

17th INTERNATIONAL CONFERENCE & EXHIBITION ON LIQUEFIED NATURAL GAS (LNG 17)



RISK-BASED LNG FACILITY SITING AND SAFETY ANALYSIS IN THE U.S.: RECENT DEVELOPMENTS

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International Organizers



Host Association



“The issue [of understanding risk] boils down to one’s view about the extent to which the past determines the future.”

From: “Against the Gods: The Remarkable Story of Risk,” Peter L. Bernstein, 1988.

About the Paper

From the *Preface*:

- Basic Understanding for Quantitative Risk Assessment (QRA) Concepts and Terminology is Assumed
- Focus is on QRA for LNG Facilities as it Might Apply in the United States (US)
- European Norm EN 1473, “Installation and Equipment of Liquefied Natural Gas – Design of Onshore Installations,” Provides the Broadest Framework for QRA Methods
- Implementation Approaches Within the European Domestic Regulatory Structures
- Control of Major Accident Hazards (COMAH) in the United Kingdom (UK) and Consultation Support from the Health and Safety Executive (HSE) Provides a Wealth of Experience and Evaluation.

Organization of Presentation

- Discussion of Basic Quantitative Risk Assessment (QRA) Concepts
- Risks Addressed and Potentially Addressed for On-Shore LNG Facilities
- Overview of US LNG Facility Regulation and Application of QRA
- Intended Improvements in LNG Facility Siting Decision Making
- Direct Challenges for Implementation of New US QRA Methods
- Equivalence Issues
- Authorities Having Jurisdiction (AHJ) and Stakeholder Issues
- Criteria and Competence Issues
- Prospects for the Near Term.

Basic QRA Concepts (in an LNG Context)

“Risk” = Frequency of Incidents x Severity of Incidents

where:

- “Incidents” Related to LNG Releases and Behaviors of Releases
- “Frequency” Related to Incidents per Unit Time (Incidents per Year)
- “Severity” Related to Consequences of LNG Releases (On Site / **Off Site**).

Relevant Incidents

- What are “Credible” LNG Releases?
- How are “Worst Case” Incidents Treated?

Design Spill Source	Design Spill Criteria	Design Spill Rate and Volume
<i>Containers with Penetrations Below the Liquid Level</i>		
Containers with penetrations below the liquid level without internal shutoff valves	A spill through an assumed opening at, and equal in area to, that penetration below the liquid level resulting in the largest flow from an initially full container If more than one container in the impounding area, use the container with the largest flow	Use the following formula: $q = \frac{4}{3}d^2\sqrt{h}$ until the differential head acting on the opening is 0. For SI units, use the following formula: $q = \frac{1.06}{10,000}d^2\sqrt{h}$ until the differential head acting on the opening is 0.
Containers with penetrations below the liquid level with internal shutoff valves in accordance with 9.4.2.5	The flow through an assumed opening at, and equal in area to, that penetration below the liquid level that could result in the largest flow from an initially full container	Use the following formula: $q = \frac{4}{3}d^2\sqrt{h}$ For SI units, use the following formula: $q = \frac{1.06}{10,000}d^2\sqrt{h}$ for 10 minutes.
<i>Containers with Over-the-Top Fill, with No Penetrations Below the Liquid Level</i>		
Full or double containment containers with concrete secondary containers	No design spill	None
<i>LNG Process Facilities</i>		
Containers with over-the-top fill, with no penetrations below the liquid level	The largest flow from any single line that could be pumped into the impounding area with the container withdrawal pump(s) considered to be delivering the full-rated capacity	The largest flow from any single line that could be pumped into the impounding area with the container withdrawal pump(s) delivering the full rated capacity as follows: (1) For 10 minutes if surveillance and shutdown is demonstrated and approved by the authority having jurisdiction (2) For the time needed to empty a full container where surveillance and shutdown is not approved
Impounding areas serving only vaporization, process, or LNG transfer areas	The flow from any single accidental leakage source	For 10 minutes or for a shorter time based on demonstrable surveillance and shutdown provisions acceptable to the authority having jurisdiction

Note: q = flow rate [ft³/min (m³/min)] of liquid; d = diameter [in. (mm)] of tank penetration below the liquid level; h = height [ft (m)] of liquid above penetration in the container when the container is full.

