interim title "Basic/National Building Code."
    - The 1987 edition was titled the "**BOCA National Building Code**."

These three "model codes" were adopted by states and local governments throughout most of the country regionally, and gradually replaced the insurance industry's National Building Code.

For the most part, the national model codes were actually "regional" codes rather than "national" codes.

DEVELOPMENT OF BUILDING & FIRE CODES

- The three “model codes”, now known as the **“Legacy Model Building Codes”** [(UBC), (SSBC) and (NBC)], eventually evolved into what we now know as the “**International Building Code**” developed by the International Codes Council (ICC).
  - In 1995, the ICC was established by ICBO, SBCCI and BOCA for the purpose to combine the three legacy model building codes into one single national model.
    - The ICC is a non-profit organization and develops construction and public safety codes through the governmental consensus process – Significant!
    - Any interested party can participate through an open code development process, and at public hearings, with final changes determined by ICC member representatives who have no vested interest in the outcome.
    - The ICC codes have no regional limitations (hence, International)
      - In 2000, the first International Building Code (IBC) was published.
      - In 2000, the first International Fire Code (IFC) was published.

CODES & FIRE PROTECTION ENGINEERING

THE CONNECTION BETWEEN CODES AND FIRE PROTECTION ENGINEERING

- History has shown us that building codes were based in large part on historical fire events, and by extension to occupant safety. (reactive)
- **More than 50%** of a modern building code refers one way or another to fire protection and life safety in the built environment, such as:
  - Building Separation Distances
  - Fire Resistance Rated (FRR) Construction (passive protection)
    - Types of Construction (Type I-A, I-B, II-A, II-B, etc.)
    - Compartmentation (limitation strategy)
  - Fire and Smoke Protection Features (passive protection)
    - Structural FRR (stability)
    - Fire Wall / Barriers / Partitions (FRR separations)

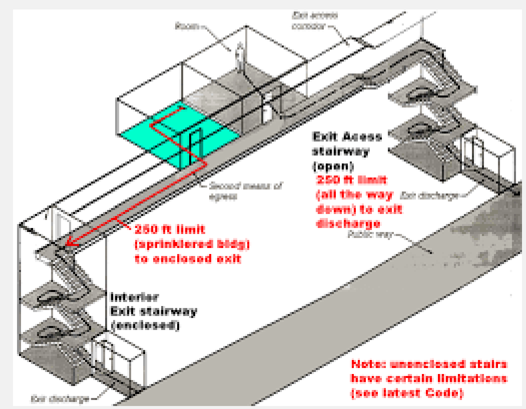
CODES & FIRE PROTECTION ENGINEERING

- Protection of Vertical Openings (smoke migration – occupant protection)

- Interior Finishes (passive protection)
  - Flame Spread Ratings

- Fire Protection Systems (active protection)
  - Fire Sprinkler Suppression Systems
  - Fire Alarm Systems / Notification Systems
  - Smoke Control Systems

- Means of Egress (MOE)
  - Evacuation Protection from Hazard
  - Exits (quantity, location, etc.)
  - Travel Distances to Exits
  - Exit Signs
  - Emergency Lighting (during occupant evacuation)

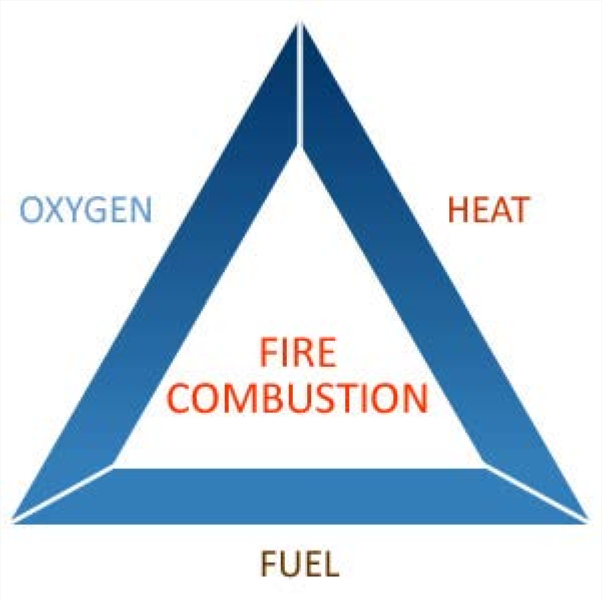


CODES & FIRE PROTECTION ENGINEERING

- What is Fire Protection Engineering?
  - Fire Protection Engineering is the application of science, engineering principles, fire science and fire dynamics to protect people and their environment from destructive fire, which includes:
    - Analysis of fire hazards,
    - Mitigation of fire damage by proper design, construction, arrangement and use of buildings,
    - Materials, structures, industrial processes, and transportation systems,
    - The design, installation and maintenance of fire detection, alarm, occupant notification, communication and suppression systems, and,
    - Post-fire investigation and analysis.
  - Fire Protection Engineering is a unique, public safety oriented field of study within the engineering discipline, and is the only discipline that deals directly with the preservation of life.

THE SCIENCE OF FIRE PROTECTION

- Fire science includes the physics and physical chemistry of fire as well as fire chemistry, and addresses:
  - Fuels
  - Ideal Gas Laws
  - The Combustion Process
  - Flame Types and Characteristics
  - Heat Release
  - Heat Transfer



THE SCIENCE OF FIRE PROTECTION

- Fire dynamics includes the physical and chemical phenomena governing fire and effects of fire on the environment, and predicts aspects of combustion and fire behavior, and encompasses:
  - Combustion
  - Fire and Smoke Behavior
  - Fire Growth
  - Fire Plume Entrainment and Temperature
  - Material Properties
  - Heat Transfer

THE SCIENCE OF FIRE PROTECTION

- Fire Protection Engineering exemplifies the concept of "**Whole Building" Design**.
  - It includes a fire and life safety strategy that comprehensively addresses all the polynomial "factors" (protection measures and techniques) that formulates the overall **fire protection "equation,"** such as but not limited to:
    - Building Occupancy
    - Construction Type / Structural Fire Resistance
    - Compartmentation / FRR Separation
    - Hazards Evaluations (Bldg. Materials; Haz. Materials; Interior Finishes, etc.)
    - Fire Detection, Alarm and Notification Systems
    - Fire Suppression Systems (Water-Based; Clean Agent, etc.)
    - Smoke Management / Control Systems
    - Systems Zoning
    - Means of Egress / Building Features / Security Related Provisions

THE SCIENCE OF FIRE PROTECTION

- The concept of the "**Whole Building" Design**, and the strategy of the **fire protection "equation,"** is formulated not to rely on any one single "factor." Rather, to rely on all "factors" simultaneously, with some degree of overlap and redundancy.
  - Should any one single "factor" (protection measures) fail there are other "factors" considered and available to assist.

- The **"Whole Building" Design**, and the formulated strategies of the **fire protection "equation,"** is broad and complex and only qualified individuals by education, training and experience should perform its application.

THE SCIENCE OF FIRE PROTECTION

- The Value of Fire Protection Engineering in Property Risk Management:
  - Until the early 1900's, the primary objective of Fire Protection Engineering was to limit a fire to its Building of origin. However, thanks to continuous Fire Protection Research, advancements in Fire Protection Engineering, and the "Whole Building" concept, this objective has been refined to limit a fire to its object or Room of origin.

- 2019 NFPA 13 Hazards Outline

THE SCIENCE OF FIRE PROTECTION

This is an overview in General terms. There are some exceptions not referenced below.

2019 NFPA 13 HAZARDS OUTLINE

50-ft. Roof/Clg.

NOT PERMITTED (12-ft. is the maximum storage height. Contents above these heights are considered High-Piled "Storage")

HIGH-PILED STORAGE**

- General Storage Requirements (CH. 20).
- CMDA Sprinklers (CH. 21).
- CMSA Applications (CH. 22).
- ESFR Applications (CH. 23).
- Alternative Designs to CH.20 - 25 (CH. 24).
- Storage Using In-Rack Sprinklers (CH. 25).

