Bridging the Gap: Addressing Inconsistencies in Industrial Fire Protection Across Canadian Facilities

Prepared for
Canadian Chemical Engineering Conference 2026
May 26, 2026

Presented by
Modusser Tufail, P.Eng.,
Fire Protection Engineer
Modusser.Tufail@Strathcona.ca
Strathcona County Emergency Services (SCES)

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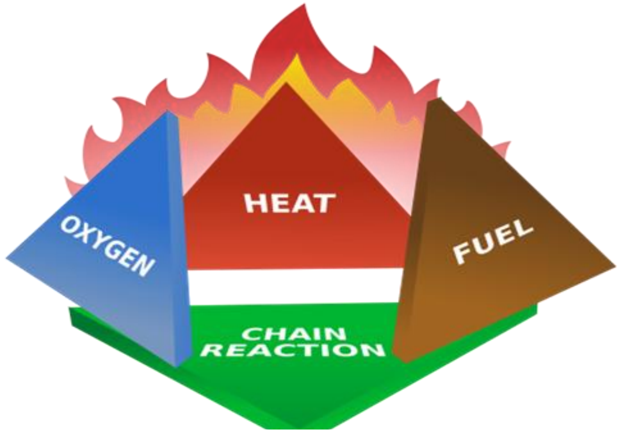
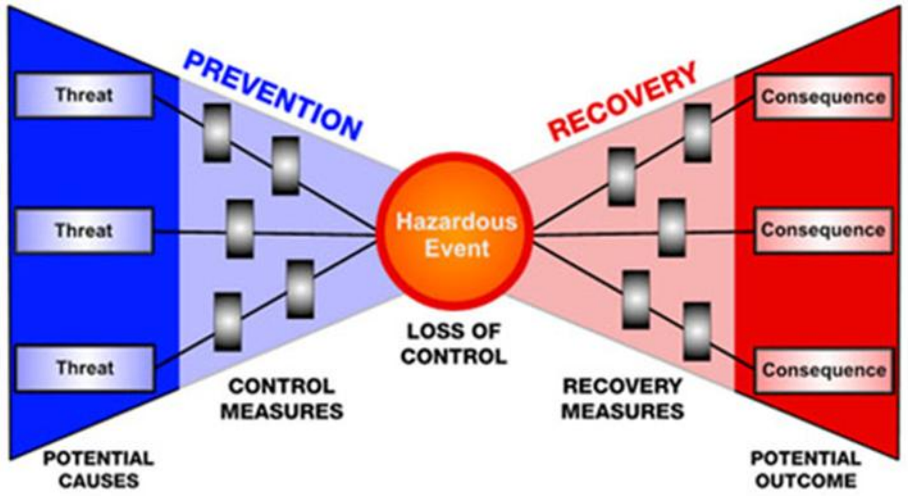
About Speaker

- BSc. (Pakistan) and MEng. in Chemical Engineering (UWaterloo)
- 12+ years of experience in process safety and fire protection engineering
- Professional Engineer (Alberta- Canada)
- Certified Fire Protection Specialist (NFPA)
- Certified Process Safety Professional (AIChE-CCPS)
- Member
  - National Model Code Committee Codes Canada (fire and building codes)
  - Technical Committee : CSA PSM Standard Z767
  - Executive of PSM Division CSChE under CIC

Fire Protection Engineering

- Focus is to prevent incidents and protect risk receptors





1- Active Fire Protection	2- Passive Fire Protection
Sprinkler systems	Fireproofing (coatings or insulation)
Clean agent gas systems	Non-combustible construction
Fire detection systems	Partitions or walls
Smoke control and management systems	Compartmentalization
Fire extinguishers	Spacing and layout
Hose cabinets	Drainage and containment
Hydrants	Electrical area classification
3- Risk Management	
Risk assessments Process Safety Management Land-use and control	

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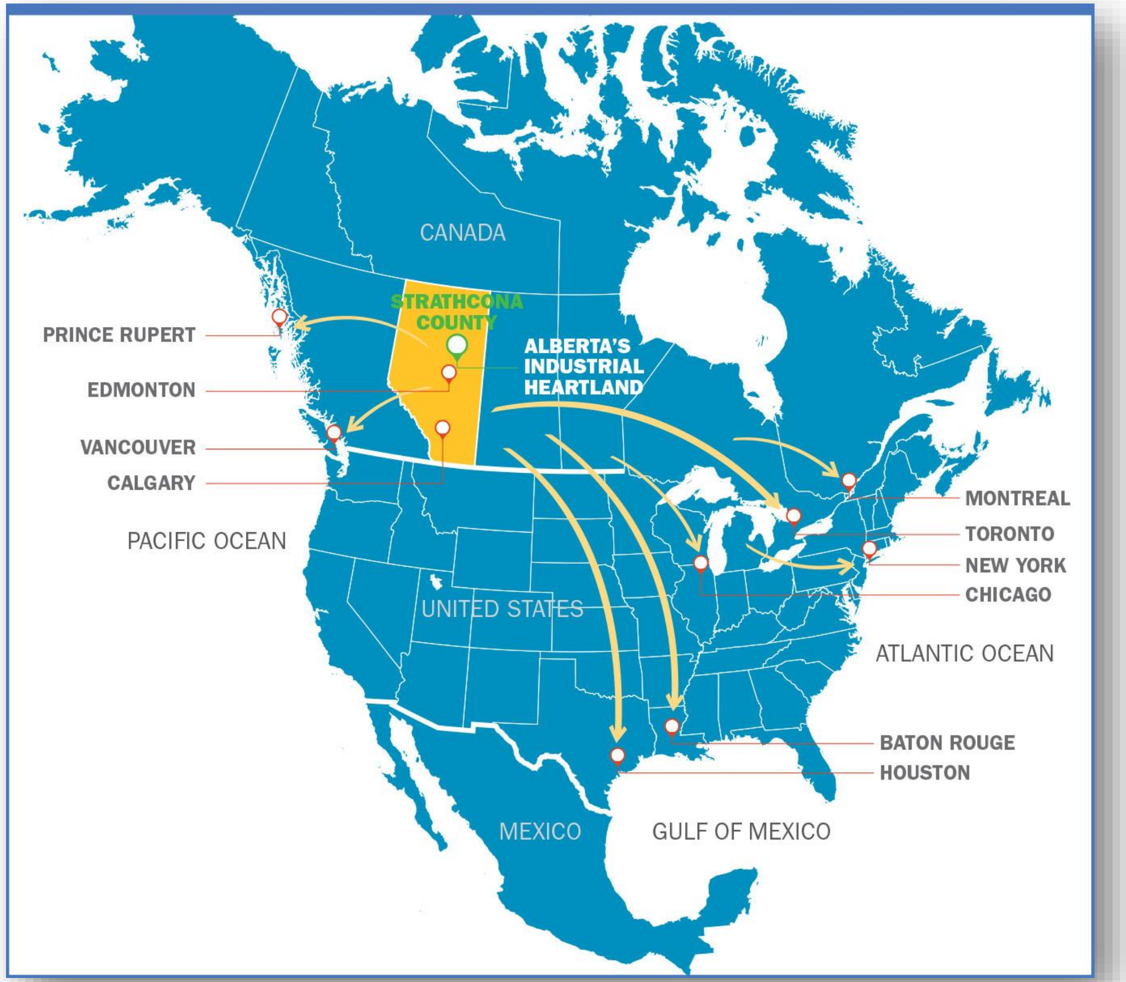
Agenda

- About Strathcona County
- Fire Protection Layers in LOPA
- Regulations on Industrial Fire Protection
- Fire Protection vs Emergency Response Scenarios
- Risk Based Triggers of Fire Protection
- Conclusion



