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Facility Siting - Is Your Facility Compliant?

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Introduction to Speaker
Neil Prophet – Senior Vice President and Partner

- B.Eng. (Honors), Chemical Engineering, University of Strathclyde
- More than 20 years' experience in the field of process safety including consulting, project management, technical support, technical sales, training course development and presentation and operations management, along with authoring many industry publications as well as presenting at various industry related organizations
- Technical Expertise includes:
  - Process Safety and Risk Management
  - Hazard Identification (FMEA, HAZOP, What-if, Checklist, SVA)
  - Auditing
  - Pressure Relief and Flare System design
  - Consequence Analysis, Quantitative Risk Analysis, Facility Siting
  - LNG
  - Litigation Support
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Agenda

- Review of Facility Siting Problems
- OSHA Requirements
- RAGAGEP’s for Facility Siting
- How to Conduct a Facility Siting Analysis
- Recommendations
- Questions

BP Texas City, TX 2005

- Explosions and fires killed 15 people, injured another 180
- Financial losses exceeded $1.5 billion
- All of the fatalities occurred in or near office trailers
- October 25, 2005, the CSB issued two urgent safety recommendations
  - API to develop new guidelines for safe siting of occupied trailers and similar temporary structures
  - API and NPRA to issue a safety alert urging members to take prompt action to ensure trailers are safely located

LPG Facility, Mexico City 1984

- 8” LPG pipeline ruptured – flame left burning near the broken pipe
- Flame heated an LPG sphere which BLEVEd
- A total of 4 spheres and 15 cylindrical tanks BLEVEd
- Officially 542 people were killed, 4,248 injured, and about 10,000 made homeless – unofficial estimates are higher
- Most killed and injured were public living in a nearby shanty town
- When built, nearest houses were 360 m away, but later encroached to only 130 m from the plant

Concept Sciences, PA 1999

- A process vessel containing several hundred pounds of hydroxylamine (HA) exploded
- 4 CSI employees and a manager of an adjacent business were killed
- 4 people in nearby buildings were injured
- Facility siting should consider all potential hazards (e.g., fire, explosion, toxic material release) to people, property, and the environment
- Siting evaluations should be an integral part of process design

Sierra Chemical Co., NV 1998

- 2 explosions in rapid succession destroyed the Sierra Chemical Company's Kean Canyon plant near Mustang, Nevada
- 4 workers killed, 6 injured
- Facility had insufficient separation distances between different operations
- Design and construction of buildings was inadequate
- PHA for Booster Room 1 didn't consider safe siting of buildings
- No PHA done for Booster Room 2 because of similarities to BR 1

First Chemical Corp., MS 2002

- Rupture of distillation column used to refine mononitrotoluene (MNT) caused an explosion and fire
- Flying glass injured 3 FCC employees who sought shelter in the unit control room
- Control room was constructed of masonry block, with sheet metal on the roof and sides
- Control room was located approximately 50’ from the distillation column
- Control rooms should be able to withstand the overpressure expected from an incident in order to protect those people sheltering inside
- Control rooms are assumed to be occupied during an emergency so they must be reviewed as part of a facility siting assessment

Formosa Plastics Corp., TX 2005

- Trailer being towed by a forklift snagged and pulled a small drain valve out in a liquid propylene system
- Propylene rapidly vaporized, forming a large flammable vapor cloud
- 16 employees were injured, one seriously
- Fire burned for 5 days, site-wide evacuation, extensive property damage
- Considered vehicle impact damage in facility siting and PSSR, but in a generic manner
- PHA team assigned low risk to potential vehicle impact due to low estimated frequency
- PSSR verified impact protection for emergency equipment, but didn’t look at process piping and equipment

Recent OSHA Citations

- The employer didn’t perform a PHA which addresses facility siting
- Assembly areas in the employer’s emergency response plan were not located at a safe distance
- PHA didn’t consider building ventilation systems to ensure there is no air intake during a release of toxic or flammable gases or vapors
- Over 50% of OSHA Refinery NEP citations for PHAs have been related to facility siting or human factors