	LIGHT HAZARD	ORDINARY HAZARD, GROUP I	ORDINARY HAZARD, GROUP 2	EXTRA HAZARD, GROUP 1	EXTRA HAZARD, GROUP 2	MISC. STORAGE (LOW-PILED STORAGE**)	STORAGE (LOW-PILED STORAGE**)
HAZARD	12-ft. (to top of stockpile*)	8-ft. (top of stockpile*)	12-ft. (to top of stockpile*): Fire: HRR is Moderate. Stockpiles: ≤12-ft. 8-ft. (to top of stockpile*)	12-ft. (to top of stockpile*)	12-ft. (to top of stockpile*)	12-ft. (to top of storage*)	12-ft. (to top of storage*)
	Contents: Qty. is Low. Contents: Comb. Is Low. Fire: HRR is Low.	Contents: Qty. is Moderate. Contents: Comb. Is Low. Fire: HRR is Moderate. Stockpiles: ≤8-ft.	Contents: Qty. is Moderate to High. Contents: Comb. Is Moderate to High. Fire: HRR is High. Stockpiles: ≤8-ft.	Contents: Qty. is Very High. Contents: Comb. Is Very High. Fire: HRR is High. Stockpiles: ≤12-ft. Flam./Comb. Liquid: Little to None. Dust / Lint	Contents: Qty. is Very High. Contents: Comb. Is Very High. Fire: HRR is High. Stockpiles: ≤12-ft. Flam./Comb. Liquid: Substantial. Shielding: Extensive.	SEE TABLE 4.3.1.7.1. (CMDA only)	Storage Arrangements That Do Not Meet the Requirements of 4.3.1.5 Through 4.3.1.8 (Misc. Storage) Shall Be Protected in Accordance with Chapters 20 Through 25 (4.3.7).
	Finished Floor	Finished Floor	Finished Floor	Finished Floor	Finished Floor	Finished Floor	Finished Floor
DESIGN CRITERIA	NFPA: 0.10-gpm/1,500-ft.^{2} FM: 0.10-gpm/1,500-ft.^{2} Coverage: 225-ft.^{2} Maximum Thermal Sensitivity: QR K-Factor: 5.6 Minimum Thread Size: 1/2" Mininum Orifice Size: 1/2" Minimum Hose Stream: 100-gpm	NFPA: 0.15-gpm/1,500-ft.^{2} FM: 0.20-gpm/2,500-ft.^{2} Coverage: 130-ft.^{2} Maximum Thermal Sensitivity: SR / QR K-Factor: 5.6 Minimum Thread Size: 1/2" Mininum Orifice Size: 1/2" Minimum Hose Stream: 250-gpm	NFPA: 0.20-gpm/1,500-ft.^{2} FM: 0.20-gpm/2,500-ft.^{2} Coverage: 130-ft.^{2} Maximum Thermal Sensitivity: SR / QR / CMSA K-Factor: 5.6 Minimum Thread Size: 1/2" Mininum Orifice Size: 1/2" Minimum Hose Stream: 250-gpm	NFPA: 0.30-gpm/2,500-ft.^{2} FM: 0.30-gpm/2,500-ft.^{2} Coverage: 100-ft.^{2} Maximum Thermal: SR / QR / CMSA K-Factor: 8.0 Minimum Thread Size: 3/4" Mininum Orifice Size: 17/32" Minimum Hose Stream: 500-gpm	NFPA: 0.40-gpm/2,500-ft.^{2} FM: 0.30-gpm/2,500-ft.^{2} Coverage: 100-ft.^{2} Maximum Thermal: SR / QR / CMSA K-Factor: 8.0 Minimum Thread Size: 3/4" Mininum Orifice Size: 17/32" Minimum Hose Stream: 500-gpm	(OH1) (EH2) • Incidental / Ancillary Use • ≤10% of Bldg. Area, or, 4,000-ft.^{2} of Sprinklered Area which ever is greater • ≤1,000-ft.^{2} per Pile • Separated from Other Storage Areas by ≥25-ft. Hose Steam: 250- / 500-gpm	(Varies per Chapter, but ≥2,000-ft.^{2}) Coverage: 100-ft.^{2} Maximum Thermal Sensitivity: SR / QR / CMDA / CMSA / ESFR K-Factor: 11.2 Minimum Thread Size: 3/4" Mininum Orifice Size: 17/32" Minimum Hose Steam: 250- / 500-gpm
	Occupancy Examples:	Occupancy Examples:	Occupancy Examples:	Occupancy Examples:	Occupancy Examples:	Occupancy Examples:	Occupancy Examples:
	Offices, incl. Data Processes Educational Libraries (except large stack rms.) Restaurant Seating Areas Museums Churches Residential Other Areas of Similar Hazard	Mechanical / Electrical Rooms General Storage Rooms (in Offices, etc.) Automobile Parking Garages/Showrooms Restaurant Service Areas (Kitchens, etc.) Laundries Electronic Plants Glass and Glass Products Manufacturing Other Areas of Similar Hazard	Chemical Plants Dry Cleaners Libraries (large stack room areas) Loading Docks (no Flam./Comb. Liq.) Machine Shops / Metal Working Wood Machining / Product Assembly Repair Garages Other Areas of Similar Hazard	Aircraft Hangars Comb. Hydraulic Fluid Use Areas Die Casting Metal Extruding Rubber Relaiming / Compounding Textiles Upholstering with Plastic Foams Other Areas of Similar Hazard	Asphalt Saturating Flammable Liquids Spraying Flow Coating Plastics Manufacturing Solvent Cleaning Varnish and Paint Dipping Car Stackers or Car Lift Systems Other Areas of Similar Hazard	(OH1) (EH2) Other Areas of Similar Hazard	Storage Warehouses Ambient-Storage Cold-Storage Other Areas of Similar Hazard

