

Annex 5E

## Hazard Identification Worksheets

System: 1. LNG Carrier (Transit in HK waters)  
[Applicable to FSRU Vessel in Transit in HK waters when required]

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
1. External Hazards	1. Powered collision of the LNGC with another vessel	1. Navigational error	1. Possible loss of LNG/natural gas containment leading to safety impacts.	1. LNGC will only enter Hong Kong (HK) waters within an agreed weather envelope
		2. Steering and/or propulsion equipment failure	2. Potential leakage of fuel oil from LNGC. Environmental impact.	2. LNGC will leave HK waters in event of impending bad weather
		3. Environmental factors (Refer to Subsystem 2 Natural and Environmental Hazards)	3. Potential sloshing leading to boil off gas through vent. Potential safety impact if ignited.	3. Low marine traffic levels in the vicinity of the LNGC transit route
	2. Drifting collision of the LNGC with another vessel	1. Steering and/or propulsion equipment failure	1. Possible loss of LNG/natural gas containment leading to safety impacts.	4. Pilot(s) onboard during transit
				5. Passive tug escort (for berthing only)
		2. Dragging anchor	2. Potential leakage of fuel oil from LNGC. Environmental impact.	6. Enforcement of speed limit
				7. Vessel Traffic System (VTS) (Hong Kong SAR and Mainland China)
			3. Potential sloshing leading to boil off gas through vent. Potential safety impact if ignited.	8. LNGC has double hull
				9. LNGC cargo area sub-divided
				10. LNGC equipped with advanced navigational aids
				11. Bow damage to LNGC unlikely to cause loss of storage containment due to configuration of cargo tanks
				12. Emergency response plan
				1. LNGC will only enter HK waters within an agreed weather envelope
	3. Collision of another vessel with the LNGC	1. Navigational error (by LNGC or by another vessel)	1. Possible loss of LNG/NG containment leading to safety impacts.	2. LNGC will leave HK waters in event of impending bad weather
			2. Potential leakage of fuel oil from LNGC. Environmental impact.	3. Bridge continuously manned in transit and when anchored.
		2. Failure to follow collision avoidance procedures (by LNGC or by another vessel)		4. Vessel Traffic System (VTS) (Hong Kong SAR and Mainland China)
		3. Environmental factors (Refer to Subsystem 2 Natural and Environmental Hazards)	3. Potential sloshing leading to boil off gas through vent. Potential safety impact if ignited.	5. Enforcement of speed limit
				6. Anchor break system onboard
				7. Automated anchor watch system (ARPA) alarm.
				8. LNGC has double hull.
				9. LNGC cargo area sub-divided.
				10. Emergency response plan.
	4. Collision of the LNGC with a fixed structure	1. Navigational error	1. Possible loss of LNG/NG containment leading to safety impacts.	1. LNGC will only enter HK waters within an agreed weather envelope
			2. Potential leakage of fuel oil from LNGC. Environmental impact.	2. LNGC will leave HK waters in event of impending bad weather
		2. Steering and/or propulsion equipment failure	3. Potential sloshing leading to boil off gas through vent. Potential safety impact if ignited.	3. Low marine traffic levels in the vicinity of the LNGC transit route
				4. Pilot(s) onboard during transit
		1. Navigational error	1. Possible loss of LNG/natural gas containment leading to safety impacts.	5. Passive tug escort (for berthing only)
				6. Enforcement of speed limit
				7. LNGC equipped with advanced navigational aids
				8. Vessel Traffic System (VTS) (Hong Kong SAR and Mainland China)
				9. LNGC has double hull
				10. LNGC cargo area sub-divided
				11. Emergency response plan
				1. Enforcement of speed limit
				2. Pilot(s) onboard during transit
				3. No known structures in the vicinity of the LNGC route
				4. Emergency response plan
				1. LNGC transit route is not close to the grounding contour

System: 1. LNG Carrier (Transit in HK waters)  
[Applicable to FSRU Vessel in Transit in HK waters when required]