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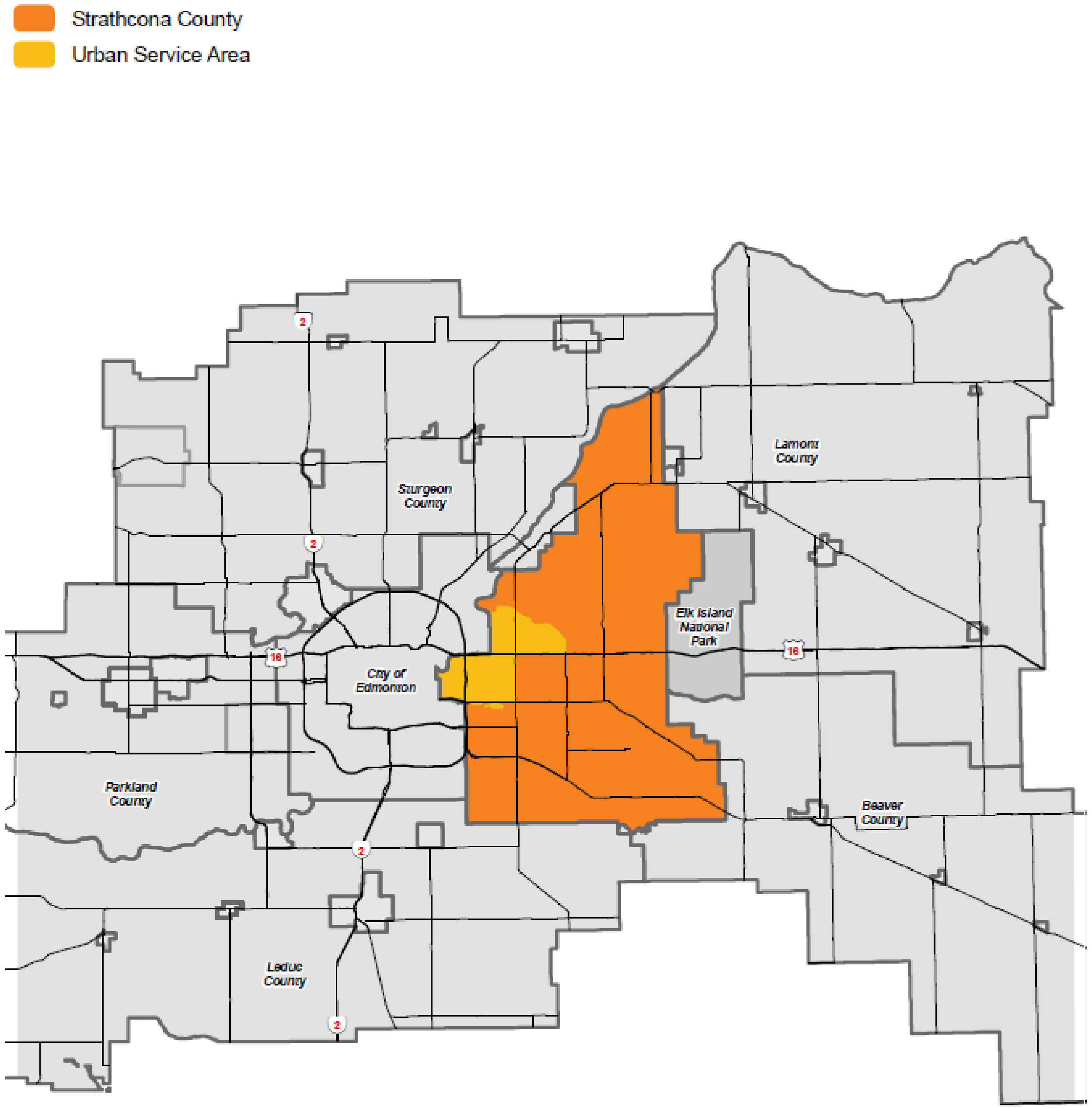
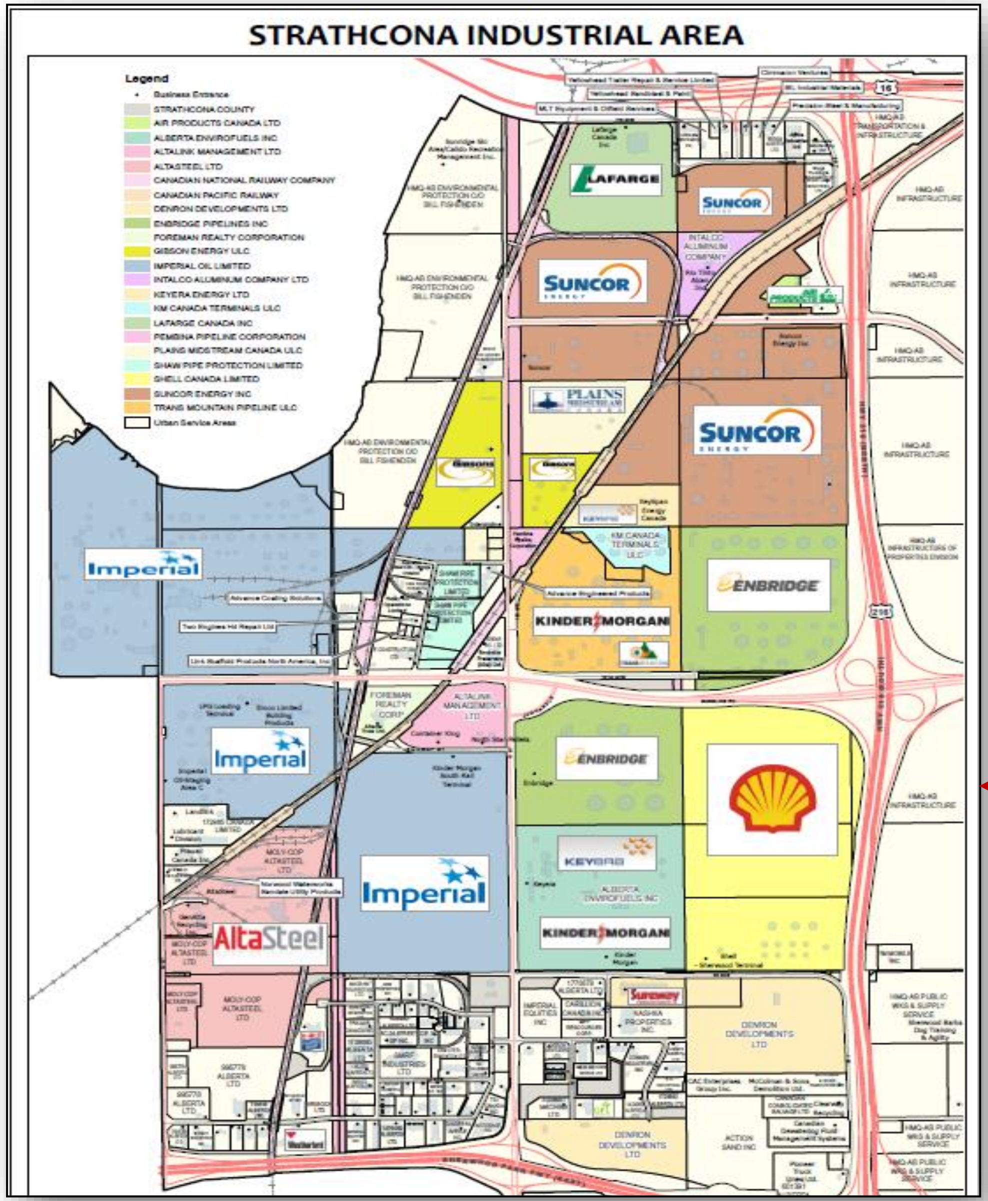
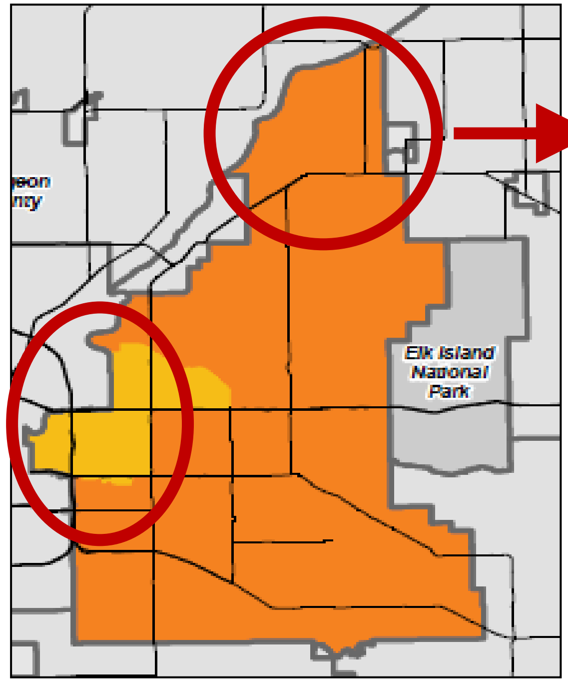
Strathcona County - AB