LEGEND:	DEFINITIIONS:
HRR: Heat Release Rate QR: Quick Response SR: Standard Response CMDA: Control Mode Density/Area CMSA: Control Mode Specific Application ESFR: Early Suppression Fast Response	Shielding: An obstruction that prevents the water from reaching the fire. Low-Piled Storage: Solid-Piled, Palletized, Rack Storage, Bin Box, and Shelf Storage up to 12-ft. in Height. High-Piled Storage: Solid-Piled, Palletized, Rack Storage, Bin Box, and Shelf Storage in Excess of 12-ft. in Height. Stockpiles: A large store or supply accumulated for future use. (British Dictionary)

* Note 1: Top of Stockpile or Storage is Measured from the Finsished Floor to the Top of the Material Stored.

**Note 2: Does Not Address Storage of Idle Pallets. Refer to Section 20.14, for Protection of Idle Pallet Storage.
(Idle Pallet Storage, Whether Wood or Plastic, Introduces a Severe Fire Condition and is One of the Greatest Challeges to Sprinklers)

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CLB 3-8-2020

THE SCIENCE OF FIRE PROTECTION

This is an overview in General terms. There are some exceptions not referenced below.

	LIGHT HAZARD	ORDINARY HAZARD, GROUP I	ORDINARY HAZARD, GROUP 2	EXTRA HAZARD, GROUP 1	EXTRA HAZARD, GROUP 2		MISC. STORAGE	
HAZARD	12-ft. (to top of stockpile*) Contents: Qty. is Low. Contents: Comb. Is Low. Fire: HRR is Low. Finished Floor	8-ft. (top of stockpile*) Contents: Qty. is Moderate. Contents: Comb. Is Low. Fire: HRR is Moderate. Stockpiles: ≤8-ft. Finished Floor	12-ft. (to top of stockpile*) Fire: HRR is Moderate. Stockpiles: ≤12-ft. 8-ft. (to top of stockpile*) Contents: Qty. is Moderate to High. Contents: Comb. Is Moderate to High. Fire: HRR is High. Stockpiles: ≤8-ft. Finished Floor	12-ft. (to top of stockpile*) Contents: Qty. is Very High. Contents: Comb. Is Very High. Fire: HRR is High. Stockpiles: ≤12-ft. Flam./Comb. Liquid: Little to None. Dust / Lint Finished Floor	12-ft. (to top of stockpile*) Contents: Qty. is Very High. Contents: Comb. Is Very High. Fire: HRR is High. Stockpiles: ≤12-ft. Flam./Comb. Liquid: Substantial. Shielding: Extensive. Finished Floor	LOW- PILED STORAGE**	12-ft. (to top of storage*) SEE TABLE 4.3.1.7.1. (CMDA only) Finished Floor	LOW- PILED STORAGE**