OSHA PSM Requirements

- 1910.119(e)(3)(v) – The process hazard analysis shall address facility siting
- 1910.119(l)(1) – The employer shall establish and implement written procedures to manage changes (except for “replacements in kind”) to process chemicals, technology, equipment and procedures; and, changes to facilities that affect a covered process
- Requirements default to RAGAGEP’s regarding facility siting
  - API 752
  - API 753
  - CCPS reference books
  - NFPA Codes, FM Data Sheets, and other OSHA regulations
- OSHA Refinery NEP guidance
- Can’t use the occupancy criteria in API 752 as the basis for an employer’s determination that adequate protection has been provided

API 753 Applicability

- “Developed for refineries, petrochemical and chemical operations, natural gas liquids extraction plants, and other facilities such as those covered by the OSHA Process Safety Management Standard, 29 CFR 1910.119.”
- All portable buildings intended for occupancy must be evaluated regardless of the occupancy levels or the company’s occupancy criteria
- Portable buildings not intended for occupancy do not need to be examined for fire, toxic or explosion release hazards
  - Controls should be implemented to ensure that the use of these portable buildings does not change

API 753 Requirements

- 3 zone method used for locating portable buildings
- Zones are based on the size of the congested process area and the distance from the edge of this congested area
- Congested volumes, regardless of the material handled, should be considered as potential explosion sites due to material drifting from adjacent facilities
- Operating status of a process unit does not exempt it from assessment
- Light wood trailers intended for occupancy should not be in Zone 1. Other portable buildings require a detailed analysis before being placed in Zone 1
- All portable buildings in Zone 2 require a detailed analysis
- Any portable building may be located in Zone 3 without a detailed analysis