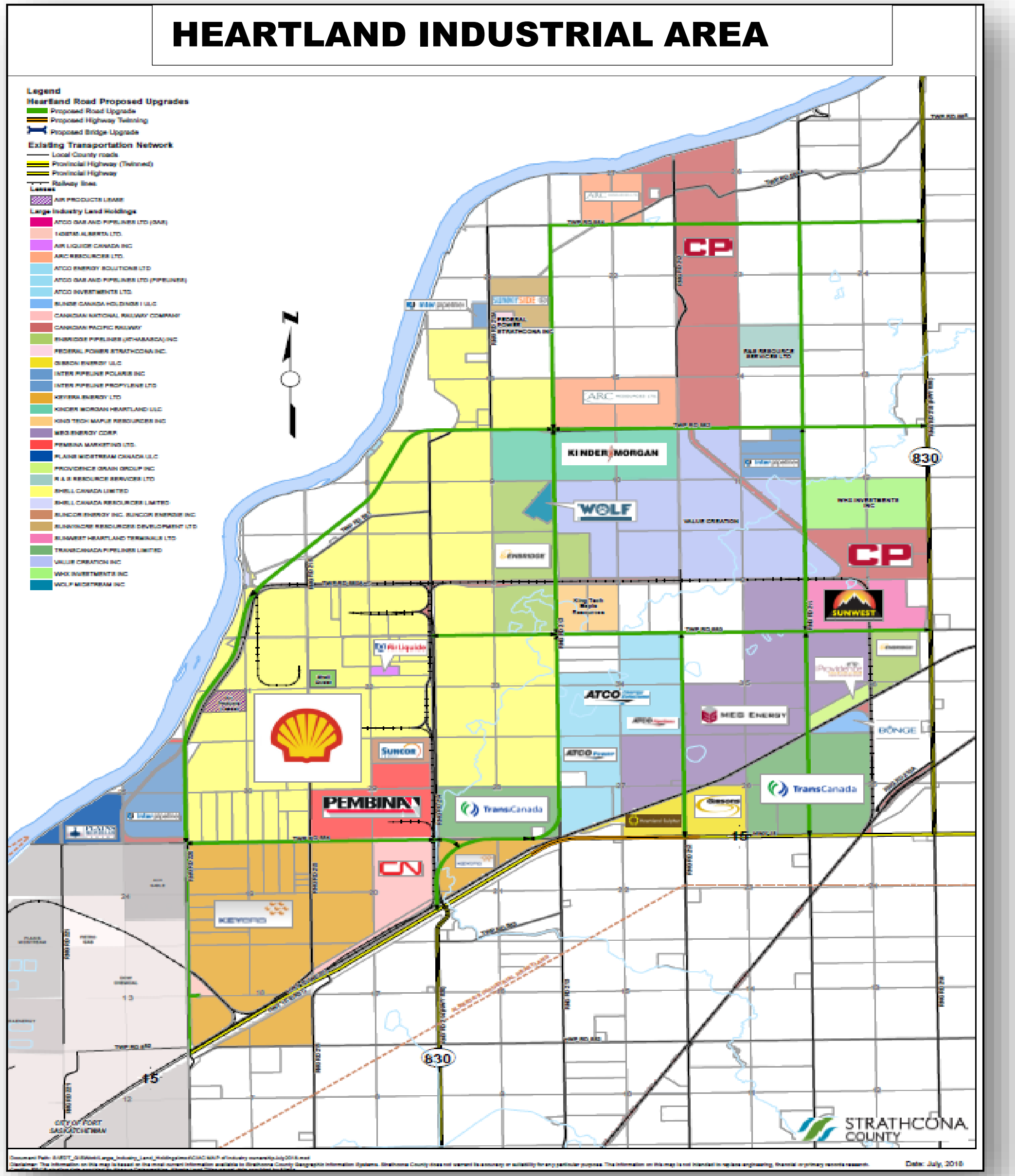


- Centre of Alberta’s energy and agricultural heartland
- More than 100,362 residents
- Home to 75 per cent of refining in Western Canada.

Heavy Industry







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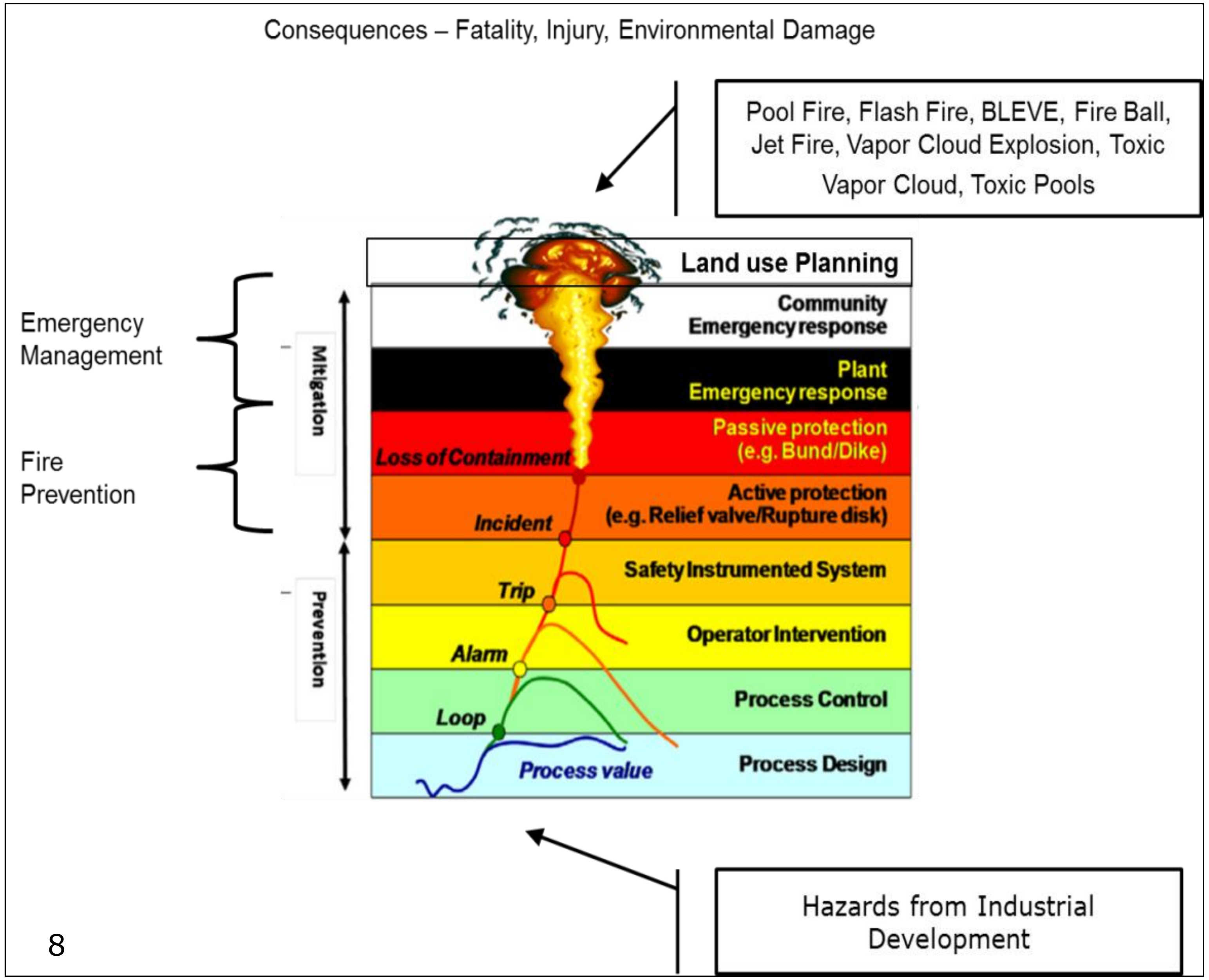
Layer of Protection

- Hazards>> Risks>> Protection
- Independent Protection Layers
- Active Fire Protection
- Passive Fire Protection