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
	5. Powered grounding of the LNGC	2. Steering and/or propulsion equipment failure	2. Potential leakage of fuel oil from LNGC. Environmental impact.	2. Pilot(s) onboard during transit
			3. Potential sloshing leading to boil off gas through vent. Potential safety impact if ignited.	3. Passive tug escort (for berthing only)
				4. Vessel Traffic System (VTS) (Hong Kong SAR and Mainland China)
				5. LNGC has double hull
				6. LNGC cargo area sub-divided
				7. Emergency response plan
	6. Drifting grounding of the LNGC	1. Propulsion equipment failure 2. Dragging anchor	1. Possible loss of LNG/natural gas containment leading to safety impacts.	1. Pilot(s) onboard during transit
			2. Potential leakage of fuel oil from LNGC. Environmental impact.	2. Passive tug escort (for berthing only)
			3. Potential sloshing leading to boil off gas through vent. Potential safety impact if ignited.	3. Vessel Traffic System (VTS) (Hong Kong SAR and Mainland China)
				4. Automated anchor watch system (ARPA) alarm
				5. LNGC has double hull
	7. LNGC anchor dropped onto subsea pipeline, or dragging causing loss of pipeline containment	1. Equipment failure leading to unintentional anchor release 2. Intention anchor release but subsea pipeline presence not known 3. Dragging anchor	1. Possible loss of pipeline containment leading to safety impact if ignited by for instance passing vessels.	6. LNGC cargo area sub-divided
				7. Bridge continuously manned in transit and when anchored
				8. Emergency response plan
				1. LNGC transit route is not close to the grounding contour
				2. No anchoring envisaged during transit
	8. Sinking or foundering of the LNGC	1. Other than the marine incidents defined above (e.g. cargo mismanagement at departure, ballast system operational failure)	1. Possible loss of LNG/natural gas containment leading to safety impacts.	3. Pilot(s) onboard during transit
				4. Anchor break system onboard
				5. Automated anchor watch system (ARPA) alarm.
				6. Passive tug escort (for berthing only)
				7. Bridge continuously manned in transit and when anchored
	9. Aircraft crash	1. Aircraft crash due to proximity of airport	1. Possible loss of LNG/natural gas containment leading to safety impacts.	8. Emergency response plan
	10. Helicopter crash	1. Helicopter crash due to proximity of helicopter flight path	1. Possible loss of LNG/natural gas containment leading to safety impacts.	1. LNGC is more likely to ground than sink due to shallow water
	11. Dropped objects	1. Refer to anchor drop above		2. Vessel management
	12. Oil or chemical spills in the vicinity	1. No additional concern identified		3. Computerized cargo management system
	13. HV cables	1. No significant concern identified		4. Ballast water transfer not anticipated during transit
2. Natural and Environmental Hazards	1. High wind/high sea conditions and typhoon	1. High wind/high sea conditions and typhoon	1. Extreme high winds, high sea conditions and typhoon may make the LNGC more difficult to control.  Collision or grounding incident may occur leading to possible loss of LNG/natural gas containment and safety impacts.	1. Refer to Safeguards in Subsystem 1 - External Hazards above
	2. Heavy rainfall and flooding	1. Heavy rainfall and flooding	1. Heavy rainfall will reduce visibility (making the LNGC more difficult to see and other vessels more difficult to be seen by the LNGC).  Collision or grounding incident may occur leading to possible loss of LNG/natural gas containment and safety impacts.	1. Refer to Safeguards in Subsystem 1 - External Hazards above
	3. Fog with poor visibility	1. Fog with poor visibility	1. Fogging will reduce visibility (making the LNGC more difficult to see and other vessels more difficult to be seen by the LNGC).	1. Refer to Safeguards in Subsystem 1 - External Hazards above

