# Three-zone map for Shell Gibraltar LNG storage design concept

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Revision 2 takes account of additional information [10-12] provided by Shell about the size and design of the bunding of the LNG storage tanks. Changes from Revision 1 are shown in blue text.

## Introduction

Following an initial review [1] of the concept design proposal prepared by Shell [2-7], it was agreed that the Health and Safety Laboratory (HSL) would prepare a 'three-zone map' (3ZM) for the concept design at the North Mole. 3ZM's are a key input to the process whereby the Health and Safety Executive (HSE) provides hazardous substances consent and land-use planning advice to local authorities in GB. The relevance of the 3ZM is described in HSE's land-use planning methodology (PADHI) [8]. For a proposed new Hazardous Installation, it is considered whether developments that HSE would 'advise against' already exist within the relevant zones of the 3ZM.

The calculation of the 3ZM uses HSE's standard methodology, software and input assumptions. Discussion of further information provided by Shell [9] in relation to the 3ZM input assumptions is provided below.

This project note presents (in Annex A):

- Input assumptions table;
- 3ZM (Figure 1) for the Shell design concept at the North Mole, in which there is a single bund around all 5 storage tanks, sloping to an impounding basin.
- 3ZM (Figure 2) for the Shell design concept at the North Mole in which the bund around the storage tanks is subdivided and sloping into the impounding basin.

## Summary/Recommendations

1. In both cases the 3ZMs indicate that the middle (blue) zone does not reach the housing to the East of the proposed LNG storage facility.
2. For the case where the bund around the storage tanks is not subdivided , the inner zone (red) and middle zone (blue) in Figure 1 are shown covering the access road and ferry terminal. However this does not take into account that the LNG carrier will not be berthed and LNG offloading operations will not

take place when a cruise ship is present. In addition, Shell [2] has undertaken to provide a barrier wall, at least 2 metres high, on the south side of the terminal to limit the hazard zone by providing a solid obstacle to vapour flow. The size of the inner zone is determined by pool fire and flash fire scenarios and such a barrier could also provide shelter from thermal radiation.

3. HSE sometimes makes a "Do not advise against" decision subject to a recommendation for a Planning Condition to include specific design features. Hazardous Substances Consent is often granted prior to the detailed design phase of a project and the Planning Condition allows the design feature to be fully specified during detailed design.
4. For the Shell proposal, "Do not advise against" is appropriate provided that there is also a planning condition that Shell design the proposed physical barrier wall to protect the road and Cruise Terminal from fire scenarios, i.e. protection from thermal radiation from fire scenarios and to provide a vapour barrier to protect against flash fire. It is expected that such a barrier should be achievable. Shell should provide modelling results to HSL to demonstrate the suitability of the barrier as part of detailed design.
5. For the case in which the bund around the tanks is subdivided, the middle zone (blue) in Figure 2 is shown covering the access road. However this does not take into account that the LNG carrier will not be berthed and LNG offloading operations will not take place when a cruise ship is present. In this case, the result would be "Do not advise against".
6. The calculations do not include any future bunkering operations, either in terms of the increased deliveries into the storage tank nor any flows out of the storage tank to supply bunkering. Reassessment would be needed with suitable assumptions before any advice could be given about bunkering.

## HSL review of further information provided by Shell

Further information had been requested by HSL and was provided by Shell [9]:

### Boiling liquid expanding vapour explosion (BLEVE) fireball

Although the proposed storage tanks are pressure vessels, a boiling liquid expanding vapour (BLEVE) scenario has not needed to be included. The further information provided by Shell [9] demonstrates that the outer skin of the tanks and perlite insulation will be capable of protecting against BLEVE caused by pool fire or jet fire. In addition, Shell have undertaken to minimise the potential for jet fires that could impinge on the storage tanks during detailed design.

### Catastrophic failure of the tanks

The storage tanks have otherwise been modelled as pressure vessels, although their construction has double stainless steel walls. The further information provided by Shell demonstrated that the outer wall would withstand a 4 inch diameter failure of piping from the inner pressure vessel but did not consider catastrophic failure of the inner vessel. Modelling the storage tanks as standard pressure vessels is conservative but is not expected to be greatly so. The sensitivity to assuming standard pressure vessels is low because of the bunding provided.

### Loading ESD system

Shell has confirmed the independence of the two emergency shut-down (ESD) systems and manual shutdown. This confirms the UK HSE standard assumptions that have been used to produce the 3ZM.

## Further information about bund design

Further information was provided about the dimensions of the bund [12] that showed that the dimensions used by HSL in Revision 1 of this HSL project note were overly conservative. The 3ZM was recalculated and Figure 1 in the Annex replaced.

Shell also asked for calculation of the 3ZM using a modified bund design in which the bund is subdivided to minimise the area of LNG as it flowed into the impounding basin following any release. It was also clarified that all LNG piping connections to the storage tanks and the vacuum plates are at the end of the tanks closest to the impounding basin and furthest from the access road to the Cruise Ship Terminal. Calculations were repeated using a reduced bund area of the subdivided bund around a single LNG storage tank plus the area of the impounding basin. This area is expected to be conservative for the design option using a subdivided bund because it assumes that the LNG from any release will flow uphill to fill the section of subdivided bund as well as flowing downhill into the impounding basin. Because the outer stainless steel tank is designed so that it will not fail if the inner tank fails, then any release will be via the vacuum plates at the impounding basin end of the storage tanks. The 3ZM for this case is shown in Figure 2 in the Annex.