Regulations on Fire Protection

- To lower consequence of exposure of fire and explosion
- Trigger 1: Company Standards (CCPS, API, FM Datasheets, NFPA)
- Trigger 2: Regulation: National Fire Code and Building Code

Fire Code Review - Summary

- The following situations potentially need engineering evaluations before and after occupancy " good engineering practice":
  - Facilities : process plants, tank farms, industrial buildings
  - Storage of Dangerous goods both Indoor and Outdoor
  - Hazardous Processes like hot works, wood processing
  - Determination of explosion hazard
  - Adequacy of features of fire protection systems of a site e.g. ventilation design, duration of fire suppression or control, worst case scenarios for fire protection, use of products that are not listed/approved
  - Variance to codes requiring engineering assessment

Code Review Summary

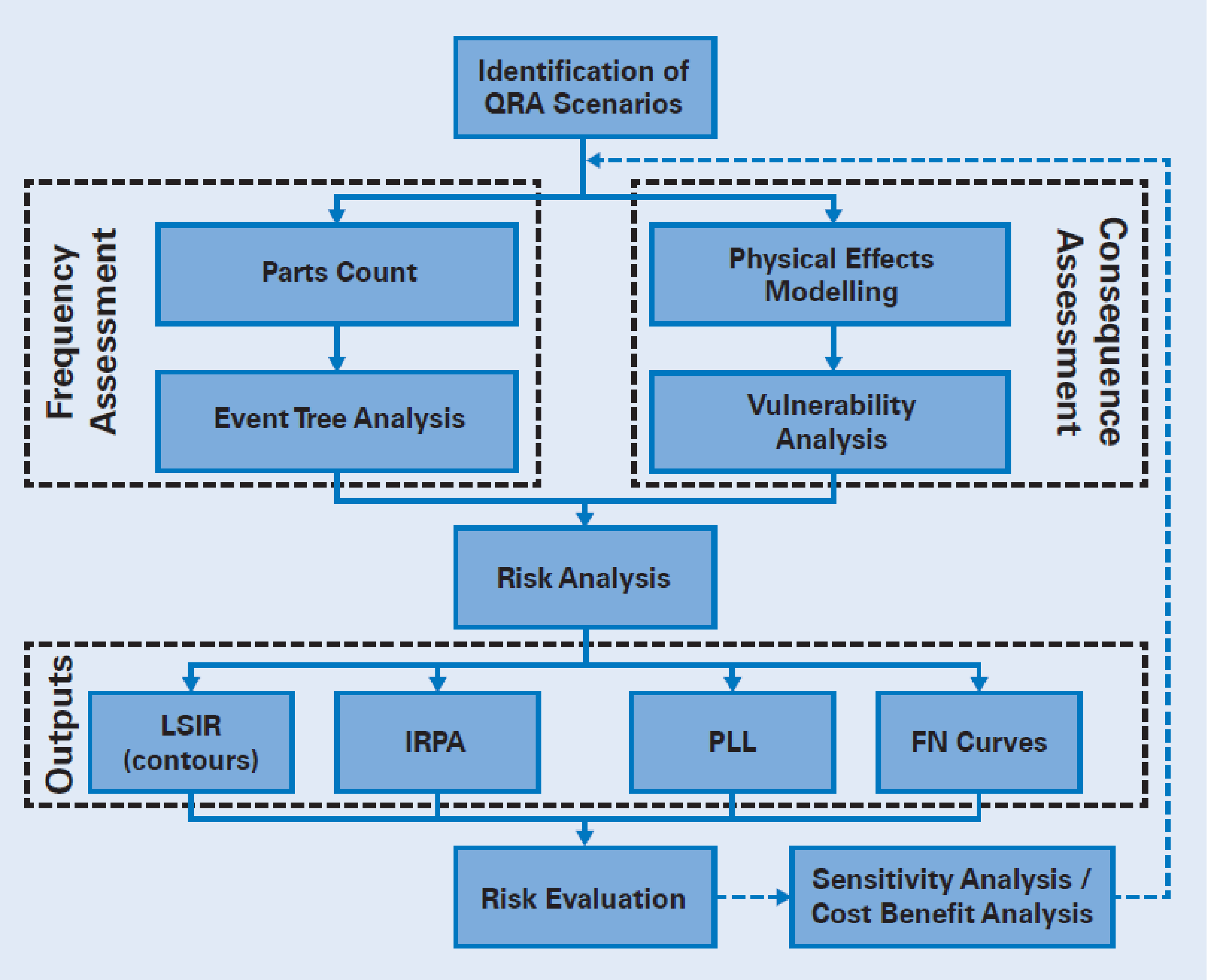
- Process Plants: Engineering judgement
- Tank Farms: 45 meters and above
- Remaining : Engineering judgement
  - Remark 1: Engineering judgement is snapshot of time and should be documented and be available for the life of the facility and needs update as site evolves and expands to include new materials and quantities.
  - Remark 2: Engineering judgement varies from one Engineer to another e.g.
    - Common containment of tanks vs single dike for every tank
    - Which size of tank triggers fire protection
    - What level of fire protection – rim seal or full surface tank
    - Inconsistencies in standards e.g. NFPA 30 vs NFC-AB on tank spacing
    - NFPA vs CCPS vs API vs FM Datasheets

Triggers of Fire Protection

RISK BASED APPROACH

Risk Analysis

- Identify hazard/scenario
- Frequency of releases
- Consequence Analysis
- Risk analysis
  - LSIR – Location Specific Individual Risk
  - IRPA – Individual Risk Per Annum
  - PLL = Potential Loss of Life
  - FN – Fatality Number
- Sensitivity analysis
  - Variations and affects
- Compare with risk tolerance