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Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
			Collision or grounding incident may occur leading to possible loss of LNG/natural gas containment and safety impacts.	
	4. Lightning	1. Lightning strike	1. Ignition on vent can lead to potential localized safety impact.	1. Flame arrestors provided on vents
	5. Earthquakes	1. No significant concern identified		
	6. Landslide	1. No significant concern identified		
	7. Subsidence/ movement	1. No significant concern identified		
	8. Tsunami	1. Tsunami	1. Tsunami impact on LNGC during transit is not envisaged due to sufficient water depth.	
	9. Tidal waves/storm surge	1. Tidal waves/storm surge	1. Tidal waves/storm surge impact on LNGC during transit is not envisaged due to sufficient water depth.	
	10. Seawater - seasonal variations in salinity and suspended solids	1. No significant concern identified		
3. Material Hazards	1. Loss of LNG/natural gas - Marine Incidents	1. Marine Incidents (Refer to Subsystem #1 External Hazards above)	1. Possible loss of LNG/natural gas containment leading to safety impacts.	1. Refer to Safeguards in Subsystem 1 - External Hazards above
	2. Loss of LNG/natural gas - Other Causes	1. Membrane and piping/flange failure due to degradation, construction/material defects, operational (human) errors and non-marine incident impacts (sloshing)	1. Possible loss of LNG/natural gas containment leading to safety impacts.	1. Limited active cargo operational activity during transit
				2. Membrane material has very high corrosion resistance
				3. LNGC inspection, testing and maintenance (ITM)
				4. Annulus between membrane and ship structure monitored for hydrocarbon presence and vented to safe location
				5. Cargo tanks either full (inbound) or empty (outbound) so potential for sloshing is minimized.
				6. Leak detection system
				7. Fire and gas detection system
				8. Emergency shutdown system
				9. Spill containment system
				10. Water spray system for rapid vaporization
				11. Fire fighting system
				12. Emergency response plan
	3. Diesel oil	1. Refer to Subsystem 5 Layout Hazard below		
	4. Marine Fuel oil	1. Refer to Subsystem 5 Layout Hazard below		
	5. Lubricating oil	1. No significant hazard envisaged, considering the small quantity of lubricating oil for machinery		
	6. Urea	1. No significant hazard envisaged, considering the small quantity of urea generated		
	7. Nitrogen	1. Potential asphyxiation hazard, no off-site impact is expected.		
	8. CO <sub>2</sub> - inert gas	1. Potential asphyxiation hazard, no off-site impact is expected.		
	9. Sodium Hypochlorite	1. Sodium Hypochlorite	1. Release of chlorine if subjected to fire. However, no significant hazard is envisaged given the limited quantity of generated chlorine expected.	
	10. Water Glycol	1. No significant issue		
4. Loss of Utilities	1. Loss of power supply	1. Loss of propulsion and/or steering	1. Marine Incidents (Refer to Subsystem #1 External Hazards above).	1. Refer to Safeguards in Subsystem 1 - External Hazards above
	2. Loss of instrument air supply	1. Not applicable		

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Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
	3. Loss of nitrogen	1. No significant hazard identified		
	4. Loss of fuel gas supply	1. Refer to Loss of Power Supply above		
	5. Loss of fuel oil supply	1. Refer to Loss of Power Supply above		
	6. Loss of fresh water supply	1. No significant hazard identified		
5. Layout Hazard	1. Escalation of Engine Room Fire	1. Escalation of Engine Room Fire	1. Potential fire escalation to other areas.	1. Engine room separated from cargo storage area to prevent fire propagation
				2. Engine room designed to Class rules to minimize likelihood of fire and provide adequate fire-fighting and containment
	2. Escalation of Accommodation Fire	1. Escalation of Accommodation Fire	1. Potential fire escalation to other areas.	1. Accommodation separated from cargo storage area to prevent fire propagation
				2. Accommodation designed to Class rules to minimize likelihood of fire and provide adequate fire-fighting and containment
6. Interface with Existing Facility	1. Not applicable			

System: 2. LNG Carrier (Approaching Jetty in HK waters)  
[Applicable to FSRU Vessel approaching Jetty in HK waters]

