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Risk Analysis of LNG Pipe-in-Pipe Options

Cynthia Spitzenger, Det Norske Veritas (USA), Inc.

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Abstract

A liquefied natural gas (LNG) liquefaction terminal used a comparative risk assessment to evaluate four different pipe-in-pipe options for the loading line design to an offshore jetty system. The safety risk posed by the installation was evaluated with a quantitative risk assessment (QRA) procedure. A separate qualitative assessment was performed to evaluate the security risks associated with the project. Evaluation of the pipe-in-pipe and pipe-in-pipe-in-pipe technologies required additional frequency analysis to address the extra protection layers provided by the multi-pipe designs. The risk assessment process for the novel designs provided a more detailed basis for selection between the alternatives.

Introduction

Quantitative risk assessment (QRA) is a systematic analysis of the risks posed from hazardous activities or situations. The quantified or calculated results can be used in support of decision making. A liquefied natural gas (LNG) liquefaction terminal used a comparative risk assessment to evaluate four different pipe-in-pipe options for the loading line design to an offshore jetty system. The safety risk posed by the installation was evaluated with the traditional quantitative risk assessment procedure. A qualitative assessment was performed to evaluate the security and economic risks associated with the project.

Methodology

The approach used in the study was that of a classical risk assessment (CCPS 1999); a systematic approach to the analysis of what can go wrong in complex industrial systems. The normal conditions of operation of the system are defined and then the following questions asked:

- What accidental events can occur in the system?
- How frequently would each event occur?
- What are the consequences of each event?
- What are the total risks (frequencies multiplied by consequences) of the system?
- What is the significance of the calculated risk levels?

These questions correspond to the basic components of risk assessment discussed in Figure 1. Once a system has been analyzed, if the risks are assessed to be too high according to the desired criterion, the system would be modified in order to reduce the risks to a tolerable level, and the risk levels then recalculated. The process may therefore be viewed as iterative, where the design and/or operation of the system may be changed until it complies with the needs of society.

By objectively quantifying the risks from each part of the system, the assessment enables the most effective measures to reduce risks to be identified. In its overall scheme, the methodology used involves the following steps:

- System definition, in which information on the facility and its operation is collected and assimilated.
- Hazard identification, in which site incident cases and external incident cases which may lead to the release of hazardous material are identified.
- Frequency estimation, in which the frequency (i.e. likelihood per year of occurrence) of each of the accidental incident cases is estimated, based on historical failure data.
- Consequence modeling, in which all the possible consequences of each event are estimated.