## References

1. HSL, Initial Review of Shell Gibraltar LNG concept design proposal, Health and Safety Laboratory project note, Revision 2, 11/9/15
2. Shell, Gibraltar Project Pre-screening Hazardous Consents Permit Application Advice, July 2015
3. Shell, Fire integrity review of 1000 $m^3$ pressurised LNG storage vessel, Gibraltar- Note for Information, Brad Otis, 28 August 2015
4. Shell, 002048-005 Gibraltar Import Layout
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6. Shell, LNG spill collection, Gibraltar – Note for Information, Vanesa Nuno Campos, 28 August 2015
7. ERM, Gibraltar LNG Onshore Terminal – Design with 5 x 1000 m3 LNG tanks: Report Quantified Risk Assessment Study, 0278551-R04, Rev 1, 28 August 2015
8. HSE, PADHI HSE's land use planning methodology, http://www.hse.gov.uk/landuseplanning/padhi.pdf
9. Shell, Gibraltar – Note for Information: response to requests from HSL, Rev 1.0, 25 September 2015
10. Shell, Drawing of bund design, 002048-005 ESCO v3 with ship.pdf, September 2015
11. Shell, LNG tank side view.jpg, September 2015
12. A Crerand, New bund size calculation, email to L Cusco & J Wilday, 30 September 2015

## Annex A: Input assumptions and 3ZM

**Table 1:** Data summary for LNG storage on reclaimed land at the North Mole

| Parameter | Value | Units |
|---|---|---|
| Storage tank volume | 1000 | $m^3$ |
| Number of Tanks | 5 | |
| Delivery Volume | 4000 | $m^3$ |
| LNG Density | 423.5 | $Kgm^{-3}$ |
| LNG Mass single tank | 423500 | kg |
| Mass delivered | 1694000 | kg |
| Delivery rate | 58.82 | $kgs^{-1}$ |

| Parameter | Value | | Units |
|---|---|---|---|
| Delivery duration | 8 | | hr |
| Height of LNG in tank | 5.8 | | m |
| Tank Diameter | 6 | | m |
| Relative Humidity | 70 | | % |
| Time to isolation Automatic | 60 | | s |
| Time to isolation Remote | 300 | | s |
| Time to isolation Manual | 1200 | | s |
| Time for no isolation | 1800 | | s |
| Refills | every 15 days 25/yr | | |
| Offloading pipe diameter | 8 | | inch |
| Bund Width | 46 & 12[1] | 9.5 & 12 | m |
| Bund Length | 55 & 12 | 54.6 & 12 | m |
| Bund Area | 2530+144 =2674 | 518.7+144 = 662.7 | $m^2$ |
| Bund Equivalent Radius | 29.2 | 14.5 | m |
| Hole Sizes for tank failure | 50 (0.05) | | mm (m) |
| Hole Sizes for tank failure | 25(0.025) | | mm (m) |
| Hole Sizes for tank failure | 13(0.013) | | mm (m) |
| Hole Sizes for tank failure | 6 (0.006) | | mm (m) |
| Failure frequency for catastrophic failure | 6 x 5 = 30 | | cpm |
| Failure Frequency 50mm holes | 25 | | cpm |
| Failure Frequency 25mm holes | 25 | | cpm |
| Failure Frequency 13mm holes | 50 | | cpm |
| Failure Frequency 6mm holes | 200 | | cpm |
| Surface Type | Land Concrete | | |
| Air Temp for D5 Weather | 288.15 | | K |
| Air Temp for F2 Weather | 278.15 | | K |
| Wind Speed for D5 Weather | 5 | | $ms^{-1}$ |
| Wind Speed for F2 Weather | 2 | | $ms^{-1}$ |
| **Ship offloading Guillotine Failure of Hard Arm** | | | |
| Failure Frequency for ASOV | $1.73e^{-4}$ | | per delivery (for 25 deliveries) |
| Failure Frequency for ASOV fail but RSOV success | $1.7e^{-6}$ | | per delivery (for 25 deliveries) |
| Release rate 1.5 x delivery rate | 88.23 | | $kgs^{-1}$ |
| **Transfer Line** | | | |
| Failure Frequency for ASOV Guillotine | $9.9e^{-6}$ | | for 50m |
| Failure Frequency for ASOV 25mm hole | $3.47e^{-6}$ | | for 50m |
| Failure Frequency for ROSOV 25mm hole | $3.4\ e^{-7}$ | | for 50m |
| Failure Frequency for RSOV 1/3 pipe diameter | $1.98e^{-5}$ | | for 50m |

[1] The impounding basin has dimensions of 12 x 12 metres

Figure 1: Three Zone Map for LNG Storage tank at North Mole (single bund around all 5 storage tanks plus impounding basin)

**Figure 2**: Three Zone Map for LNG Storage tank at North Mole (subdivided bund around storage tanks plus impounding basin)