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
1. External Hazards	1. Collision of the LNGC with the Jetty	1. Navigational error	1. Collision with Jetty on approach may occur leading to possible loss of LNG/natural gas containment and safety impacts.	1. LNGC will only enter HK waters within an agreed weather envelope
		2. Tug error/failure	2. Collision with Jetty on approach may occur leading to potential high pressure natural gas release from pipeline risers.	2. LNGC will leave HK waters in event of impeding bad weather
		3. Environmental factors (Refer to Subsystem #2 Natural and Environmental Hazards)		3. Pilot(s) onboard during transit
				4. Active tug control
				5. Extra tug redundancy
				6. Enforcement of speed limit
				7. Safety Zone
				8. LNGC has double hull
			9. LNGC cargo area sub-divided	
	10. LNGC equipped with advanced navigational aids			
	11. Vessel Traffic System (VTS) (Hong Kong SAR)			
	12. Riser located within jetty structure			
	13. Emergency response plan			
	2. Collision of the LNGC with another vessel	1. Navigational error	1. Possible loss of LNG/natural gas containment leading to safety impacts.	1. LNGC will only enter HK waters within an agreed weather envelope
		2. Tug error/failure	2. Potential leakage of fuel oil from LNGC. Environmental impact.	2. LNGC will leave HK waters in event of impeding bad weather
		3. Environmental factors (Refer to Subsystem 2 Natural and Environmental Hazards)	3. Potential sloshing leading to boil off gas through vent. Potential safety impact if ignited.	3. Pilot(s) onboard during transit
				4. Active tug control
				5. Extra tug redundancy
				6. Enforcement of speed limit
				7. Safety Zone
				8. Low marine traffic levels in the vicinity of the LNGC transit route
9. Safety zone				
10. LNGC has double hull				
11. LNGC cargo area sub-divided				
12. LNGC equipped with advanced navigational aids				
13. Vessel Traffic System (VTS) (Hong Kong SAR)				
14. Bow damage to LNGC unlikely to cause loss of storage containment due to configuration of cargo tanks				
15. ISPS (Port Security) Plan				
16. Emergency response plan				
3. Collision of another vessel with the LNGC	1. Navigational error (by LNGC or by another vessel)	1. Possible loss of LNG/natural gas containment leading to safety impacts.	1. Pilot(s) onboard during approaching	
	2. Failure to follow collision avoidance procedures (by LNGC or by another vessel)	2. Potential leakage of fuel oil from LNGC. Environmental impact.	2. Active tug control	
	3. Environmental factors	3. Potential sloshing leading to boil off gas through vent. Potential safety impact if ignited.	3. Enforcement of speed limit	
			4. Safety zone	
			5. ISPS (Port Security) Plan	
			6. Emergency response plan	
4. Collision of the LNGC with a fixed structure	1. Refer to Hazard #1 above - Collision of the LNGC with jetty			
5. Grounding of the LNGC	1. Navigational error	1. Possible loss of LNG/natural gas containment leading to safety impacts.	1. LNGC will only enter HK waters within an agreed weather envelope	
	2. Tug error/failure	2. Potential leakage of fuel oil from LNGC. Environmental impact.	2. LNGC will leave HK waters in event of impeding bad weather	
		3. Potential sloshing leading to boil off gas through vent. Potential safety impact if ignited.	3. Pilot(s) onboard during approaching	
				4. Active tug control

System: 2. LNG Carrier (Approaching Jetty in HK waters)  
[Applicable to FSRU Vessel approaching Jetty in HK waters]