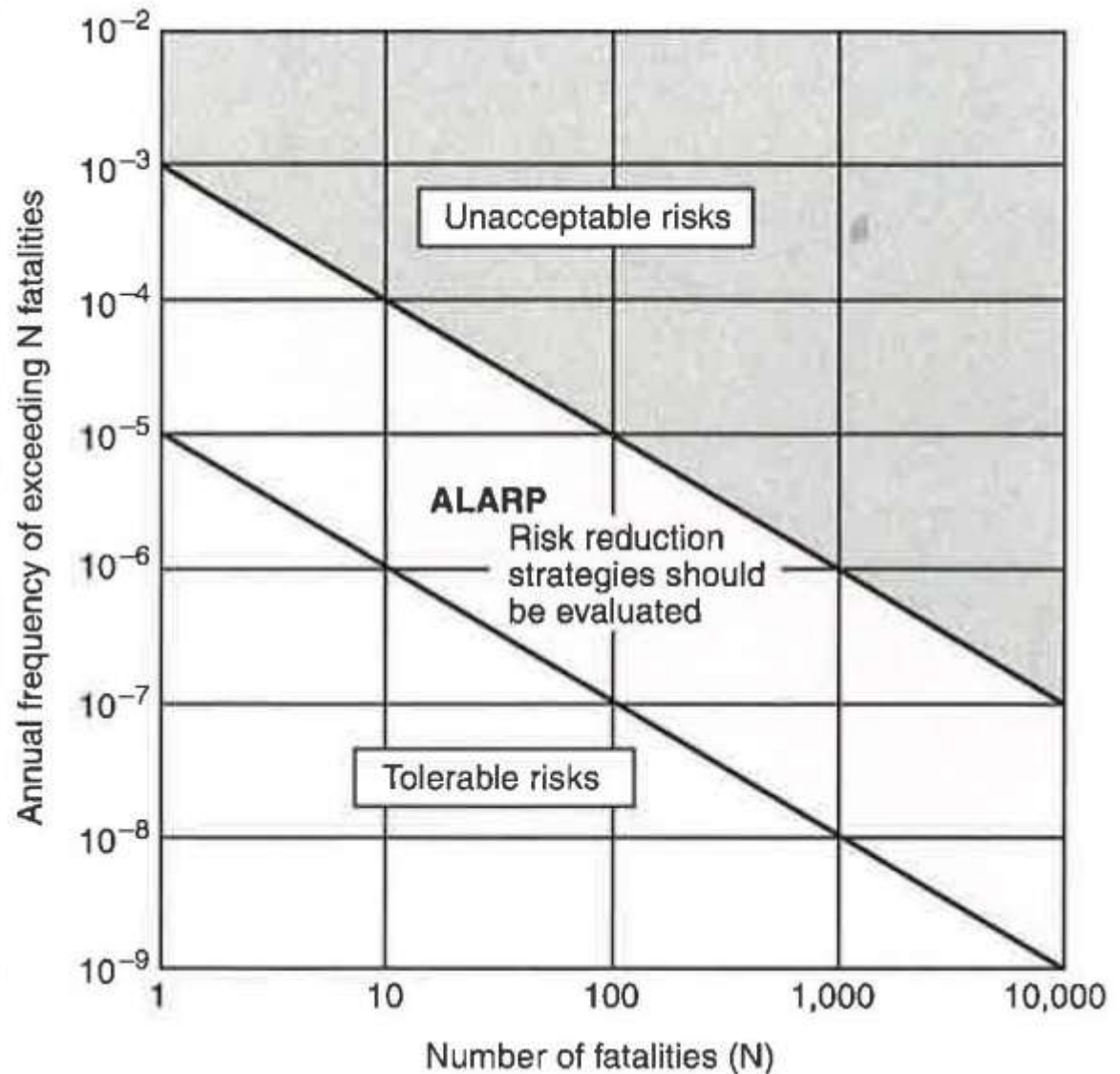
Incident Frequencies

Component	Annual Probability of Failure
Atmospheric Cryogenic Tanks	
(1) Instantaneous failure of primary container and outer shell, release of entire contents (single containment tank)	5E-07
(2) Instantaneous failure of primary container and outer shell, release of entire contents (double containment tank)	1.25E-08
(3) Instantaneous failure of primary and secondary container, release of entire contents (full containment tank)	1E-08
Pressurized Storage	
(Containers) — instantaneous release of entire contents	5E-07
Piping — aboveground	
(1) Rupture for nominal diameter <75 mm	1E-06
(2) Rupture for 75 mm < nominal diameter < 150 mm	3E-07
(3) Rupture for nominal diameter > 150 mm	1E-07
Pressure relief valves — outflow at the maximum rate	2E-05
Process equipment	
(1) Pumps — catastrophic failure	1E-04
(2) Compressors with gasket — catastrophic failure	1E-04
(3) Heat exchanger — instantaneous release of entire contents from plate heat exchanger	5E-05
Transfer equipment — rupture of loading/unloading arm	3E-08

- Incident Experience that is Applicable?
- Frequencies that are Traceable to Experience?