API 753 Zones

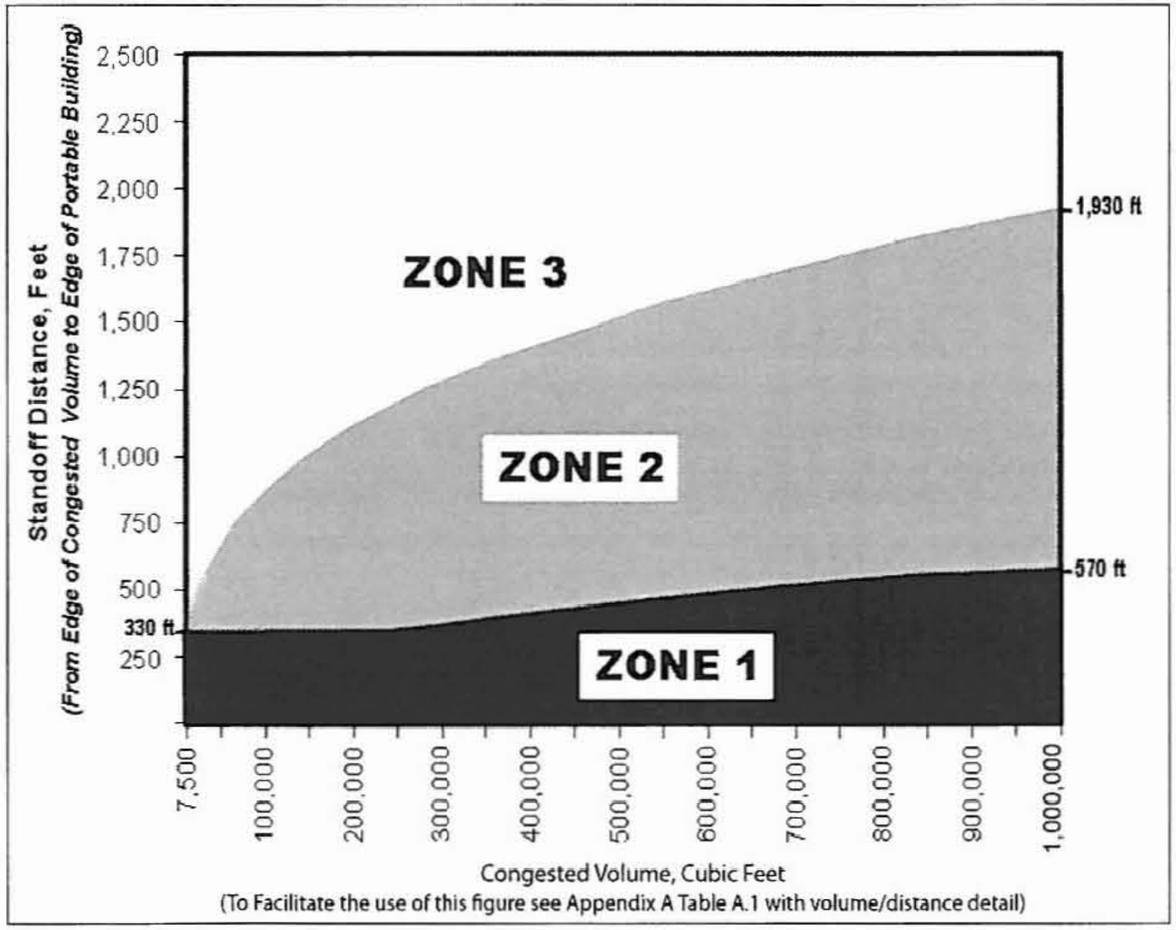


Figure 1—Portable Buildings Location Guidance

Source: API 753

API 752 Applicability

- “Applies to refineries, petrochemical and chemical operations, natural gas liquids extraction plants, and other facilities covered by OSHA Process Management Standard, 29 CFR 1910.119.”
- “This publication is intended to assist in identifying the siting issues for process plant buildings, understanding the associated hazards, and managing the risk. Hence, this publication provides a framework that can be used to address facility siting within the PHA requirements of OSHA 29 CFR 1910.119 as applies to buildings.”
- Applies to permanent buildings only. API 753 superseded this for portable buildings

API 752 Requirements

- Covers risks from explosions, fires and toxic releases
- Companies need to determine the following information prior to applying the analysis techniques outlined in API 752
  - Occupancy criteria and emergency roles of personnel
  - Evaluation-case events
  - Consequence modeling/analysis programs
  - Risk acceptance criteria
- API 752 allows the use of a variety of occupancy criteria to reduce the level of evaluation for some buildings
- **OSHA will not accept occupancy criteria from API 752 as an alternative to performing a detailed risk assessment for occupied buildings**
- Evaluation options include: Design or compare to industry standards; Consequence analysis; Screening risk analysis

Consequence Analysis

- The facility siting study should identify scenarios that lead to loss of containment, which could result in:
  - Vapor cloud explosion
  - Fireball
  - Boiling Liquid Expanding Vapor Explosion (BLEVE)
  - Flame jet
  - Pool fire
  - Toxicity impact
  - Dust Explosion
- Evaluation-case events of concern may be identified through the PHA process
- Passive and active mitigation systems should be considered when determining the extent of the event

Consequence Analysis for Explosions

- Multiple methods available for calculating overpressure
- For Permanent Buildings:
  - If the calculated overpressure exceeds the design for the building, further analysis is required
  - If the building can withstand the overpressure, then only a simple checklist is needed
- For Portable Buildings:
  - The suitability of a particular portable building and the appropriate standoff distance shall be determined based on the blast response of the structure
  - Don’t use the guidance and tables in API 752
- Assume the occupants could incur injuries if the integrity of the building is exceeded

Consequence Analysis for Explosions

- Vapor Cloud Explosions can be influenced by the released fluid properties, released amount, and surrounding geometry
  - Influences:
    - Fuel sensitivity
    - Fuel flammability limits
    - Fuel quantity within flammable limits
    - Ignition source strength
    - Degree of confinement / congestion

Source: ioMosaic Stock Image

Consequence Analysis for Explosions

- Response of Different Building Types to Overpressure

Building Type	Peak Side-on Overpressure (psi)	Consequences
Wood-frame trailer	1.0	Roof & walls collapse
	5.0	Total Destruction
Steel-frame/metal siding pre-engineered building	2.5	Frame stands, walls destroyed, frame distorts
	5.0	Total Destruction
Unreinforced masonry bearing walls	1.5	Complete collapse
	3.0	Total Destruction
Steel or concrete frame w/ unreinforced masonry infill or cladding	2.0	Roof slab collapses
	2.5	Total destruction
Reinforced concrete or masonry shear wall building	6.0	Building has major damage and collapses
	12.0	Total Destruction