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
				5. Extra tug redundancy
				6. Maintenance of sufficient water depth for berth access way and turning point
				7. LNGC equipped with advanced navigational aids
				8. Vessel Traffic System (VTS) (Hong Kong SAR)
				9. LNGC has double hull
				10. LNGC cargo area sub-divided
				11. Emergency response plan
	6. LNGC anchor dropped onto subsea pipeline	1. Equipment failure leading to unintentional anchor release	1. Possible loss of pipeline containment leading to safety impact if ignited by for instance passing vessels.	1. LNGC transit route is not close to the grounding contour
		2. Intention anchor release but subsea pipeline presence not known		2. No anchoring activity envisaged during approaching
				3. Pilot(s) onboard during transit
				4. Active tug control
				5. Anchor break system onboard
				6. Automated anchor watch system (ARPA) alarm
				7. Bridge continuously manned during approach and berthing
				8. Emergency response plan
	7. Sinking or foundering of the LNGC	1. Other than the marine incidents defined above (e.g. cargo mismanagement at departure, ballast system operational failure)	1. Possible loss of LNG/natural gas containment leading to safety impacts.	1. LNGC is more likely to ground than sink due to shallow water
				2. Vessel management
				3. Computerized cargo management system
				4. Ballast water transfer not anticipated during approach and berthing
2. Natural and Environmental Hazards	8. Aircraft crash	1. Aircraft crash due to proximity of airport	1. Possible loss of LNG/natural gas containment leading to safety impacts.	
	9. Helicopter crash	1. Helicopter crash due to proximity of helicopter flight path	1. Possible loss of LNG/natural gas containment leading to safety impacts.	1. No helipad on LNGC
	10. Dropped objects	1. No additional concern identified		
	11. Oil or chemical spills in the vicinity	1. No additional concern identified		
	12. HV cables	1. No significant concern identified		
	1. High wind/high sea conditions and typhoon	1. High wind/high sea conditions and typhoon	1. Extreme high winds, high sea conditions and typhoon may make the LNGC more difficult to control.  Collision or grounding incident may occur leading to possible loss of LNG/natural gas containment and safety impacts.	1. Refer to Safeguards in Subsystem 1 - External Hazards above
	2. Heavy rainfall and flooding	1. Heavy rainfall and flooding	1. Heavy rainfall will reduce visibility (making the LNGC more difficult to see and other vessels more difficult to be seen by the LNGC).  Collision or grounding incident may occur leading to possible loss of LNG/natural gas containment and safety impacts.	1. Refer to Safeguards in Subsystem 1 - External Hazards above
				2. Fog horn/bell system on LNGC and Jetty
				3. Operational procedure considering visibility limit
	3. Fog with poor visibility	1. Fog with poor visibility	1. Fogging will reduce visibility (making the LNGC more difficult to see and other vessels more difficult to be seen by the LNGC).  Collision or grounding incident may occur leading to possible loss of LNG/natural gas containment and safety impacts.	1. Refer to Safeguards in Subsystem 1 - External Hazards above
				2. Fog horn/bell system on LNGC and Jetty
				3. Operational procedure considering visibility limit
	4. Lightning	1. Lightning strike	1. Ignition on vent can lead to potential localized safety impact.	1. Flame arrestors provided on vents
	5. Earthquakes	1. No significant concern identified		
	6. Landslide	1. No significant concern identified		
	7. Subsidence/ movement	1. No significant concern identified		
	8. Tsunami	1. Tsunami	1. Tsunami impact on LNGC during approach is not envisaged (due to sufficient water depth).	

System: 2. LNG Carrier (Approaching Jetty in HK waters)  
[Applicable to FSRU Vessel approaching Jetty in HK waters]