Severity: Probability-Weighted Consequences

- Individual and/or Societal Risks?
- Injuries, Deaths, and/or Property Damage?
- Probabilities of Exposures
- Criteria for Acceptability.



Risks Addressed and Potentially Addressed for On-Shore LNG Facilities

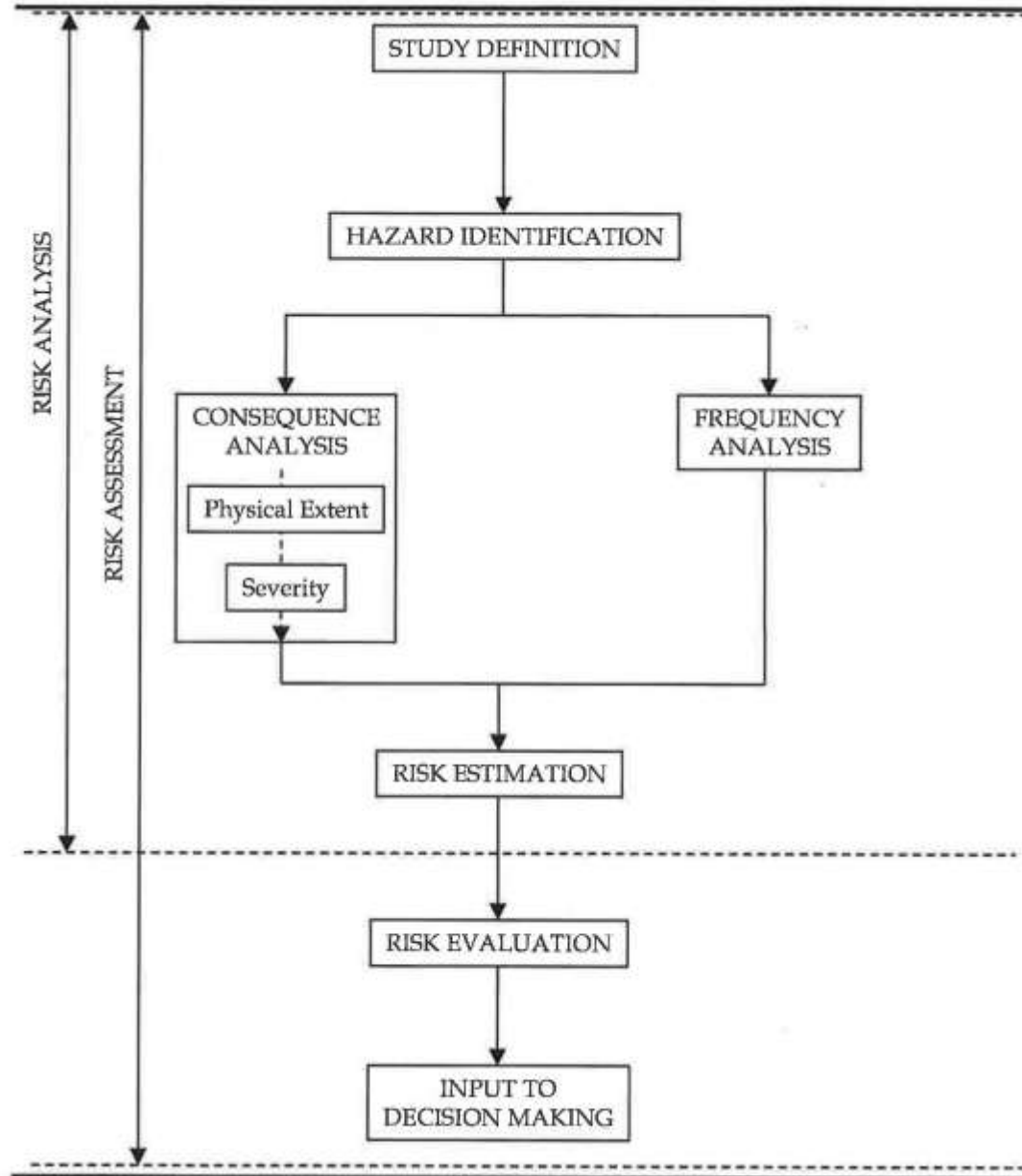
On Site Examples:

- Pool Fire Engulfment and Radiation
- Vented Explosions from Overpressures
- Cryogenic Hazards,
- Suffocation

Off Site Examples:

- Pool Fire Radiation Distances
- Vapor Cloud Fire (“Flash Fire”) Engulfment
- Flash Fire Radiation Distances
- Deflagration Overpressure Distances.

