

lighthouses, navigational safety facilities, coastal police stations, Indian coast guard stations and the like.

7.3 Risk assessment

QRA study is to quantify and assess risk from process hazards from the FSU and Land Regasification facilities was carried out by DNV. The detailed study report is attached as **Annexure 17**. The summary of various segment and leak size considered and conclusion is given below:

Failure Case Definitions

QRA study for various isolatable sections mentioned in **Table 7-4** has been carried out by DNV for the proposed project. The isolatable sections are identified according to the location of emergency shutdown ESD valves that can isolate relevant hydrocarbon volume in one section from hydrocarbon volumes in other sections. In the event of a release, only the material in a single isolatable section is considered to be released.

Table 7-4: Isolatable Section

Isolatable Segment	Description	Pressure (barg)	Temperature (°C)
LNGC to FSU Transfer			
LNG Transfer/Iso1/ LNG Loading Hose LNGC to FSU/L	LNG Transfer from LNGC to FSU via Loading Hose	7.5	-162
FSU			
FSU/Iso2/LNG Loading main/L	LNG Loading main location-1 (Typical)	7.0	-162
FSU/Iso3/BOG Vapour main/G	BOG vapour main location-1 (Typical)	0.24	-140
FSU/Iso4/LNG Offloading main/L	LNG offloading main location-1 (Typical)	7.0	-162
FSU/Iso5/Spray Main/L	Spray main location-1 (Typical)	6.0	-162
Land based BOG Unit			
Compressor unit/Iso6/ Compressor S/G	Suction to BOG Compressor	0.09	-140
Compressor unit/Iso7/Compressor D/G	Discharge from BOG Compressor	7.5	84
Ship to Shore Transfer (FSU to Land Based Storage)			
LNG Transfer/Iso8/ LNG Loading Hose FSU to Onshore/L	LNG Loading Arm	7.5	-162
	LNG Pipeline	7.5	-162
Land based storage (Pressurized bullet)			
LNG Transfer/Iso12/From ESD (33HV1135) to ESD (33HV1170)/L	Pressurised Bullet	8	-162
LNG Transfer from land based storage to TFL			
LNG Transfer/Iso13/From ESD (33HV1170) to XV at loading bay/L	LNG Transfer Pump 33PA6001A	7.5	-162
TFL Bay to road tanker			
LNG Transfer/Iso14/Loading arm/L	Tank Tanker Loading arm	2	-162
Land regas unit			
Regas unit/Iso9/LNG HP	BOG Recondenser	7	-145

Pump_D/L			
	LNG HP Pump send-out upto LNG vaporization train inlet	110	-157
Regas unit/Iso10/LNG Vaporizer_D/G	Discharge from LNG vaporizers in the vaporization train	103	5
NG send out to Essar Steel Plan			
NG Offloading/Iso11/NG Pipeline/G	NG Offloading	103	5

Leak Size Categories

A release of flammable material could occur through holes of size from small to large. Large leaks tend to produce very significant but short-lived fires and explosions whereas small leaks tend to produce localized but long-lasting fires or delayed explosions. Considering the severity and failure frequency, the following representative hole sizes have been adopted for each identified isolatable sections by DNV.

Leak Size for Process Installations

- Small leak –with the leak size diameter of 10 mm.
- Medium leak - with the leak size diameter of 50 mm.
- Large leak –with the leak size diameter of 100 mm.

Release from loading hoses

- Small leak –with the leak size diameter of 10 mm.
- Medium leak- with the leak size diameter of 50 mm.
- Large leak –with the leak size diameter of 100 mm.
- Full-bore leak (Rupture)

Release from HP Natural Gas

- Small leak –with the leak size diameter of 10 mm.
- Medium leak - with the leak size diameter of 50 mm.
- Large leak –with the leak size diameter of 100 mm.

Release from LNG Storage Tanks

- Leak –with the leak size diameter of 50 mm

Key Findings of QRA Study

Individual Risk

Risk criteria for Individual Risk for Worker are as follows:

- Individual risk levels above 1×10^{-3} per year will be considered unacceptable and will be reduced, irrespective of cost.
- Individual risk levels below 1×10^{-6} per year will be deemed acceptable.
- Risk levels between 1×10^{-3} and 1×10^{-6} per year will be reduced to levels as low as reasonably practicable (ALARP). That is the risk within this region is tolerable only if further risk reduction is considered impracticable because the cost required to reduce the risk is grossly disproportionate to the benefit gained.

Risk criteria for Individual Risk for Public are as follows:

- Individual risk levels above 1×10^{-4} per year will be considered unacceptable and will be reduced, irrespective of cost
- Individual risk levels below 1×10^{-6} per year will be deemed acceptable
- Individual risk between 1×10^{-4} per year to 1×10^{-6} per year will be considered to be in the ALARP region.

Societal risk

- It is observed that the societal risk when compared to the risk criteria falls within the ALARP region resulting in a maximum fatality of 69 deaths at a frequency of $1.12\text{E-}08/\text{year}$.

Safety exclusion zone

Society of International Gas Tanker and Terminal Operators (SIGTTO) guidelines recommend the establishment of an exclusion zone around the ship to ship LNG Transfer Hose to reduce the likelihood of ignition in the event of a release of LNG. The extent of the exclusion zone is a matter for local determination, in the context of the prevailing conditions, and this can be informed by predicted dispersion distances for credible spills of LNG. The credible spill was agreed as a release of LNG through a 50 mm hole from the unloading hose for a 120 second duration assuming operation of the emergency shutdown facilities. For this credible spill, the dispersion modelling indicated a distance of 230 m. Thus an exclusion zone of around ~230 m from the location of the LNG loading facilities shall be considered.

7.4 Disaster Management Plan

Emergency Response Plan including Disaster Management Plan prepared by ESSAR is attached as ***Annexure 18***.