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
	9. Tidal waves/storm surge	1. Tidal waves/storm surge	1. Tidal waves/storm surge impact on LNGC during approach is not envisaged (due to sufficient water depth).	
	10. Seawater - seasonal variations in salinity and suspended solids	1. No significant concern identified		
3. Material Hazards	1. Loss of LNG/natural gas - Marine Incidents	1. Marine Incidents (refer to Subsystem #1 External Hazards)	1. Possible loss of LNG/natural gas containment leading to safety impacts.	1. Refer to Safeguards in Subsystem 1 - External Hazards above
	2. Loss of LNG/natural gas - Other Causes	1. Membrane and piping/flange failure due to degradation, construction/material defects, operational (human) errors and non-marine incident impacts (sloshing)	1. Possible loss of LNG/natural gas containment leading to safety impacts.	1. Limited active cargo operational activity during transit
				2. Annulus between membrane and ship structure monitored for hydrocarbon presence and vented to safe location
				3. Membrane material has very high corrosion resistance
				4. LNGC inspection, testing and maintenance (ITM)
				5. Cargo tanks either full (inbound) or empty (outbound) so potential for sloshing is minimized.
				6. Leak detection system
				7. Fire and gas detection system
				8. Emergency shutdown system
				9. Spill containment system
				10. Water spray system for rapid vaporization
				11. Fire fighting system
				12. Emergency response plan
	3. Diesel oil	1. Refer to Subsystem 5 Layout Hazard below		
	4. Marine Fuel oil	1. Refer to Subsystem 5 Layout Hazard below		
	5. Lubricating oil	1. No significant hazard envisaged, considering the small quantity of lubricating oil for machinery		
	6. Urea	1. No significant hazard envisaged, considering the small quantity of urea generated		
	7. Nitrogen	1. Potential asphyxiation hazard, no off-site impact is expected.		
	8. CO <sub>2</sub> - inert gas	1. Potential asphyxiation hazard, no off-site impact is expected.		
	9. Sodium Hypochlorite	1. Sodium Hypochlorite	1. Release of chlorine if subjected to fire. However, no significant hazard is envisaged given the limited quantity of generated chlorine expected.	
	10. Water Glycol	1. No significant issue		
4. Loss of Utilities	1. Loss of power supply	1. Loss of propulsion and/or steering	1. Marine Incidents (Refer to Subsystem #1 External Hazards)	1. Refer to Safeguards in Subsystem 1 - External Hazards above
	2. Loss of instrument air supply	1. Not applicable		
	3. Loss of nitrogen	1. No significant hazard identified		
	4. Loss of fuel gas supply	1. Refer to Loss of Power Supply above		
	5. Loss of fuel oil supply	1. Refer to Loss of Power Supply above		
	6. Loss of fresh water supply	1. No significant hazard identified		
5. Layout Hazard	1. Escalation of Engine Room Fire	1. Escalation of Engine Room Fire	1. Potential fire escalation to other areas.	1. Engine room separated from cargo storage area to prevent fire propagation
				2. Engine room designed to Class rules to minimize likelihood of fire and provide adequate fire-fighting and containment



System: 2. LNG Carrier (Approaching Jetty in HK waters)  
[Applicable to FSRU Vessel approaching Jetty in HK waters]

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
	2. Escalation of Accommodation Fire	1. Escalation of Accommodation Fire	1. Potential fire escalation to other areas.	1. Accommodation separated from cargo storage area to prevent fire propagation
				2. Accommodation designed to Class rules to minimize likelihood of fire and provide adequate fire-fighting and containment
6. Interface with Existing Facility	1. Not applicable			

System: 3. LNG Carrier (LNG Unloading at Jetty up to FSRU Storage)

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
1. External Hazards	1. Collision of passing vessel, service vessel and support vessel (including refueling barge operation, maintenance barge, supply vessel and tug) with LNGC/Jetty/FSRU Vessel	1. Navigational error of the passing vessel	1. Possible loss of LNG/natural gas containment due to breach of cargo, leading to safety impact (fire/explosion) with possible escalation.	1. Enforcement of speed limit
		2. Propulsion or steering equipment failure of the passing vessel	2. Possible loss of LNG/natural gas containment due to unloading arm failure, leading to safety impact (fire/explosion) with possible escalation.	2. Navigation aid system
		3. Environmental factors (See Subsystem #2)	3. Possible loss of natural gas containment due to high pressure natural gas arm failure, leading to safety impact (fire/explosion) with possible escalation. 4. Possible loss of natural gas containment due to higher pressure natural gas riser failure, leading to safety impact (fire/explosion) with possible escalation.	3. Safety zone
				4. Bridge will be always manned
				5. Jetty will be manned during unloading operation
				6. Standby tug (with impact characteristic less than the design criteria of LNGC and FSRU Vessel)
				7. Routing of high pressure natural gas pipework above impact elevation for most vessels
				8. Standard SIGTTO ship to shore connections in place
				9. Provision of fenders with considering angled berthing
				10. LNGC cargo area sub-divided
				11. Emergency shutdown system with PERC activation
				12. Shut-off valves on loading arm connections
				13. Jetty designed to allow for emergency departure
				14. ISPS (Port Security) Plan
				15. Emergency response plan
	2. Mooring line failure	1. Extreme loads	1. Potential drifting of LNGC or FSRU Vessel leading to potential grounding, impact on structure, impact with another vessel. Ultimately release of LNG/natural gas and safety impacts.	1. LNGC will only enter HK waters within an agreed weather envelope.
		2. Fatigue		2. LNGC will leave HK waters in event of impending bad weather.
		3. Corrosion and wear		3. Testing and maintenance program for mooring lines
		4. Improper selection of mooring lines		4. Line tension monitoring
	3. Aircraft crash	1. Similar to System 2 - LNG Carrier Approaching Jetty in HK waters		5. Vetting procedures for LNGC
	4. Helicopter crash	1. Similar to System 2 - LNG Carrier Approaching Jetty in HK waters		6. Vetting procedures by supplier
	5. Oil or chemical spills in the vicinity	1. No additional concern identified		7. Built in redundancy in the mooring configuration
	6. Grounding	1. No additional concern identified		8. Load monitoring and mooring hooks
	7. Dropped objects - from supply crane operation	1. Swinging/dropped objects from crane operation	1. Potential damage to high pressure natural gas pipeworks leading to safety impacts (fire/explosion).	9. DGPS
	8. Dropped objects - for jetty maintenance	1. Swinging/dropped objects during jetty maintenance due to for instance unloading arm maintenance	1. Potential damage to high pressure natural gas pipeworks leading to safety impacts (fire/explosion).	10. Standby tug (with impact characteristic less than the design criteria of LNGC and FSRU Vessel)
	9. HV cables	1. No additional concern identified		11. Emergency response plan
	10. Anchor drop/ drag of service and support vessel (including refueling barge operation,	1. Equipment failure leading to unintentional anchor release	1. Possible loss of subsea high pressure natural gas pipeline containment leading to safety impact if ignited by for instance passing vessels.	1. Safety zone
		2. Intention anchor release		2. Automatic Identification System (AIS) to enable monitoring of nearby vessels