Risk Analysis/Risk Assessment Scopes and Process



Five Components of Risk Analysis for Facility Siting and Substantial Modifications

- Characterizing Types of Releases
- Accounting for LNG Release Location, Size, Rate, Duration
- Determining Probabilities of Release Types
- Evaluating Consequences of Releases – “Specific Hazard Exposure” or Exposures to People and Property
- Comparing Calculated Risk in Terms of Consequences to Risk Acceptability Criteria.

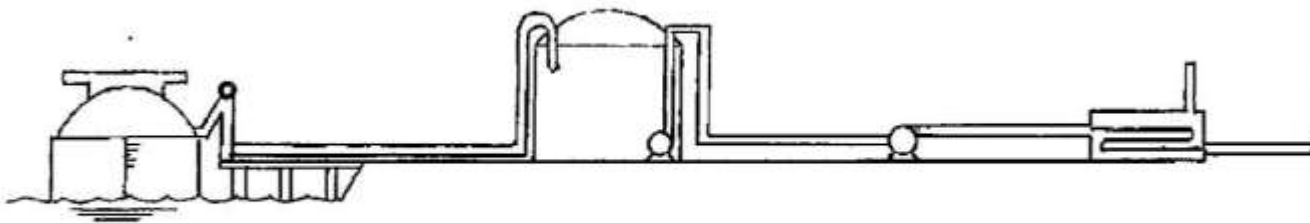
Overview of U.S. LNG Regulations

- Two principal Federal agencies for regulating safety of onshore LNG facilities with respect to potential releases of LNG and offsite hazards
 - FERC: review of proposed new and significantly modified onshore facilities serving LNG marine terminal activities up to the pipeline leaving the terminal
 - DOT: large onshore facilities covered by 49 CFR 193 up to the exit of the plant and interconnection to the gas transmission piping system
- NFPA 59A Standard
 - Enforcement-ready standard outside of Federal jurisdiction
 - Reference standard for technical requirement for 49 CFR 193.

US Regulatory “Jurisdictional Boundaries” for LNG Terminal Facilities

Multi-Agency Jurisdiction

Interagency Agreement of February 2004 ensures integrated and concurrent review



FERC – Section 3 of the Natural Gas Act

Section
7

FERC – Lead Agency for Environmental Review Under NEPA

USCG – 33 CFR Part 127

DOT – 49 CFR Part 193 Safety Standards

USCG – 33 CFR Part 105 Facility Security



National Consensus Standard in the US for Onshore LNG Facilities

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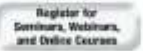

NFPA® 59A

Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)

2013 Edition



NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

Intended Improvements in LNG Facility Siting Decision Making from QRA

- QRA analysis serve as part of an organization's total risk management approach to business
- Allows quantitative measures of risk to be balanced with risk management measures to make cost-effective decisions for risk reduction
- Special permit from local authority not required for the risk assessment process to proceed
- Risk analysis provides a means of testing the effect of any type of mitigation approaches in the extent of the reduction of risk.