DESIGN CRITERIA	NFPA: 0.10-gpm/1,500-ft.^{2} FM: 0.10-gpm/1,500-ft.^{2} Coverage: 225-ft.^{2} Maximum Thermal Sensitivity: QR K-Factor: 5.6 Minimum Thread Size: 1/2" Mininum Orifice Size: 1/2" Minimum Hose Stream: 100-gpm	NFPA: 0.15-gpm/1,500-ft.^{2} FM: 0.20-gpm/2,500-ft.^{2} Coverage: 130-ft.^{2} Maximum Thermal Sensitivity: SR / QR K-Factor: 5.6 Minimum Thread Size: 1/2" Mininum Orifice Size: 1/2" Minimum Hose Stream: 250-gpm	~~NFPA: 0.20-gpm/1,500-ft.^{2}~~ FM: 0.20-gpm/2,500-ft.^{2} Coverage: 130-ft.^{2} Maximum Thermal Sensitivity: SR / QR / CMSA K-Factor: 5.6 Minimum Thread Size: 1/2" Mininum Orifice Size: 1/2" Minimum Hose Stream: 250-gpm	NFPA: 0.30-gpm/2,500-ft.^{2} FM: 0.30-gpm/2,500-ft.^{2} Coverage: 100-ft.^{2} Maximum Thermal: SR / QR / CMSA K-Factor: 8.0 Minimum Thread Size: 3/4" Mininum Orifice Size: 17/32" Minimum Hose Stream: 500-gpm	~~NFPA: 0.40-gpm/2,500-ft.^{2}~~ FM: 0.30-gpm/2,500-ft.^{2} Coverage: 100-ft.^{2} Maximum Thermal: SR / QR / CMSA K-Factor: 8.0 Minimum Thread Size: 3/4" Minimum Orifice Size: 17/32" Minimum Hose Stream: 500-gpm		(OH1) (EH2) • Incidental / Ancillary Use • ≤10% of Bldg. Area, or, 4,000-ft.^{2} of Sprinklered Area which ever is greater • ≤1,000-ft.^{2} per Pile • Separated from Other Storage Areas by ≥25-ft. Hose Steam: 250- / 500-gpm	T
	Occupancy Examples:	Occupancy Examples:	Occupancy Examples:	Occupancy Examples:	Occupancy Examples:		Occupancy Examples:	
	Offices, incl. Data Processes Educational Libraries (except large stack rms.) Restaurant Seating Areas Museums Churches Residential Other Areas of Similar Hazard	Mechanical / Electrical Rooms General Storage Rooms (in Offices, etc.) Automobile Parking Garages/Showrooms Restaurant Service Areas (Kitchens, etc.) Laundries Electronic Plants Glass and Glass Products Manufacturing Other Areas of Similar Hazard	Chemical Plants Dry Cleaners Libraries (large stack room areas) Loading Docks (no Flam./Comb. Liq.) Machine Shops / Metal Working Wood Machining / Product Assembly Repair Garages Other Areas of Similar Hazard	Aircraft Hangars Comb. Hydraulic Fluid Use Areas Die Casting Metal Extruding Rubber Relaiming / Compounding Textiles Upholstering with Plastic Foams Other Areas of Similar Hazard	Asphalt Saturating Flammable Liquids Spraying Flow Coating Plastics Manufacturing Solvent Cleaning Varnish and Paint Dipping Car Stackers or Car Lift Systems Other Areas of Similar Hazard		(OH1) (EH2) Other Areas of Similar Hazard	