System: 3. LNG Carrier (LNG Unloading at Jetty up to FSRU Storage)

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
	maintenance barge, supply vessel and tug)	3. Extreme weather		3. Automated anchor watch system (ARPA) alarm.
		4. Improper anchoring		4. Emergency response plan
2. Natural and Environmental Hazards	1. High wind/high sea conditions	1. High wind/high sea conditions	1. Extreme high winds and high sea conditions may create excessive movements and impact unloading arm operation. Refer to Material Hazard - LNG/natural gas above.	1. Refer to Safeguards in Subsystem 1 - External Hazards above
			2. Potential impact on mooring lines. Refer to External Hazard - Failure of mooring lines.	
	2. Heavy rainfall and flooding	1. No significant concern identified		
	3. Fog with poor visibility	1. No significant concern identified		
	4. Tidal waves/storm surge	1. Tidal waves/storm surge	1. Tidal waves/ storm surge may create excessive movements and impact unloading arm operation. Refer to Material Hazard - LNG/natural gas above.	1. Refer to Safeguards in Subsystem 1 - External Hazards above
			2. Potential impact on mooring lines. Refer to External Hazard - Failure of mooring lines.	
	5. Lightning	1. Lightning strike	1. Ignition on vent at jetty can lead to potential localized safety impact. Potential gas release and possible fire if ignited leading to safety impact.	1. Flame arrestors provided on vents
	6. Earthquakes	1. Earthquakes of high intensity	1. Differential movement between the jetty and carrier( FSRU Vessel/LNGC) leading to potential disconnection of unloading arm. Refer to Material Hazard - LNG/natural gas above.	1. Basis of Design considers seismic activity
	7. Landslide	1. No significant concern identified		
	8. Subsidence/ movement	1. No significant concern identified		
	9. Tsunami	1. Tsunami	1. Tsunami impact is expected in the worst case of disconnection of unloading arm. No further impact is envisaged due to sufficient water depth.	
	10. Seawater - seasonal variations in salinity and suspended solids	1. No significant concern identified		
3. Material Hazards	1. LNG/natural gas	1. Excessive LNGC/FSRU Vessel movement	1. Possible loss of LNG/natural gas containment due to unloading arm failure, leading to safety impact (fire/explosion) with possible escalation.	1. Terminal, FSRU Vessel, LNGC inspection, testing and maintenance (ITM).
		2. Loading arm failure	2. Possible loss of natural gas containment due to high pressure natural gas arm failure, leading to safety impact (fire/explosion) with possible escalation.	2. Unloading operation is supervised and bridge is always manned
		3. Flange failure	3. Possible loss of natural gas containment due to higher pressure natural gas riser failure, leading to safety impact (fire/explosion) with possible escalation.	3. Jetty structures would be provided cryo bar to withstand any cryogenic impact
		4. External corrosion	4. Potential cryogenic impact leading to safety issue. However this will be localized.	4. Operation procedure will be in place
		5. Process upset due to equipment failure/ human error	5. Potential rapid phase transition when LNG comes in contact with water.	5. Process control systems and alarms (DCS)
		6. Vessel collisions (Refer to Subsystem 1 - External Hazards above)		6. Emergency shutdown system to trip the unloading system including pumps shutdown valves to initiate the closing of PERC valves
		7. Dropped Objects		7. Pressure safety devices
	8. PERC system provided for unloading arms for quick disconnection and isolation, in case of excessive movement			
	9. Fire and gas detection			
	10. Water spray curtain provided at manifold, which is in operation during unloading operation to minimize cryogenic impact on the jetty structure			
	11. LNG spill tray system under the manifold			
	2. Fuel oil/ lubricating oil/ hydraulic oil	1. Refer to Subsystem 5 Layout Hazard below		12. Fire fighting system (hydrants, monitors)
				13. Standby tug with fire fighting equipment
				14. Emergency response plan

