CONCLUSIVE SUMMARY OF CARBON DIOXIDE

Introduction

Cintra is developing a CO_2 Liquid Logistics Shipping Concept (LLSC) that will provide CO_2 emitters a complete logistical transportation solution for their captured CO_2 from their site to an offshore storage location. Vopak and Anthony Veder, as Joint venture partners in Cintra, have received a fund from the Global CCS institute (GCCSI) to study the Liquid Logistics Shipping Concept.

DNV has been asked to perform a safety study of the different activities as input for the Safety, Health and Environment report of the LLSC.

Objective

The objective of the safety study is to provide Vopak, its partners and the public with an understanding of the possible hazardous consequences and risks posed by the different CO_2 activities of the LLSC to the surrounding areas. The results of the identified consequences and risks are compared with the applicable Dutch risk criteria and, where needed, recommendations are made for possible mitigation measures to reduce the risks.

Approach

The safety study addresses the potential hazardous consequences and risks associated with the following activities of the LLSC:

- Local CO_2 terminal at one of the CO_2 sources (named “inland emitter E” or “Emitter E”) including liquefaction, storage and loading activities.
- Transport of CO_2 by barge from emitter E to the central CO_2 terminal in the Port of Rotterdam.
- Pipeline transport of low pressure CO_2 from different emitters located in the Port of Rotterdam to the CO_2 terminal in the Port of Rotterdam.
- CO_2 terminal in the Port of Rotterdam (including liquefaction, storage, compression and (un)loading activities).
- Onshore part of the pipeline transport of high pressure CO_2 from the CO_2 terminal in the Port of Rotterdam to an offshore sink.
- Transport of CO_2 by sea going vessels from the CO_2 terminal location in the Port of Rotterdam to open sea.
- CO_2 offloading at open sea at a single point mooring system.

For each activity the possible Loss of Containment (LOC) scenarios have been identified. The consequences, dangerous CO_2 concentrations and lethality ranges, of these LOC scenarios have been calculated.

Together with the failure frequency of these LOC scenarios the cumulative risk of most of the activities was calculated and the results were compared with the applicable Dutch risk criteria. The identification of the LOC scenarios and their corresponding failure frequencies followed the Dutch guidelines for Quantitative Risk Assessments.

Results

The safety study simulated the LOC scenarios (e.g. leak of a pipeline) for the different LLSC activities. The table below presents the maximum hazardous effect distances, the 1% lethality distance and the maximum risk levels for the different activities.

The maximum effect distance of a certain LOC scenarios is the maximum distance where a CO_2concentration of 50,000 ppm could occur. The CO_2 concentration of 50,000 ppm is the concentration where 1% of the humans exposed for 30 minutes are expected to die. However, the concentrations at the maximum effect distance are, most of the time, not sustained for such a long period of time.

Therefore the lethality distances are calculated. The lethality distance of a certain LOC scenario is determined by calculating the dose at a specific location and using this as input for the CO_2 probit function to calculate the fatalities.

The dose is a combination of concentration and exposure time. The 1% lethality distance, presented in the table below, is the distance where 1% of the humans are expected to die.

The individual risk is the risk of a fatality at a specific location when a person would be present at that location 100% of the time. The individual risk is calculated by combining the risks of all identified LOC scenario of an activity, which means that the individual risk presents the total risk of an activity. The risk of a LOC scenario is a combination of the effects and the probability of that scenario to occur.

Activity	**Maximum effect distance (m)**	**1% Lethality distance (m)**	**Maximum individual risk (per year)**
CO_2 emitter terminal	540	280	10^{-5}
Barges	780	510	10^{-8}
Low pressure pipeline	440	380	10^{-7}
CO_2 terminal in Rotterdam	680	680	10^{-5}
Seagoing vessels	950	710	–
High pressure pipeline	1980	740	10^{-6}
CO_2 offloading offshore	100	–	–

The results show that the maximum 1% lethality distances of the activities is in the range of 280 meters up to 740 meters from the location of the accidental CO_2 release. This means that the different activities might affect persons present in the direct vicinity. However, these distances do not say anything about the risk of the activities since likelihood has not been taken into account here.

The individual risk levels appear to be the highest in the direct vicinity of the terminals, which is caused by the process installations and the (un)loading activities over there. In the direct vicinity of the terminals no vulnerable objects, such as housing, should be present and this is also not the case. The CO_2 transportation activities do not result in onshore risk levels higher than 10^{-7} per year. For the seagoing vessels and the offshore offloading no risk calculations were performed since no vulnerable objects are located in these areas and therefore a risk assessment is not needed according to the Dutch risk criteria.

Conclusions

Based on the results it can be concluded that all of the CO_2 activities could pose an effect on the direct vicinity when an unintentional release occurs. However, the corresponding risk levels appear to be below the Dutch risk criteria. Therefore, in DNV's opinion the safety risks associated with the Liquid Logistics Shipping Concept are acceptable for all of the considered activities.

This means that, besides designing and operating according to industry standards / practice, no extra mitigations measures are needed to reduce the risk for the activities.

Source: http://hub.globalccsinstitute.com/publications/co2-liquid-logistics-shipping-concept-llsc-safety-health-and-environment-she-report-4