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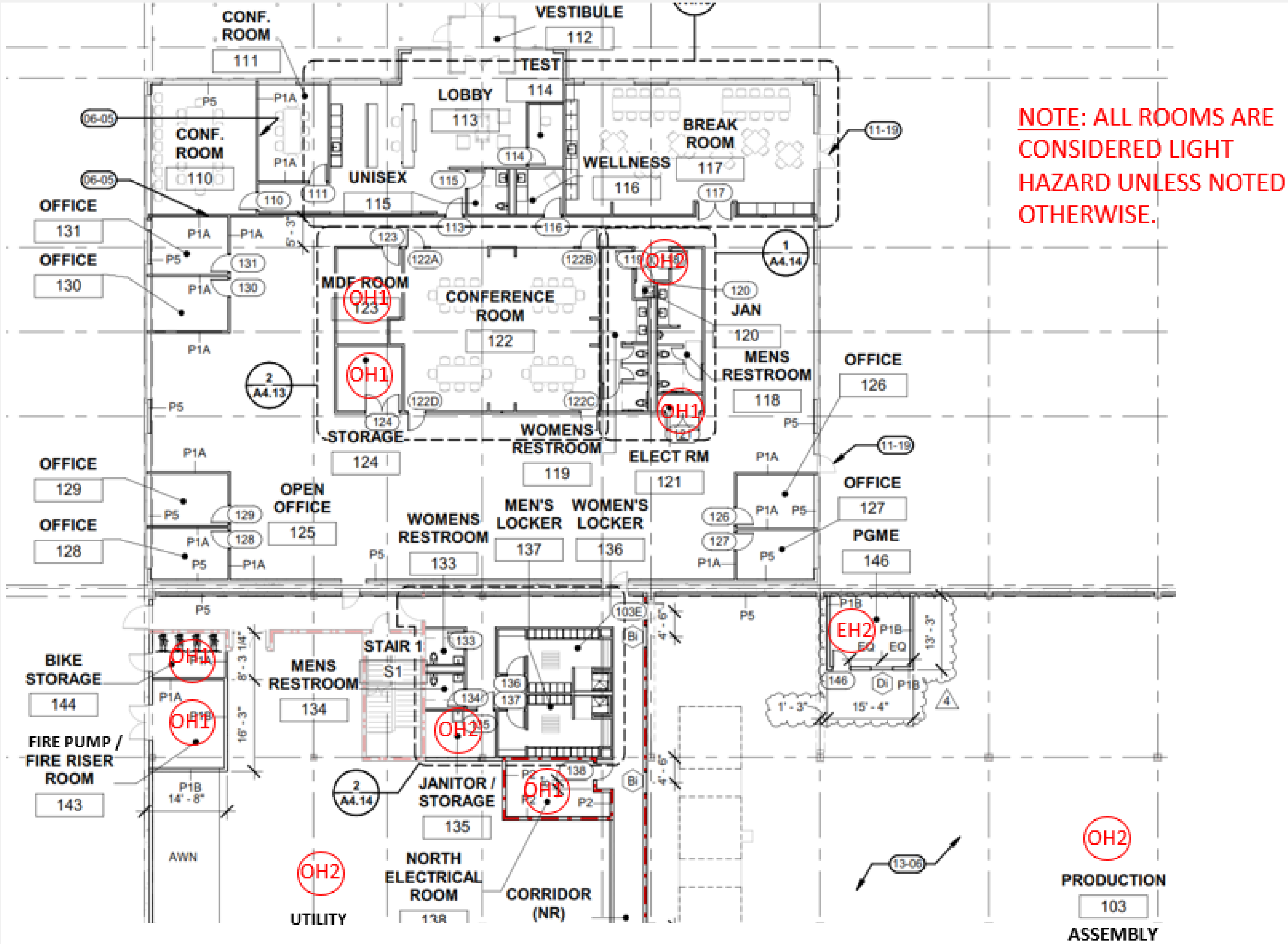
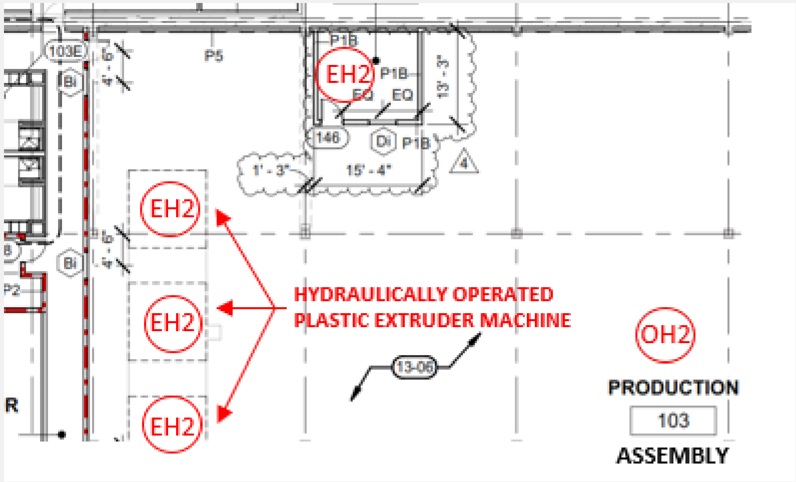
EXAMPLE – HAZARD IDENTIFICATION



