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LNG decision making approaches compared

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Abstract

Hazard zones associated with LNG handling activities have been a major point of contention in recent terminal development applications. Debate has reflected primarily worst case scenarios and discussion of these. This paper presents results from a maximum credible event approach. A comparison of results from several models either run by the authors or reported in the literature is presented. While larger scale experimental trials will be necessary to reduce the uncertainty, in the interim a set of base cases are suggested covering both existing trials and credible and worst case events is proposed. This can assist users to assess the degree of conservatism present in quoted modeling approaches and model selections.

Keywords: LNG; Modeling; Risk; DNV; Spills

1. Introduction

There are close to 45 LNG projects proposed for North America, predominantly in the USA, but with additional terminals in Mexico and Canada. A key issue that has emerged is consequence zones from large LNG vessels used to deliver the LNG product to the terminals. It has been voiced that there is greater potential for releases that might affect people during shipping from marine accidents or from terrorism than from the terminal itself.

Two important factors cause confusion in decision making—the hole size and the model used to predict consequence effects. This paper reviews consequence modeling approaches and compares results from several publicly or commercially available models.

2. Hazardous area decision approaches

There are several approaches for establishing appropriate hazard separations between hazardous activities and nearby vulnerable installations or people. The main approaches are:

- Worst-case consequence based separations;
- Maximum credible event based separations;
- Risk assessment based separations.

Terminology can be difficult as there are no widely agreed definitions of these terms. To the public, a worst case release would be a total inventory release, regardless of the safeguards, occurring during the worst weather conditions. In reality, most worst case events are limited by the physics or the design to be less than the total inventory. The EPA RMP Regulations define the worst case event as the consequences from a total loss of containment within 10 min (interpreted as the largest isolatable section), and allowance can be made for administrative controls limiting the inventory. Outcomes are modeled to the ERPG2 toxic end-point, LFL, 5 kW/m^2, or 1 psi overpressure. These are mostly injury level outcomes. Under the regulations, lesser more frequent events can be modeled and these are termed Alternative Release Scenarios. In reality, there are events which are worse than this worst case definition—a failure the largest bottom connection to a large pressure vessel will often empty the vessel in less than 10 min. Also a common cause event (e.g. an airplane crash can affect several isolatable sections simultaneously) can be worse than this worst case. Therefore in practice, what is termed worst case events in regulatory parlance may be less than truly worst case, and implicitly include some aspect of safeguarding.

2.1. Worst case approaches

The worst case event can be defined [1] as the most severe incident, considering only incident outcomes and

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their consequences, of all identified incidents and their outcomes.

The worst case approach appears attractive as a decision support tool as "whatever happens, it can not be worse than this" and those responsible for public protection can be assured that the nominated consequence levels will not be exceeded. In reality, for major energy sources, it is often very difficult for industrial facilities located in proximity to people or infrastructure to demonstrate acceptability. This can apply to nuclear facilities, refineries, chemical plants, LNG terminals, and dams. A catastrophic failure of any of these, without any regard to the safeguards or barriers in place, is unlikely to be able to demonstrate no impact to infrastructure or people within possible hazard zones.

A disadvantage of the worst case approach is that ignoring safeguarding features (technical or people-based) tends to move public discussions away from safeguarding and specific means of improving these towards more mathematical definitions of the worst case event and modeling the outcomes.

2.2. Maximum credible event approaches

A maximum credible event can be defined [1] as the most severe incident, considering only incident outcomes and their consequences, of all identified incidents and their outcomes, that is considered plausible or reasonably believable. By bringing in the aspect of plausibility, the ability of safeguarding to reduce the scale of possible events from the maximum possible to some lesser scale is allowed. Safeguarding can reduce the likelihood of the event (prevention) or reduce its potential outcome (mitigation). The judgment of plausibility is imprecise, but would take account of the level of threat, the number and quality of safeguards, and the number of installations. What may not be credible at a single installation may be credible when taken over the entire USA.

2.3. Risk assessment approaches

A risk assessment approach should include the entire range of potential events from frequent small events, through infrequent but credible events, to much rarer worst case events. It combines each event scenario with its likelihood of occurrence and the multiple possible outcomes. The advantage of a risk assessment approach is that safeguarding is explicitly included in a manner that allows cost-benefit to be established. The USA currently does not use risk assessment approaches for process or LNG facilities, but the Office of Management and Budget does for medical investments at the national scale. Companies are concerned about public reaction and legal liability.

3. Failure case selection for LNG vessels

3.1. LNG vessels overview

LNG shipments began in the late 1950s. The first commercial trades started in the early 1960s and by the 1970s international trades had been established with the subsequent requirement for LNG carriers. The LNG trade has been fairly stable in this period, characterized by long term supply contracts. Bainbridge (2003) reports the world fleet of LNG ships as 146, and about half of these are over 20 years old. Around 60 more are on order. A little more than half of these are GTT membrane designs (GazTransport Technigaz), and the bulk of the remainder are spherical designs (Kvaerner Moss). The current large LNG vessel size is 125–138,000 m^3 LNG, and concept designs exist for sizes up to 240,000 m^3 of LNG. All these vessels employ a double hull with additional barriers between the hull and the LNG cargo not present for crude oil tankers. While this is no absolute guarantee of safety, the current LNG fleet has substantial operating history with the full range of challenges (grounding, transfer accidents, etc.) with no bulk cargo loss of containment. There have been three serious grounding accidents, one vessel under full load and two empty. No cargo was lost from the El Paso Kayser event (the loaded case) in 1979, which ran aground onto rocks at 17 kts. This was a very serious grounding event. The unloaded cases had either no damage to the LNG containment (LNG Taurus in 1979) or as yet undetermined damage (Tenaga Lima in 2004).

Several safety studies have been completed for LNG risks. These include: Fay [2] Lehr and Simecek-Beatty [3] ABS [4,5], DNV (Pitblado et al. [8]), and Sandia National Laboratories [18] for DoE. A study by Sandia National Laboratories for the DoE is expected soon. Many earlier safety studies were completed in the 1960s and 70s [6].

3.2. Worst case event

Several studies quote a hole size of 5 m from a single 25,000 m^3 LNG tank [2,4,7]. In effect the 5 m is a worst case as it can potentially empty an LNG tank in 2 min, faster than the EPA definition of worst case. No specific mechanism is suggested in these papers as to how a 5 m hole would be caused and this is a deficiency. Studies do not normally assess a rapid total loss of inventory from an LNG vessel (e.g. 125,000 m^3 in five tanks).

3.3. Maximum credible event

Pitblado et al. [8] describe the hazard identification approach that yields a several maximum credible events for different threat types. The basis for maximum credible event was the potential for a loss of cargo during the foreseeable future of LNG operations in the USA. This was taken to be 30 terminals, for 30 years, with 100 deliveries/year—about 100,000 loaded visits. The current operational history of LNG vessels is about 80,000 loaded port transits, very close to the foreseeable LNG activity in the USA. As noted there has not been a case of loss of cargo from the cargo tanks to date, thus the simple historical projection would say the expected hole size in USA activities might be zero. A Hazid session, involving close to 20 industry specialists, however identified several maximum credible events that have never happened. Five specific holes sizes were developed from the Hazid based on different threats. These were: