

Q17. Please provide justification for the frequencies and durations of unloading arm failures used in the QRA.

The Shannon LNG QRA uses an unloading arm failure frequency of 7.6×10^{-5} per cargo transfer. The base frequency of 7.6×10^{-5} per cargo transfer is taken from work performed by the Advisory Committee on Dangerous Substances (ACDS) in the UK ⁽¹⁾, and is specifically related to transfer accidents from transfers refrigerated flammable liquefied gases to or from ships. Historical data for leaks during LNG transfers indicate that the value used is conservative. The release durations used in the QRA are considered to be appropriate given the safety measures that will be provided at the Terminal.

Sensitivity

It should be noted that the individual risks at the nearest receptors are not particularly sensitive to these assumptions, as was illustrated by the sensitivity analysis performed in response to question relating to the use of 85% of the LFL as the end-point for dispersion modelling. This is further illustrated by the sensitivity case that has been performed in response to this question.

The additional sensitivity case has considered the sensitivity of the results to the frequency of unloading arm ruptures. This sensitivity case uses the ACDS base frequency of 7.6×10^{-5} per cargo transfer operation (as used in the QRA) with the grossly conservative assumption that all failures result in a full bore release from the arm.

The resulting individual risk contours for hypothetical house residents are displayed in the figure below, alongside the original contours from the QRA. It can be seen that modelling of the arm failures as ruptures increases the size of the contours, but the nearest residences remain outside the 1×10^{-6} per year individual risk contour.

It should also be noted that no credit has been taken in the QRA for the mitigating effect of the steep cliffs that will be created between the water's edge and the nearest locations of interest on land (please see *Section 7.2* of the QRA report for a discussion of this issue).

(1) ACDS (1991). *Major Hazard Aspects of the Transport of Dangerous Substances*.

Frequencies

As stated above, the Shannon LNG QRA uses an unloading arm failure frequency of 7.6×10^{-5} per cargo transfer, with 1% of failures being modelled as ruptures. The base frequency of 7.6×10^{-5} per cargo transfer is taken from work performed by the Advisory Committee on Dangerous Substances (ACDS) in the UK ⁽¹⁾, and is specifically related to transfer accidents from transfers refrigerated flammable liquefied gases to or from ships.

Correspondence with SIGTTO indicates that there have been no significant releases of LNG in over 50,000 cargos transported. With two transfer operations per cargo transported (one loading, one off-loading), this represents over 100,000 transfer operations. Small liquid or vapour releases from swivel seals have been known to occur but are considered too small to constitute a major accident hazard. Hence the historical frequency of releases of LNG during transfer operations is less than 1×10^{-5} per transfer. Hence the value of 7.6×10^{-5} per transfer that is used in the QRA is conservative.

Although the ACDS study used event tree analysis to provide a breakdown by failure size and release duration, this did not fully reflect the safety measures that will be employed at the Shannon LNG facility (please see *Section 3.1.3* of the QRA report for a description). The assumed proportion of ruptures gives credit for these systems.

Other unloading arm failure frequency data are publicly available but do not relate to transfer of specific cargos or particular safety measures employed. For example, The 'Purple Book' ⁽²⁾ quotes generic transfer operation failure frequencies of 6×10^{-5} and 6×10^{-4} for rupture and leak cases respectively, without specifying cargo type or safety measures.

In developing the risk model it was considered most appropriate to use data presented for the specific type of cargo that will be handled at the Terminal. Therefore, the ACDS data were used in the QRA.

Release Duration

The QRA has used a release equivalent to 10 seconds forward flow to represent the volume of LNG released where emergency shutdown has been successful and a release equivalent to 1 minute forward flow to represent the case where the emergency shutdown valves (ESDVs) fail to close.

The 1 minute duration was used for the case where the ESDV fails to close automatically following consideration of the other safety measures provided, including:

- Continuous manning of the unloading operation, providing fast response in the event of an emergency;

(1) ACDS (1991). *Major Hazard Aspects of the Transport of Dangerous Substances*.

(2) VROM, Publication Series on Dangerous Substances (PGS 3), Guidelines for quantitative risk assessment (December 2005)

- High current trips on the ship's pumps that cause the pump to shut down on loss of pressure head and pump overload (as would occur in the event of a rupture of the arm).