Consequence Analysis for Explosions

- Biological and Structural Damage Criteria from Explosion

Overpressure (psi)*	Biological Damage	Structural Damage
70	99% Fatality	Total structural damage
50	50% Fatality	Total structural damage
35	1% Fatality	Total structural damage
15	Lung damage	Sever structural damage
7-8		Shearing and flexure failure of brick wall panel 8 to 12 inches thick (not reinforced)
5	Eardrum rupture	Shattering of concrete wall panels, 8 to 12 inches thick (not reinforced)
2-4		Non-reinforced cinderblock walls shattered; 50% destruction of brick buildings; steel frame building distorted; light industrial buildings ruptured
1-2		Failure of wood siding panels. Shattering of asbestos siding and corrugated steel and aluminum panel failure
0.5-1		Shattering of glass windows

Consequence Analysis for Explosions

- Mitigation options include:
  - Relocation of personnel
  - Siting the building sufficiently remote from the hazard
  - Elimination of windows
  - Use strengthened windows or shatterproof glass
  - Strengthen doorways
  - Structural reinforcement
  - Install external walls for additional protection
  - Secure internal furniture, office equipment and fixtures
  - Floor and hub drains designed to prevent backflow of explosive vapors

Consequence Analysis for Fires

- Use standard industry references:
  - NFPA Codes
  - CCPS Guidelines for Facility Siting and Layout
  - API 521
- Risks are to personnel who are expected to be outside in the vicinity of a fire

Consequence Analysis for Fires

- Damage Criteria from Fires

Radiation Intensity (kW/m2)	Observed Effect
37.5	Sufficient to cause damage to process equipment
25	Minimum energy to ignite wood at sufficiently long exposures (non-piloted)
12.5	Minimum energy required for piloted ignition of wood, melting of plastic tubing
9.5	Pain threshold reached after 8 seconds, second degree burns after 20 seconds
4	Sufficient to cause pain if unable to reach cover within 20 seconds, however blistering of the skin is likely, zero lethality
1.6	Will cause no discomfort for long exposure

Consequence Analysis for Fires

- Mitigation and emergency response should consider the following:
  - Physical separation through barriers or distance
  - Fire rating of the building
  - Isolation valves and spill containment
  - Position of exits and possible escape routes
  - Fire protection systems
  - Emergency procedures and training for evacuation
  - PPE for personnel to use during evacuation
  - Locate mustering areas away from fire hazards

Consequence Analysis for Toxic Releases

- Evaluate portable and permanent buildings where a toxic release can reach hazardous levels
- If buildings are designed to detect and prevent the influx of toxic materials into the building, then risks are only to personnel expected to be outside at the time of a toxic release
- Mitigation and emergency response should consider the following:
  - Means to remotely shut down the process
  - Shelter-in-place designation
  - Ventilation system that can shut off fresh air make-up and is equipped with toxic gas detection alarms
  - Elevated air intake stack
  - Pressurized ventilation system
  - Seals for windows, doors, and duct penetrations
  - Reduce the number of people normally in the building
  - Emergency communications equipment
  - Evacuation plan with appropriate PPE for all occupants