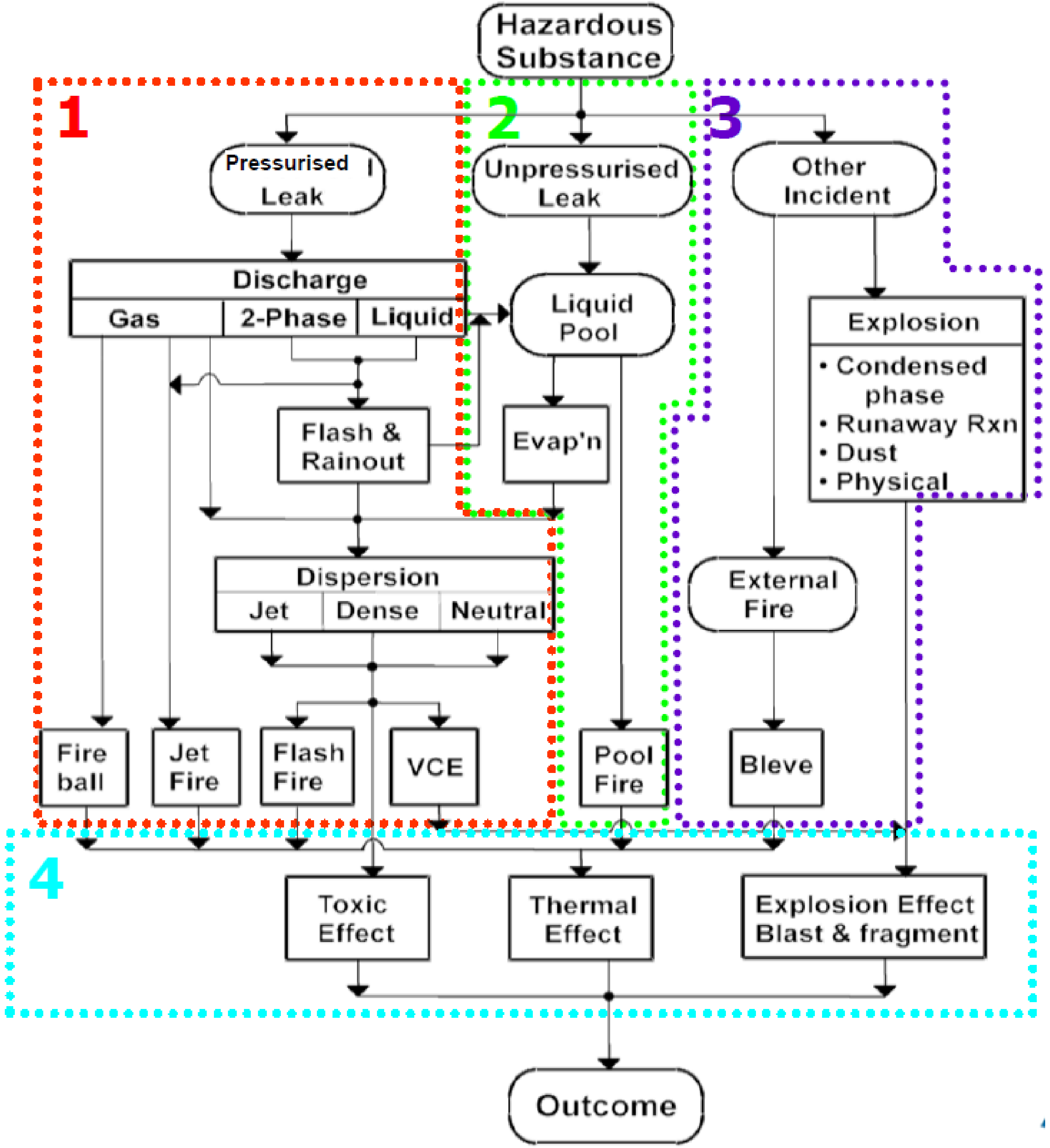
Risktec – QRA Publication

Consequence Analysis

- Fire Ball
- Jet fire
- Flash Fire
- Vapor Cloud Explosion

- Pool Fire
- BLEVE – Boiling liquid expanding vapor explosion

- Toxic Vapor Cloud
- Toxic Pool



International Association of Oil and Gas Producers, Risk Assessment Data Directory: Consequence Modelling, 434-07, March 2010

Calculating Frequency (IOGP Risk Data Directory)

Table 2.4 Summary of Pressure Vessel Leak Frequencies

Hole Diameter		Leak Frequency (per vessel year)	
Range	Nominal	Storage Vessels	Small Containers
1-3 mm	2 mm	2.3×10^{-5}	4.4×10^{-7}
3-10 mm	5 mm	1.2×10^{-5}	4.6×10^{-7}
10–50 mm	25 mm	7.1×10^{-6}	
50-150 mm	100 mm*	4.3×10^{-6}	
>150 mm	Catastrophic	4.7×10^{-7}	1.0×10^{-7}
TOTAL		4.7×10^{-5}	1.0×10^{-6}

*Or diameter of largest pipe connection if this is smaller

Table 2.1 Atmospheric Storage Tank Leak Frequencies

Type of Tank	Type of Release	Leak Frequency (per tank year)
Floating roof	Liquid spill on roof	1.6×10^{-3}
	Sunken roof	1.1×10^{-3}
Fixed/ floating roof	Liquid spill outside tank	2.8×10^{-3}
	Tank rupture	3.0×10^{-6}

Table 2.2 Atmospheric Storage Tank Fire Frequencies

Type of Fire	Floating Roof Tank (per tank year)	Fixed Roof Tank (per tank year)	Fixed plus Internal Floating Roof Tank (per tank year)
Rim seal fire	1.6×10^{-3}		1.6×10^{-3}
Full surface fire on roof	1.2×10^{-4}		
Internal explosion & full surface fire		9.0×10^{-5}	9.0×10^{-5}
Internal explosion without fire		2.5×10^{-5}	2.5×10^{-5}
Vent fire		9.0×10^{-5}	
Small bund fire	9.0×10^{-5}	9.0×10^{-5}	9.0×10^{-5}
Large bund fire (full bund area)	6.0×10^{-5}	6.0×10^{-5}	6.0×10^{-5}

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Process Leak Frequencies Ref 1 and Fire Water Application Rates Ref 2

Item	Fire Water Application Rate [gpm/ft²]
Air-Cooled Fin-Tube Heat Exchangers	0.25
Cable Trays	0.30
Compressors	0.25
Exposure Protection	0.25
Fired Heaters	0.25
LPG Loading Racks	0.25
Motors	0.25
Pipe Racks	0.25
Pressurized Storage Tanks	0.25
Pumps	0.25-0.50
Towers	0.25
Turbines	0.25
Vessels and Heat Exchangers	0.25

Source: CCPS book "Guidelines for Fire Protection in Chemical, Petrochemical, and Hydrocarbon Processing Facilities"

Table 4-2: PLOFAM2 model Parameters From [10]

Equipment type	A_0	m_0	A_D	m_D	B_D	α	$F_{hist,Significant}$	$F_{hist,Marginal}$
Air-cooled heat exchanger	1.00	0	0	0	3.0E-2	0	5.00E-4	0
Atmospheric vessel	1.00	0	0	0	1.0E-1	0	5.00E-4	0
Centrifugal compressor	1.00	0	0	0	6.0E-3	0	1.30E-3	0
Centrifugal pump	1.00	0	0	0	3.0E-5	0	3.00E-3	0
Compact flange	1.00	0	0	0	1.0E-3	0.9	3.00E-6	0
Filter	1.00	0	0	0	8.0E-4	0	2.30E-3	0
Flexible pipe	1.00	0	0	0	4.0E-1	0.75	1.40E-4	0
Gas lift well	1.00	0	0	0	2.5E-2	0	1.00E-4	1.00E-04
Hose	1.00	0	0	0	4.0E-1	0.75	6.00E-5	1.00E-05
Instrument	1.00	0	0	0	1.5E-1	0	1.30E-4	0
Pig trap	1.00	0	0	0	2.0E-2	0	1.70E-3	0
Plate heat exchanger	1.00	0	0	0	1.0E-3	0	3.50E-4	0
Process vessel	1.00	0	0	0	6.0E-4	0	5.00E-4	0
Producing well	1.00	0	0	0	2.0E-2	0	2.00E-5	1.30E-05
Reciprocating compressor	1.00	0	0	0	1.0E-2	0	5.00E-3	-
Reciprocating pump	1.00	0	0	0	3.0E-5	0	3.00E-3	-
Shell and tube heat exchanger exchanger	1.00	0	0	0	7.5E-3	0	3.30E-4	-
Standard flange	1.00	0	18.0	-1.45	5.0E-3	0.5	2.50E-5	5.00E-06
Steel pipe	4.20	-0.30	17.6	-1.75	1.0E-3	0.9	1.40E-5	2.00E-06
Valve	1.11	-0.10	16.0	-1.70	1.0E-3	0.5	2.15E-4	3.50E-05

Values denoted by "-" should be taken as zero.

Ref 1:IOGP Risk Data Directory
Ref 2: CCPS Fire Protection Guidelines

Risk Based Trigger

- According to API 2510A a thermal radiation threshold of 22 KW/m2 (7000 BTU/hr-ft2) is the limit at which fixed fire water system is needed for cooling of LPG vessel.

- From CCPS guidelines, risk areas greater than 1.00 E-05 yr-1 LSIR will require fixed fire protection.

- In simple words: Assets within a risk contour of 1.00 E-05 yr-1 will require fixed fire protection system [Ref]

Reference: Adam Baker P.E., “A Risk Based Approach to Calculating Fire Water Demand”, Iomosaic, January 25-26, 2021 | 15th Annual Global Software Users Group Meeting | Virtual

Fire Protection vs Emergency Response

Fire Protection Scenarios

- Worst case realistic likely fire scenario for fire protection (more frequent)
- 10 % volume of material for Loss of Containment and fire modelling
- Rim seal and full surface fire scenario
- Single fire event that demands most resources goes in design basis

Emergency Response Scenarios

- Worst case realistic scenario (less frequent)
- 100% Hazardous Material is involved in fire modelling
- Catastrophic Failure of Tank and dike pool fire
- Single fire event usually domino effect not considered
- Used for land buffering and Emergency Response Planning Zones (EPZ)
- Mostly short of resources

Engineering Assessment = Fire Protection Design Basis

- Indirectly there is a performance-based approach necessary for most of the industrial occupancies
- A fire protection design basis captures:
  - Site processes and materials that are fire and explosion hazards
  - Selection of potential fire scenarios and their consequence analysis
  - Determination of worst case fire scenario that is planned for fire protection
  - Plans and drawings of the planned fire protection systems
  - ITM requirements
  - Identification of codes and standards that will be complied with
  - Details of HVAC, Smoke Control systems, etc. and their assumptions
  - Must be updated as the site conditions change just like P&IDs

Conclusion

1. Inconsistency in fire protection of industrial occupancies.
   - E.g. one hydrant vs many hydrants
2. There is no management of change in code compliance.
3. There exists complexity in processes, facility storage and operations which requires documentation of fire protection design basis that is reviewed periodically, e.g. every 5 years or anytime there is a material or process change
4. Variation in engineering assessments needs a national guideline especially for source of data, credible fire scenarios, and to write an adequate fire protection design basis e.g. battery fires, bess, recycling plants etc.
5. It is required under CSA PSM Standard 767 to keep up with design basis such as process design basis, flare system design basis and fire protection design basis.
6. FPDB is key in risk reduction of Small and Medium Enterprises (SMEs)

References

Tufail, Modusser ,"Strathcona County's Industrial Engagement Program: Leading the Way Using the MIACC Model", Global Congress of Process Safety, New Orleans 2019 (Link)

Risktec – Quantitative /Probabilistic Risk Assessment(QRA/PSA) (Link)

API 2510A: 2025 - Fire-Protection Considerations for the Design and Operation of Liquefied Petroleum Gas Storage Facilities

NFC-AE 2023 – National Fire Code Alberta Edition 2023

International Association of Oil and Gas Producers, Risk Assessment Data Directory: Consequence Modelling, 434-07, March 2010 (Link)

Adam Baker P.E., "A Risk Based Approach to Calculating Fire Water Demand", Iomosaic, January 25-26, 2021 | 15th Annual Global Software Users Group Meeting | Virtual (Link)

Questions?

THANKS

Back up slides

ENGINEERING IN FIRE CODE

General fire code compliance

- Need engineering assessments for complex products and processes

Conformity Assessment

The NFC(AE) establishes minimum measures, either within its own text or that of referenced standards. However, the NFC(AE) does not deal with the question of who is responsible for assessing conformity to the measures or how those with this responsibility might carry it out. This responsibility is usually established by the governing legislation of the adopting provinces or territories. Provincial or territorial authorities should be consulted to determine who is responsible for conformity assessment within their jurisdiction.

Those persons responsible for ensuring that a material, appliance, system or equipment meets the requirements of this Code have several means available to assist them. These means vary from on-site inspection to the use of certification services provided by accredited third-party organizations. Test reports or mill certificates provided by manufacturers or suppliers can also assist in the acceptance of products. Engineering reports may be required for more complex products.

Engineering in Fire Code

3.2.7 Indoor Storage of DG

3.2.7.5. Storage Arrangements

1) The method of storage of *dangerous goods* shall
a) be determined to ensure the physical and chemical stability of the stored products,
b) except as provided in Sentences (2) and (5), not exceed the maximum heights of storage shown in Table 3.2.7.5., and
c) not exceed the maximum base areas for *individual storage areas* shown in Table 3.2.3.2. (see Note A-3.2.7.5.(1)(c)).

2) Storage heights for a protected storage area stated in Table 3.2.7.5. are permitted to be exceeded provided the *dangerous goods* are stored on *racks* or shelves.

3) When a storage area is required by this Article to be protected, it shall be *sprinklered* or protected with a special fire suppression system, in conformance with Part 2 and good engineering practice with respect to specific *dangerous goods*. (See Note A-3.2.7.9.(1).)

3.2.7.9 Fire Suppression Systems

3.2.8.2. Flammable Gases

1) Except as provided in Sentences (2) and (3), cylinders of *dangerous goods* classified as flammable gases stored indoors shall be located in a room that
a) is separated from the remainder of the *building* in conformance with Sentence 3.3.6.3.(1) of Division B of the NBC(AE),
b) is located on an exterior wall of the *building*,
c) can be entered from the exterior, and whose *closures* leading to the interior of the *building* are in conformance with Sentence 3.3.6.3.(1) of Division B of the NBC(AE),
d) is designed to prevent critical structural and mechanical damage from an internal explosion in conformance with good engineering practice such as that described in NFPA 68, "Explosion Protection by Deflagration Venting" (see Note A-3.2.8.2.(1)(d)),
e) is provided with natural or mechanical ventilation in conformance with Subsection 4.1.7.,
f) does not contain fuel-fired *appliances* or high-temperature heating elements, and
g) is used for no purpose other than the storage of *dangerous goods* classified as compressed gases.

Engineering in Fire Code – cont.

3.2.7.3 Ambient Conditions

3.2.7.3. Ambient Conditions

1) Rooms or parts of *buildings* used for the storage of *dangerous goods*
a) shall be dry and cool, and
b) where the products being stored are capable of releasing flammable or toxic gases or vapours under normal ambient conditions, shall be provided with a ventilation system to exhaust such gases or vapours outdoors to an area where they will not return to the *building* (see Note A-3.2.7.3.(1)(b)).

A-3.2.7.3.(1)(b) Part 4 of the NFC(AE) specifies ventilation rates to prevent the buildup of dangerous concentrations of flammable vapours in rooms used for storing flammable and combustible liquids. The same principles should apply to dangerous goods capable of releasing toxic gases, or where the accidental mixing of incompatible substances could generate flammable vapours or toxic gases. Where no guidance is given, the design of the ventilation system should conform to good engineering practice. Recommendations in the NFPA standards or in ACGIH, "Industrial Ventilation: A Manual of Recommended Practice for Design," are considered examples of good engineering practice.

3.3.2 Outdoor Storage: General

3.3.2.15. Fire Protection

1) It is permitted to increase the height and size of *individual storage areas* prescribed in this Section if fire extinguishing measures conforming to good engineering practice are provided.

3.3.2.8. Ignition Sources

1) Unless controlled in a manner that will not create a fire hazard, a device, operation or activity that produces open flames, sparks or heat shall not be permitted in an outdoor storage area. (See Note A-4.1.5.2.(1).)

2) Except as provided in Subsection 2.4.2., smoking shall not be permitted in an outdoor storage area.

3) Except as provided in Subsection 2.6.2., the burning of materials in an outdoor storage area shall be performed only in a burner that is
a) designed, constructed and maintained in conformance with good engineering practice, and
b) located not less than 15 m from a *building* or stored products.

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Engineering in Fire Code – cont.

Section 4.1. General

4.1.1. Scope

4.1.1.1. Application

1) Except as provided in Sentences (2) and (3), this Part applies to the storage, handling, use and processing of

a) *flammable liquids* and *combustible liquids* in *buildings*, structures and open areas, and

b) *dangerous goods* classified as flammable gases at *fuel-dispensing stations*.

(See Note A-4.1.1.1.(1).)

2) Areas in *process plants*, where conditions must be addressed by design and operational details specific to the hazard, need not conform to this Part, where alternative protection is provided in conformance with Article 1.2.1.1. of Division A. (See Note A-4.1.1.1.(2).)

A-4.1.1.1.(2) Certain areas in refineries, chemical plants and distilleries will not meet all Code requirements because of extraordinary conditions. Design should be based on good engineering practice and on such factors as manual fire suppression equipment, daily inspections, automated transfer systems, location of processing units, and special containment systems, piping, controls and materials used. NFPA 30, "Flammable and Combustible Liquids Code," and NFPA 36, "Solvent Extraction Plants," are examples of good engineering practice and can be referred to by the designer and the authority having jurisdiction.

This Sentence directs the owner or designer to either meet the requirements of this Part or submit a proposal for an alternative solution to the authority having jurisdiction as required by Clause 1.2.1.1.(1)(b) of Division A.

4.1.7. Ventilation

4.1.7.1. Rooms or Enclosed Spaces

1) Where *flammable liquids* and *combustible liquids* are processed, handled, stored, dispensed or used within rooms or enclosed spaces, ventilation shall conform to the appropriate provincial or territorial regulations or municipal bylaws, or in the absence of such legislation, to this Part and the NBC(AE). (See Note A-4.1.7.1.(1).)

A-4.1.7.1.(1) Article 3.3.1.20. of Division B of the NBC(AE) specifies that ventilation must be provided in conformance with Part 6 of that Code if flammable vapour, gas, or dust could create a fire or explosion hazard. However, Part 6 of Division B of the NBC(AE) does not provide specific information on the design of ventilation systems to prevent an accumulation of dangerous concentrations of flammable vapours. It refers instead to "good engineering practice" and directs the user to a number of NFPA standards for examples of good practice, which varies according to the nature of the vapours or dusts. Subsection 4.1.7. of the NFC(AE) represents a minimum level of good practice for preventing the accumulation of explosive concentrations of vapours from flammable or combustible liquids.

