CHALLENGES IN USING RISK AND PERFORMANCE BASED DESIGN METHODS FOR FLNG SAFETY ENGINEERING

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Introduction
Introduction

Floating LNG Facilities will be:

- ‘New’ kind of facilities
  - A major innovation that brings huge new energy resources within reach
  - Limit the environmental impact and land use issues associated with constructing and operating a plant onshore

- ‘New’ safety issues
  - Proximity of a gas processing units with the FLNG Living Quarters and LNGC
  - High potential for severe explosions
    - Each leak leads to a gas release
    - Congested environment (typically 1/6 the size of an onshore plant of same capacity)
  - Release of cryogenic material with potential for steel embrittlement
Introduction

This context requires particularly detailed safety studies that aim at:

- Providing the proper input to the design
  - Extent of hazardous events
  - Design accidental loads

- Demonstrating that the installation is designed so that the risks figures are ALARP
  - Regulatory requirement (depending on the region of the world)
  - Codes and Standards (NORSOK or ISO-19901) or Client requirement

- Ensuring that people will be able to escape safely in case of a major accidental event

Establishment of robust safety studies are particularly challenging given the novelty of the FLNG as a concept
Safety Design Approaches
Safety Design Approaches

Inherent Safety principles

- Hazard prevention, to reduce the likelihood of loss of containment and ignition
  - Reduce leakage probability
  - Reduce ignition probability

- Control and mitigation to reduce the severity of the consequences of loss of containment
  - Reduce the released inventory
  - Reduce the consequences of un-ignited releases (including cryogenic leaks)
  - Reduce the consequences of ignited releases
Safety Design Approaches

Inherent Safety principles

- Control and mitigation to reduce the severity of the consequences of loss of containment
  - Un-ignited releases (cryogenic releases)
    - Grouping cryogenic equipment and providing effective dedicated drainage systems
    - Providing separation distances
    - Applying passive cryogenic protection to critical structures and equipment
  - Ignited releases
    - Grouping process equipment and sections by type of hazards
    - Providing the necessary separation distance or by installing fire/blast protection barriers
    - Applying active or passive fire protection to critical structures and equipment
    - Designing critical structures and equipment against blast

Items highlighted in red require input from Safety Studies
# Safety Design Approaches

A comparison

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<th>Prescriptive Approach</th>
<th>Performance-based Approach</th>
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<td>(Focus on Means)</td>
<td>(Focus on Objectives)</td>
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| **Strengths**           | • Very efficient for conventional cases  
                        | • Well-known and well controlled  
                        | • Straightforward application  
                        | • Compliance is “easy” to demonstrate for the designer, to endorse (owner) and to accept (authority, classification society)  | • More flexible to cope with project specificities  
                        | • Explicit definition of objectives and associated performance criteria  
                        | • Optimisation of mitigation measures (cost reduction, reduced MTO, less time on construction site for implementation)  |
| **Weaknesses**          | • Implicit objectives  
                        | • Acceptance criteria may be more difficult to define (by owner or authorities) or acceptance may be more difficult to grant  
                        | • Special cases not covered  
                        | • More resources (skills) needed for each step of the detailed design process  
                        | • Long process for acceptance of any deviation to the codes & regulations  
                        | • Time consuming during engineering phase (demonstration that the system satisfies the performance criteria)  
                        | • Safety Management System required during the entire lifecycle of the facility to account for potential design modifications which can change scenarios  |
Risk-Based Design
Risk based-design

Design flow chart

1. Safety Philosophies
2. Safety Studies
   - Explosion Risk Analysis
   - Fire Risk Analysis
   - Cryogenic Risk Analysis
3. Magnitude of consequences
   - Hazard Frequency Contours
   - Overpressure Exceedance curve
4. Design Accidental Loads
   - e.g. specification of design resistance
     requirement of Safety critical Elements
5. Specification of SCE protection requirements
   - e.g. Blast rating, Fire and/or cryogenic
     protection
Risk based-design

Example of application: PFP requirement

- PFP requirement is assessed as follows
  - Identification of Safety Critical Element Criticality (and the associated Risk Acceptance Criterion – target frequency)
  - Specification of the survival time or minimum duration of item functionality
  - Identification of hazards extent

- Definition/ Optimization of PFP requirements
Challenges associated with Risk and Performance-based approaches
Performance and Risk-based design challenges

- Much more resources are required

- Large amount of detailed results can be produced and special attention shall be paid to their interpretation and utilization

- Performance and Risk-based approaches result in significant modifications of the internal work process

- Performance and Risk-based approaches requires more discussions with the stakeholders
Conclusion
Conclusions

- The Performance-based approach is deemed the only proper approach for safety Engineering of FLNG facilities to date

- During the last 5 years Technip completed several FLNGs projects and developed robust risk-based study methods

Innovative, acceptable safety protection systems and protection means have been provided in designs that are now under construction, ensuring that FLNG is both safe and also economically viable
Questions