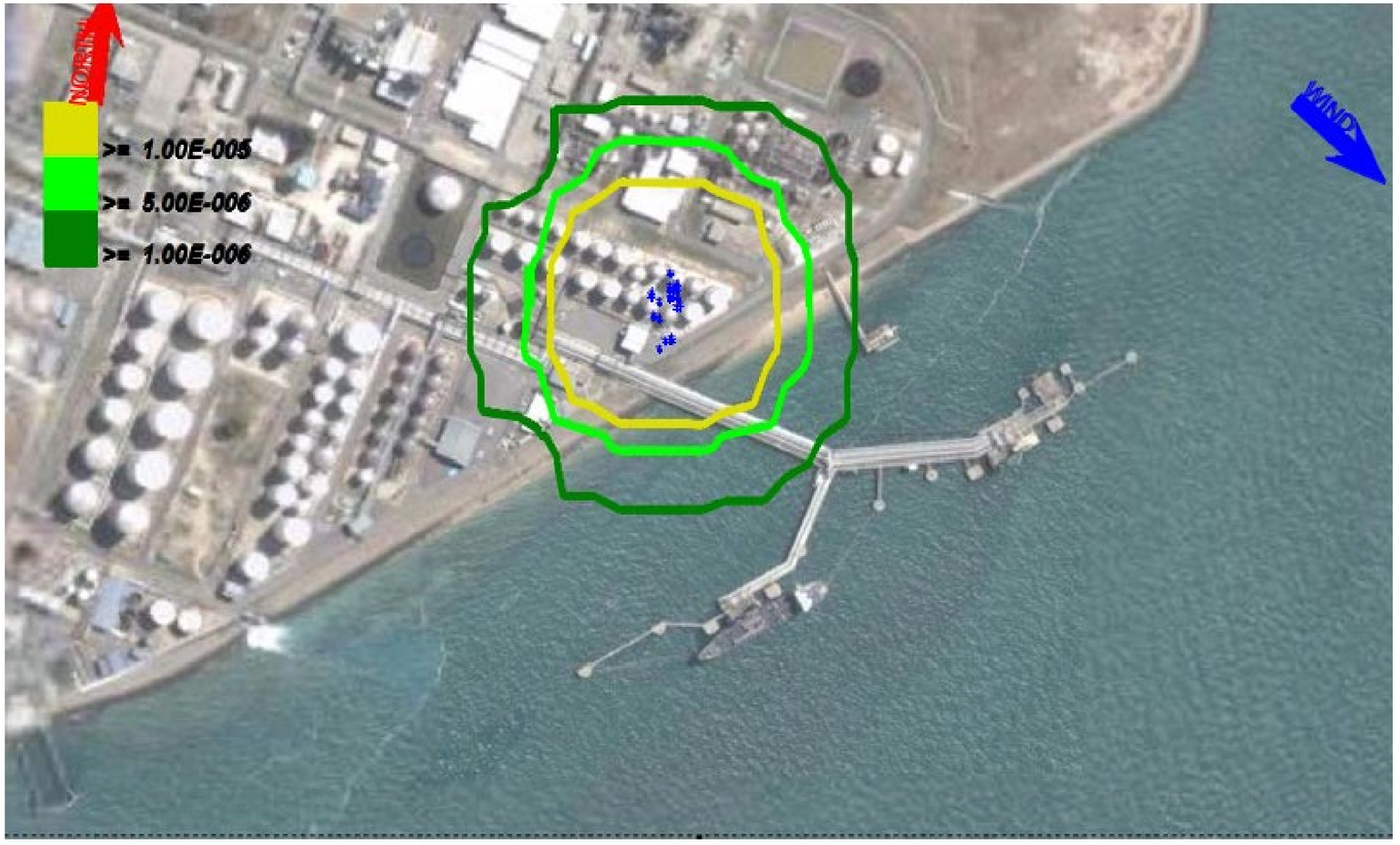
Quantitative Risk Analysis

- Used to determine approximate aggregated and individual risk to occupants of a process plant building or other plant personnel
- Combines estimates of event frequencies with explosion consequences to determine risk to a process plant building occupant
- Methodology
  - Identify plant buildings, construction type and population
  - Determine consequence of event
  - Determine frequency of event
  - Determine vulnerability of occupants
  - Calculate risk to an individual
  - Calculate the aggregate risk to building occupants
  - Compare calculated risk with company's risk acceptance criteria
  - For portable buildings, assume it is occupied at least 40 hrs/wk by 1 person

Quantitative Risk Analysis

- Gives far greater understanding of level of risk, and main contributors
- Allows for significant segmentation of risk
  - Overall risk contours
  - Overpressure risk contours
  - Thermal radiation risk contours
  - Toxic impact risk contours
  - Risk ranking of evaluation-cases
  - Risk ranking of impacted buildings
- Risk can be reduced by:
  - Reducing event frequency
  - Moving non-essential personnel away from the hazard
  - Improving structure to resist the hazard