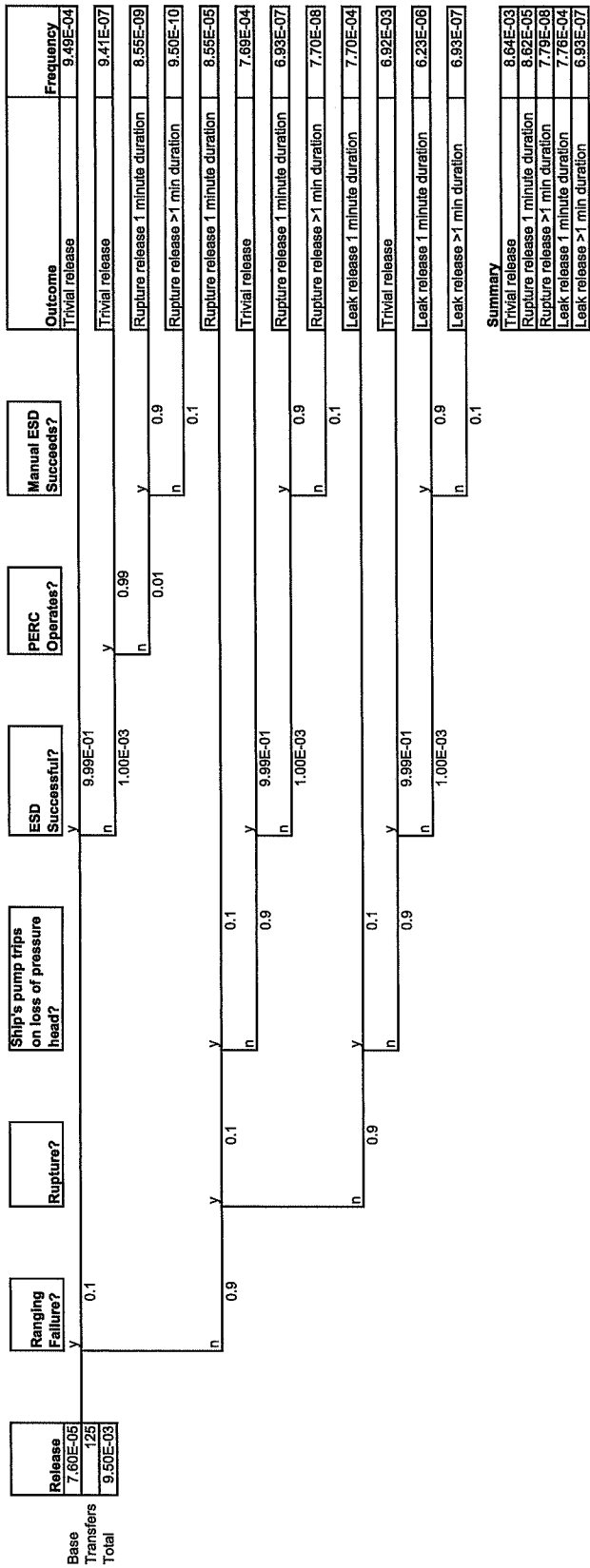
In view of this, it was judged that longer duration release would be of very low frequency.

To provide further justification of the release duration used, an event tree analysis has been performed which considers the various safety measures provided. The event tree is shown in the figure below. The event tree considers both failures arising from excessive movement during transfer (ranging failures) and failures arising from other causes (mechanical failure, impact, mal-operation etc.).

Quantification of the event tree has assumed the following:

- A base release frequency of 7.6×10^{-5} per transfer and 125 transfers per year, as per the QRA;
- Failures are split 10:90 between ranging and other failures (the ACDS study used a split of 6:94, therefore this is a conservative assumption);
- All ranging failures result in rupture of the arm (a conservative assumption);
- Non-ranging failures are split 10:90 between ruptures and leaks;
- The ship's pumps fail to trip out on 10% of demands;
- The ESD system achieves a Safety Integrity Level of 2, resulting in a probability of failure on demand of 0.1%;
- The probability of the PERC valves failing to close on demand is 1%; and,
- Operators are able to activate manual shutdown 90% of the time.

The results show that the frequency of releases with a duration of longer than 1 minute is below 1×10^{-7} per year and therefore these scenarios would not contribute significantly to the individual risk to people on land.



Unloading Event Tree