A-4.1.7.2.(3) Natural ventilation is normally adequate for the storage of flammable liquids and combustible liquids, or the dispensing of Class II and IIIA liquids. Such ventilation should consist of permanent openings at ceiling and floor levels leading to the outside. At least 0.1 m^2 each of free inlet and outlet openings per 50 m^2 of floor area should be provided. A mechanical ventilation rate of at least 18 m^3/h per square metre of floor area, but not less than 250 m^3/h, is normally adequate for rooms with low floor to ceiling height or small enclosed spaces where Class I liquids are dispensed. Ventilation for process areas must be designed to suit the nature of the hazard in accordance with good engineering practice.

Engineering in Fire Code – cont. 2

4.1.8 Handling of Flammable and Combustible Liquids

4.1.8.3. Transfer

1) Class I liquids shall be drawn from or transferred into containers or *storage tanks* within a *building*
- a) through a piping or transfer system conforming to Section 4.5.,
- b) by means of a pump designed in conformance with good engineering practice on top of the container or *storage tank*, or
- c) by gravity through a self-closing valve designed in conformance with good engineering practice.

(See Note A-4.1.8.3.(1).)

A-4.1.8.3.(1) Products tested and listed by recognized agencies are considered to be designed in conformance with good engineering practice. Underwriters Laboratories Inc., ULC and FM Global are currently listing these products.

4.1.8.4. Fuel Tanks of Vehicles

1) It is permitted to use movable tanks for dispensing *flammable liquids* or *combustible liquids* into the fuel tanks of vehicles or other motorized equipment provided such movable tanks are used in conformance with the requirements of this Part for *storage tanks*. (See Note A-4.1.8.4.(1).)

2) Only enclosed pumping equipment designed in conformance with good engineering practice shall be used to transfer Class I liquids to or from the fuel tanks of vehicles inside *buildings*. (See Note A-4.1.8.3.(1).)

4.2 Container Storage and Handling

4.2.9. Rooms for Container Storage and Dispensing

4.2.9.4. Dispensing

1) Dispensing of *flammable liquids* or *combustible liquids* from containers having a capacity of more than 30 L shall be by pumps or through self-closing valves, designed in conformance with good engineering practice. (See Note A-4.1.8.3.(1).)

4.2.7. Industrial Occupancies

4.2.7.6. Fire Suppression Systems

1) Where protection is required by this Code, storage areas for *flammable liquids* and *combustible liquids* shall be
- a) *sprinklered* in conformance with NFPA 30, "Flammable and Combustible Liquids Code," or
- b) protected by an automatic fire suppression system.

(See Note A-4.2.7.6.(1).)

A-4.2.7.6.(1) Options for fixed fire suppression systems for protection of flammable or combustible liquid storage areas include: automatic sprinkler, foam sprinkler, water spray, carbon dioxide, dry chemical or halon systems. Examples of good engineering practice for the design of sprinkler or foam water systems for flammable and combustible liquid storage areas can be found in NFPA 30, "Flammable and Combustible Liquids Code."

Engineering in Fire Code – cont. 3

4.3 Tank Storage

4.3.1.2. Atmospheric Storage Tanks

3) When necessitated by possible contamination of the liquid to be stored or possible rapid corrosion of the tank, *storage tanks* need not conform to Sentence (1), provided that they are designed and built in conformance with good engineering practice for the material being used. (See Note A-4.3.1.2.(3).)

4.3.1.10. Reuse

1) A *storage tank* that has been taken out of service shall not be reused for the storage of *flammable liquids* or *combustible liquids* unless it has been

a) refurbished so as to conform to one of the standards listed in Sentence 4.3.1.2.(1), or

b) refurbished in conformance with Sentence (2) or (3).

2) A *storage tank* is permitted to be refurbished for aboveground use in conformance with good engineering practice such as that described in

a) API 653, "Tank Inspection, Repair, Alteration, and Reconstruction," and

b) STI SP031, "Repair of Shop Fabricated Aboveground Tanks for Storage of Flammable and Combustible Liquids."

3) A *storage tank* is permitted to be refurbished for underground use in conformance with good engineering practice such as that described in CAN/ULC-S669, "Internal Retrofit Systems for Underground Tanks for Flammable and Combustible Liquids." (See Note A-4.3.1.10.(3).)

4.3.2.5. Fire Protection Systems

(See Note A-4.3.2.5.)

1) Where the diameter of a *storage tank* exceeds 45 m, the *storage tank* shall be provided with protection against fires or explosions in conformance with Sentence (2).

2) Protection against fires or explosions required for a *storage tank* shall consist of fixed protection systems designed in conformance with good engineering practice such as that described in

a) NFPA 11, "Low-, Medium-, and High-Expansion Foam,"

b) NFPA 15, "Water Spray Fixed Systems for Fire Protection," and

c) NFPA 69, "Explosion Prevention Systems."

A-4.3.2.5. Guidelines for the protection of storage tanks can also be found in standards published by the NFPA and FM Global. Such guidelines are considered as good engineering practice in assessing the protection necessary for tanks.

4.3.13.11. Supports, Foundations and Anchorage

1) Except as provided in Sentence (2), where *storage tanks* for *flammable liquids* or *combustible liquids* are installed inside *buildings*, the supports, foundations and anchorage for such *storage tanks* shall be in conformance with Subsection 4.3.3.

2) Where a *storage tank* is suspended, rather than supported on a foundation, supports shall be designed and installed in conformance with good engineering practice. (See Note A-4.3.13.11.(2).)

4.3.13. Installation of Storage Tanks inside Buildings

4.3.13.10. Vents

1) Except as provided in Sentence (2), normal and emergency vents for *storage tanks* in *buildings* shall be provided in conformance with Subsections 4.3.4. and 4.3.5. (See Note A-4.3.13.10.(1).)

2) The use of weak roof-to-side shell seams, designed to rupture before the allowable design stress of the *storage tank* is reached, shall not be permitted as a means of emergency venting of *storage tanks* inside *buildings*.

A-4.3.13.10.(1) For the design of normal and emergency venting of indoor storage tanks, Sentence 4.3.13.10.(1) refers to Subsection 4.3.4., which in turn refers to API 2000, "Venting Atmospheric and Low-Pressure Storage Tanks." However, API 2000 is intended for outdoor tanks rather than indoor tanks. The venting rate reduction factors for water spray on the tank surface, or drainage rates for spilled liquids, should not be used to calculate the emergency venting rate of a storage tank installed inside a building. The effects of water spray cooling, and room drainage on the calculated emergency venting rate must be worked out according to good engineering practice. Increased emergency venting capacity may be required.

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Section 4.4. Leak Detection of Storage Tanks and Piping Systems

4.4.2. Leak Detection Testing and Monitoring Methods

4.4.2.1. Definition and Performance of Leak Detection Testing and Monitoring Methods

3) A leak detection method that monitors vapours in the soil or liquids on the groundwater shall conform to good engineering practice and meet the requirements of vapour monitoring or groundwater monitoring systems. (See Note A-4.4.2.1.(3).)

6) A continuous in-tank leak detection system shall conform to good engineering practice and meet the requirements of a precision leak detection test. (See Note A-4.4.2.1.(6).)

Section 4.5. Piping and Transfer Systems

4.5.10. Operating Procedures for Piping Systems

4.5.10.7. Maintenance

1) Except as provided in Sentence (6), maintenance shall not be carried out on piping systems while they are under pressure.

2) If connections or piping are to be opened, the system shall be drained of *flammable liquids* and *combustible liquids*.

3) Where equipment for handling *flammable liquids* or *combustible liquids* has to be repaired, it shall be removed and taken to maintenance areas when possible.

4) Tags shall be attached to all valves on piping systems that are shut off for maintenance purposes to indicate that such valves are not to be opened.

5) Piping that has been used for the transfer of *flammable liquids* or *combustible liquids* shall be removed or capped when it is no longer intended to be used.

6) The maintenance of pressurized piping systems shall be carried out in conformance with good engineering practice. (See Note A-4.5.10.7.(6).)