Overall Risk Contours



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5 psi Risk Contours

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3 psi Risk Contours

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1 psi Risk Contours

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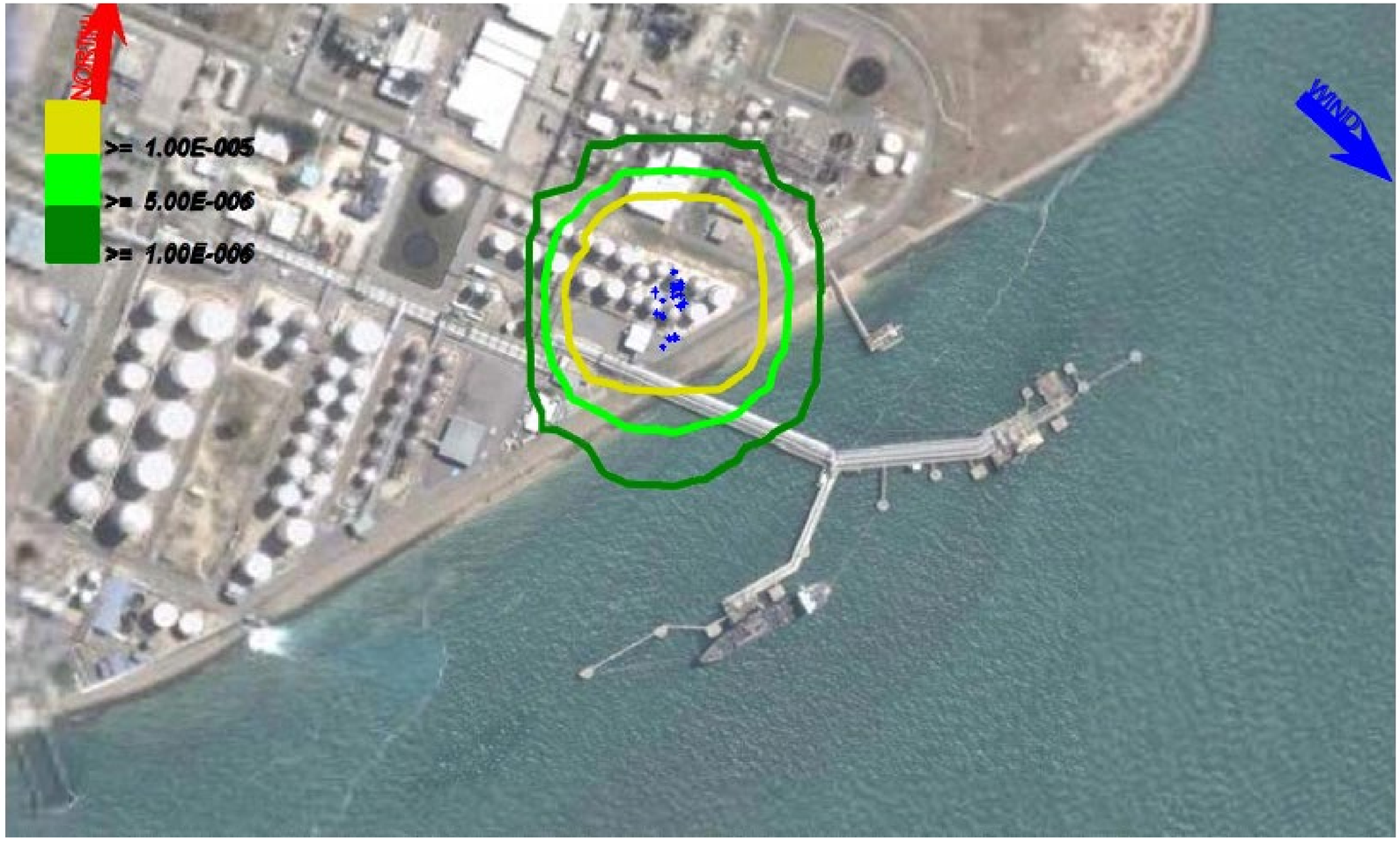
Thermal Risk Contours