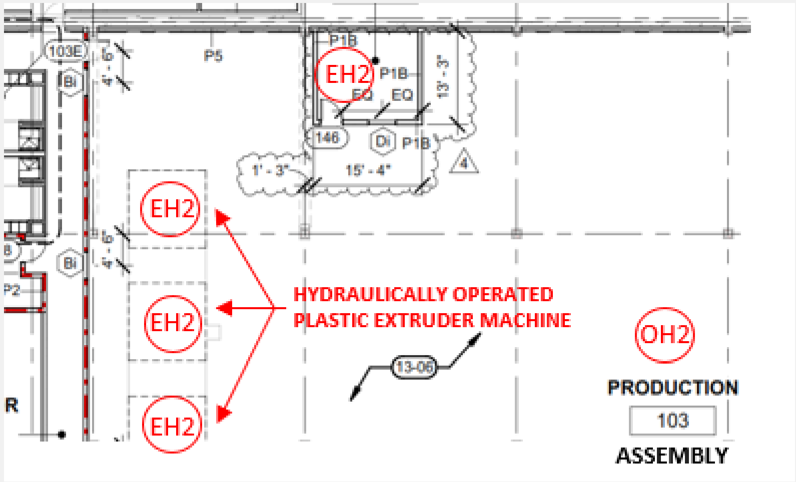
NOTE: ALL ROOMS ARE CONSIDERED LIGHT HAZARD UNLESS NOTED OTHERWISE.

EXAMPLE – HAZARD IDENTIFICATION



EXAMPLE – HAZARD ANALYSIS

- Loss Exposure Analysis:
  - Production Assembly is OH2 level of protection. Existing protection is considered adequate.
  - Extruder is a higher Hazard EH2 located in an OH2 Area.
  - Hydraulic fluid in use under pressure.
  - Exposed rubber hose under pressure.
  - Extruder Hazard is inadequately protected and requires a Treatment strategy.



EXAMPLE – HAZARD TREATMENT

- Treatment:
  - Add Sprinkler Protection at each side of each Extruder Machine.
    - Add Sprinklers at exposed rubber hoses, or,
  - Change hose from rubber to noncombustible materials.
  - Add Heat Detection above each Extruder.
    - Interlock Detector with Extruder for auto Shut-down.
    - Send Alarm signal to the Fire Alarm Control Panel (FACP)
  - Verify if the Equipment supervises fluid pressure.
  - Provide bollard or other physical protection measure at exposed hoses to prevent mechanical damage.
  - Ensure operators have an Emergency Action Plan in case of fire event.

SUMMARY

- Property Risk Management is a sub-set of Enterprise Risk Management Framework.
- Fire Protection Engineering is Valued in ERM to Identify, Analyze and Treat Hazards and mitigate Loss Exposure.
- Early fire and Life Safety concerns lead to Fire Research and Development, and eventually evolved into Fire Protection Engineering Programs of study, as a distinct, Professional discipline.
- Fire Protection and Life Safety features are inherent considerations in Codes.
- Fire Protection Engineering is an application of Science, Engineering Principals, Fire Science and Fire Dynamics.
- Proper application of the "Whole Building" Design Concept, or Fire Protection Equation, can reduce Risk and Loss Exposure by limiting the Exposure to the Room of Origin or the Object itself.