A-4.5.10.7.(6) The following documents contain examples of good engineering practice as regards the maintenance of pressurized piping systems:

- API 1104, "Welding of Pipelines and Related Facilities,"
- API RP 2200, "Repairing Crude Oil, Liquefied Petroleum Gas, and Product Pipelines," and
- API RP 2201, "Safe Hot Tapping Practices in the Petroleum and Petrochemical Industries."

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Section 4.6. Fuel-Dispensing Stations

4.6.6. Remote Pumping Systems

4.6.6.5. Marine Fuel-Dispensing Stations

6) Piping between *storage tanks* located on shore and dispensers at a *marine fuel-dispensing station* shall conform to Section 4.5., except that where dispensing is from a floating structure, it is permitted to use suitable lengths of flexible hose designed in conformance with good engineering practice between the piping on shore and the piping on the floating structure. (See Note A-4.8.8.1.(1)(a).)

Section 4.8 Piers and Wharves

4.8.4. Piping, Valves and Fittings

4.8.4.4. Flexible Connections

1) Piping between the shore and piers or wharves shall be provided with swing joints or flexible connections designed in conformance with good engineering practice to permit the independent movement of the pier or wharf and shore piping without strain on the pipe.

4.8.8. Cargo Hose

4.8.8.1. Cargo Hose

1) The transfer of *flammable liquids* or *combustible liquids* between tanks of marine vessels and piers or wharves shall be through
a) flexible cargo hose designed in conformance with good engineering practice (see Note A-4.8.8.1.(1)(a)), or
b) jointed tubing or piping
  i) suitable for the cargo to be transferred, and
  ii) designed to withstand the maximum design working pressure.

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- Section 4.7 Bulk Plants

4.7.4.5. Bonding and Grounding
(See Note A-4.7.4.5.)

A-4.7.4.5. API RP 2003, "Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents," is an example of good engineering practice for the activities described in Article 4.7.4.5.

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Section 4.9 Process Plants

4.9.4. Fire Prevention and Protection

4.9.4.3. Fire Protection

1) The risks of fire and explosion at *process plants* shall be evaluated based on
a) material properties,
b) material quantities,
c) operating conditions,
d) arrangement of stored materials,
e) transportation of materials,
f) process design, and
g) operating and maintenance procedures.

2) Based on the evaluation required in Sentence (1), measures to minimize the occurrence of fires and explosions and to mitigate their effects shall be identified.

3) Where the process warrants protection, *process plants* shall be supplied with
a) water supplies of adequate pressure and quantity to meet the probable fire demands,
b) hydrants,
c) hoses connected to a permanent water supply and located so that all equipment containing *flammable liquids* or *combustible liquids*, including pumps, can be reached with at least one hose stream, and
d) fire protection systems conforming to Part 2.

Section 4.10 Distilleries

4.10.3. Storage Tanks and Containers

4.10.3.3. Storage Tank Vents

1) Normal and emergency vents shall be provided on *storage tanks* in conformance with good engineering practice. (See Note A-4.10.3.3.(1).)

A-4.10.3.3.(1) The use of "good engineering practice" in the design of normal and emergency venting is intended to prevent an accumulation of flammable vapours inside the building that may present an explosion hazard. For new tank installations, this can be achieved by directing breather vents and emergency vents, equipped with flame arrestors or pressure/vacuum valves, to the outside of the building. However, on existing tank installations, installation of such vents may be impractical. Venting into the interior space may not constitute an undue hazard where certain measures are taken to ensure an adequate degree of fire safety. Such measures include, but are not limited to:

- the installation of automatic sprinklers throughout the tank room and under any raised tanks greater than 1.2 m in diameter;
- the classification of electrical equipment and wiring according to the zone classifications of CSA C22.1, "Canadian Electrical Code, Part I";
- the provision of adequate natural or mechanical ventilation meeting the objectives of Article 4.10.6.1.; and
- the training of personnel in safe operating procedures.

A-4.10.5.1.(1) Piping and pumping systems should be designed to recognized engineering standards and accepted industry practice.

Section 5.2

Section 5.2. Hot Works

5.2.3. Prevention of Fires

5.2.3.4. Work on Containers, Equipment or Piping

1) *Hot work* shall not be performed on containers, equipment, or piping containing *flammable liquids*, *combustible liquids* or *dangerous goods* classified as flammable gases unless

a) they have been cleaned and tested with a gas detector to ascertain that they are free of explosive vapours, or

b) safety measures are taken in conformance with good engineering practice (see Note A-5.2.3.4.(1)(b)).

A-5.2.3.4.(1)(b) The following documents are examples of good engineering practice as regards safety measures for the activities described in Clause 5.2.3.4.(1)(b):

- API RP 2009, "Safe Welding, Cutting and Hot Work Practices in the Petroleum and Petrochemical Industries,"
- API 2015, "Safe Entry and Cleaning of Petroleum Storage Tanks, Planning and Managing Tank Entry From Decommissioning Through Recommissioning,"
- API RP 2201, "Safe Hot Tapping Practices in the Petroleum and Petrochemical Industries," and
- API RP 2207, "Preparing Tank Bottoms for Hot Work."

Section 5.5 Laboratories

5.5.5. Dangerous Goods

5.5.5.3. Compressed Gases

5) Except as provided in Sentence (7), where cylinders of *dangerous goods* classified as toxic gases are used in a laboratory,

a) they shall be located in a continuously mechanically ventilated gas storage cabinet,

b) all exhaust shall be directed to a treatment system designed to process the accidental release of gas (see Note A-5.5.5.3.(5)(b) and (7)(b)), and

A-5.5.5.3.(5)(b) and (7)(b) NFPA 55, "Compressed Gases and Cryogenic Fluids Code," is an example of good engineering practice for the design of a treatment system referred to in Clauses 5.5.5.3.(5)(b) and (7)(b).

Section 5.3. Dust-Producing Processes

5.3.1.3. Dust-Collecting Systems

1) Dust-collecting systems shall be provided to prevent the accumulation of dust and keep suspended dusts at a safe concentration inside a *building*.

2) A dust-collecting system required in Sentence (1) shall
a) be designed in conformance with good engineering practice,
b) be made of noncombustible materials, and
c) not create sparks upon physical contact in the fan assembly.
(See Note A-5.3.1.3.(2).)

5.3.1.6. Explosion Venting

1) Except as provided in Article 5.3.1.7., an activity that creates an atmosphere containing significant concentrations of *combustible dusts* shall be located only in a *building* provided with explosion venting to the outdoors.

2) When explosion venting is required in this Section, it shall be designed to prevent critical structural and mechanical damage to the *building* in conformance with good engineering practice such as that described in NFPA 68, "Explosion Protection by Deflagration Venting." (See Note A-3.2.8.2.(1)(d).)

5.3.1.7. Explosion Prevention Systems

1) In processes where an explosion hazard is present and conditions exist that prevent adequate explosion venting as required in this Section, an explosion prevention system shall be provided.

2) When an explosion prevention system is required in this Section, it shall be designed in conformance with good engineering practice such as that described in NFPA 69, "Explosion Prevention Systems."

Section 6.1. General

6.1.1. General

6.1.1.1. Application

1) This Part includes requirements for the inspection, testing, maintenance, and operation of portable extinguishers, water-based fire protection systems, special extinguishing systems, fire alarm systems, emergency electrical power supply systems, emergency lighting, and *exit* signs.

6.1.1.2. Maintenance

1) Fire protection installations shall be maintained in operating condition. (See Note A-6.1.1.2.(1).)

A-6.1.1.2.(1) Both the NBC(AE) and the NFC(AE) assume that all fire protection systems in a building, whether required by Code or voluntarily installed, will be designed in conformance with good fire protection engineering practice and will meet the appropriate installation requirements in relevant standards. Such good design is necessary to ensure that the level of safety established by the Code requirements is not reduced by a voluntary installation. Thus, a voluntarily installed system should be maintained in operating condition, at least to the extent that it was originally intended to function, in conformance with the applicable installation standards.

Section 2.3. Alternative Solutions

2.3.1. Documentation of Alternative Solutions

(See Note A-2.3.1.)

2.3.1.1. Documentation

3) The Code analysis referred to in Clause (2)(a) shall identify the applicable objectives, functional statements and acceptable solutions, and any assumptions, limiting or restricting factors, testing procedures, engineering studies or performance parameters that will support a Code compliance assessment.

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