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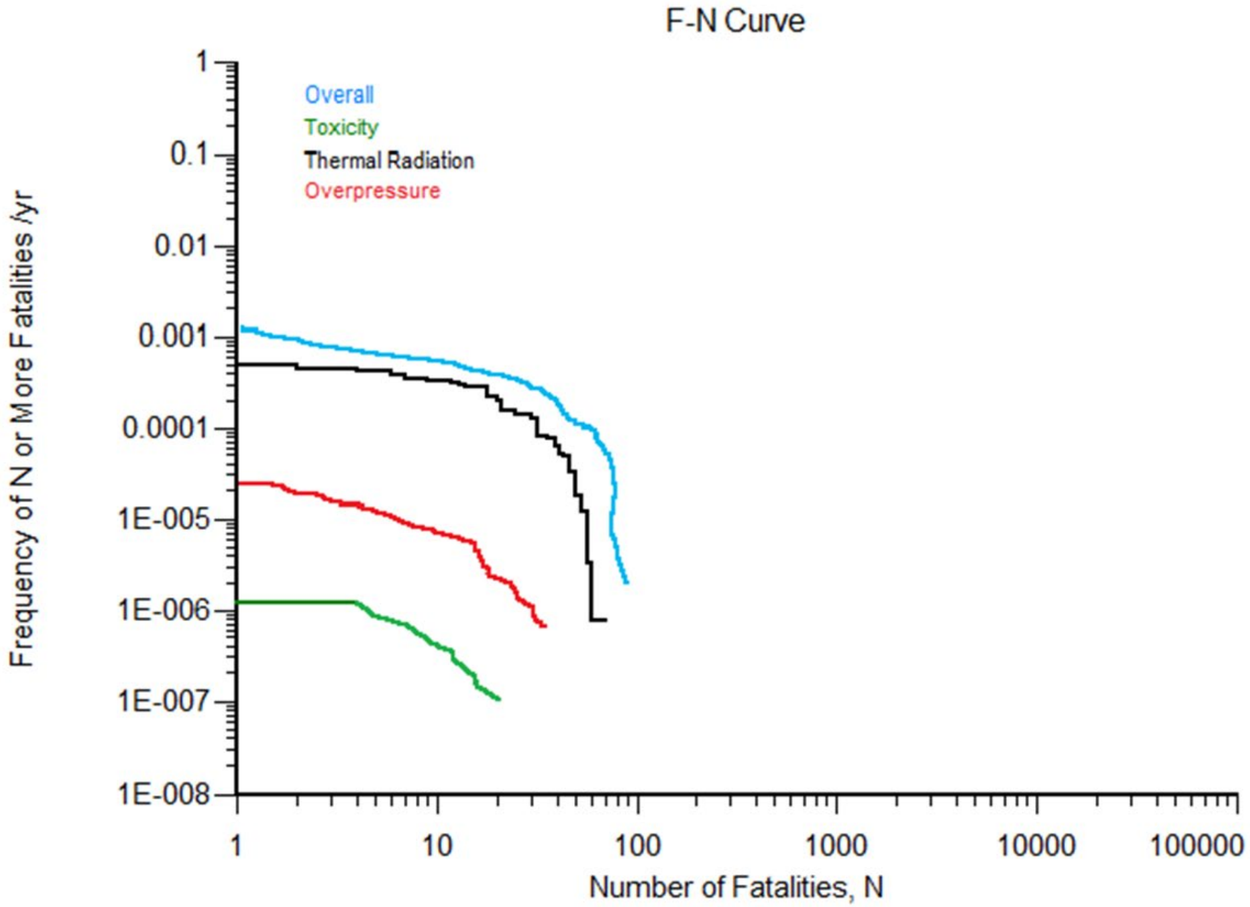
FN Curves



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Recommendations

PHA – Facility Siting

- Identify potential events which could expose personnel to fire, explosion or toxic chemical hazards
- Ensure that buildings in or near the process area have been evaluated for the effects of the identified potential adverse events
- For all permanent buildings subject to risk, OSHA requires a RAGAGEP approach
- API 753 requires a detailed analysis for all occupied portable buildings in Zones 1 or 2
- If a checklist is used, ensure each individual situation/condition pertinent to a global question is addressed individually

MOC – Facility Siting

- Ensure MOC procedure is applied to facility changes
- Use MOC process prior to siting any portable buildings
- Use MOC process whenever building occupancy changes
- If process change adds a new potential hazard to building occupants, ensure that the facility siting analysis is reviewed for changes to the aggregate risk level to building occupants
- Use MOC process if changes are made to the ventilation system of occupied buildings potentially exposed to fire or toxic hazards

Questions | Comments

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About ioMosaic Corporation

Through innovation and dedication to continual improvement, ioMosaic has become a leading provider of integrated process safety and risk management solutions. ioMosaic has expertise in a wide variety of areas, including pressure relief systems design, process safety management, expert litigation support, laboratory services, training, and software development.

ioMosaic offers integrated process safety and risk management services to help you manage and reduce episodic risk. Because when safety, efficiency, and compliance are improved, you can sleep better at night. Our extensive expertise allows us the flexibility, resources, and capabilities to determine what you need to reduce and manage episodic risk, maintain compliance, and prevent injuries and catastrophic incidents.

Our mission is to help you protect your people, plant, stakeholder value, and our planet.

For more information on ioMosaic, please visit: **www.ioMosaic.com**