Challenges for Implementation of NFPA 59A QRA Methods

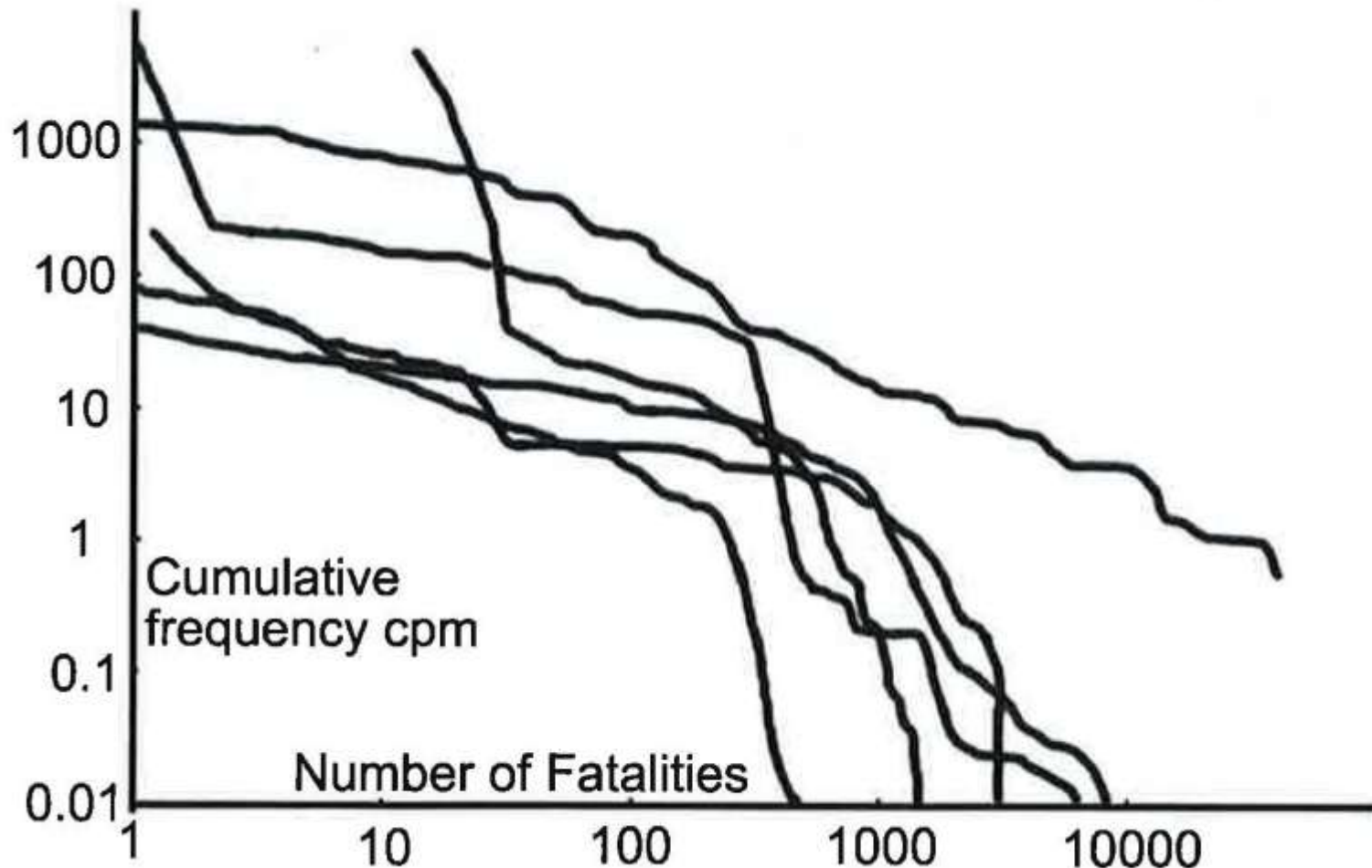
- QRA methods should be reproducible by a number of practitioners. Not so demonstrated to date.
- QRA methods in Chapter 15 still need to be fully developed and validated – for applications where events are rare – otherwise it will be very difficult to use effectively
- Ambiguities regarding acceptability of modeling and discretion of enforcing authorities and lack of clear identification of alternatives reduces ability to effectively implement the Chapter 15 methodology.

Equivalence Issues: Performance vs Prescriptive Approach in NFPA 59A

- Design Spills
- Release Behaviors and Hazards
- Radiant Flux Limits
- Conditional Probabilities
- Flammability Limits
- Ignition Sources.

Equivalence Issues (cont.) : Equivalence Among QRA Approaches

- ASSURANCE Project Experience (UK)



AHJ and Stakeholder Issues

- AHJ Discretion
 - QRA as an Alternative or Part of Requirements?
 - QRA on Top of Prescriptive Requirements?
 - AHJ Technical Latitude (Consequence Modeling)
- Public Risk Perception, Risk Aversion, and Risk Communication
 - “Public Consensus” on Tolerable/Unacceptable Risks
 - Public Outreach
 - “Outrage”
- Industry Response in “Independent Review” of HSE Methodology.

Regulatory and Technical Criteria and Competence Issues

- Alignment of Methods and Goals
- Hazard Criteria
- Event and Failure Rate Data
- Consequence Modeling.

Prospects for the Near Future: US and NFPA 59A

- US Regulatory Environment: Conservative and Prescriptive
- Emphasis on Accident Avoidance and Multiple Barriers to Prevent All Incidents
- Continuation of Movement to QRA, but At a Slower Rate Than NFPA 59A Promulgation
- European-Like Institutional Support and Experience –Will It Develop?
- Will Regulatory Structure Align for Greater Adoption?
- Is NFPA 59A QRA “Ready for Prime Time?”



www.aga.org

The American Gas Association, founded in 1918, represents more than 200 local energy companies that deliver clean natural gas throughout the United States. There are more than 71 million residential, commercial and industrial natural gas customers in the United States, of which 92% — more than 65 million customers — receive their gas from AGA members. Today, natural gas meets almost one-fourth of the United States' energy needs.