System: 3. LNG Carrier (LNG Unloading at Jetty up to FSRU Storage)

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
	3. Calibration gas for analyzers	1. No significant hazard envisaged. Only localized hazard envisaged due to small inventory.		
	4. Urea	1. No significant hazard envisaged, considering the small quantity of urea generated		
	5. Nitrogen	1. Potential asphyxiation hazard, no off-site impact is expected.		
	6. CO <sub>2</sub> - inert gas	1. Potential asphyxiation hazard, no off-site impact is expected.		
	7. Sodium Hypochlorite	1. Sodium Hypochlorite	1. Release of chlorine if subjected to fire. However, no significant hazard is envisaged given the limited quantity of generated chlorine expected.	
	8. Water Glycol	1. No significant issue		
	9. Pressurized air	1. No significant concern identified		
4. Loss of Utilities	1. Loss of power supply	1. No significant concern identified, since all systems will revert to safe conditions.		
	2. Loss of hydraulic system	1. Unable to operate unloading arms. No significant concern identified		
	3. Loss of instrument air supply	1. Unable to operate unloading arms. No significant concern identified		
	4. Loss of nitrogen	1. Loss of nitrogen for prolonged duration	1. Potential impact on unloading arm joints leading to minor leakage of LNG/natural gas	1. Redundant compressor system
			2. Potential impact on compressor seals leading to minor leakage of gas	2. High reliability of nitrogen generation package (membrane type)
			3. Loss of nitrogen will lead to potential vacuum in the inter space between the membranes. This will lead to air ingress with moisture ingress. Moisture can freeze leading to potential loss of mechanical integrity of the membranes.	3. FSRU Vessel tanks can tolerate days without any impact in case of loss of nitrogen
	5. Loss of fuel gas supply	1. Refer to Loss of Power Supply above		
	6. Loss of fuel oil supply	1. Refer to Loss of Power Supply above		
	7. Loss of fresh water supply	1. No significant hazard identified		
5. Layout Hazard	1. Escalation of Engine Room Fire	1. Escalation of Engine Room Fire	1. Potential fire escalation to other areas.	1. Engine room separated from cargo storage area to prevent fire propagation 2. Engine room designed to Class rules to minimize likelihood of fire and provide adequate fire-fighting and containment
	2. Escalation of Accommodation Fire	1. Escalation of Accommodation Fire	1. Potential fire escalation to other areas.	1. Accommodation separated from cargo storage area to prevent fire propagation 2. Accommodation designed to Class rules to minimize likelihood of fire and provide adequate fire-fighting and containment
6. Interface with Existing Facility	1. Not applicable			

System: 4. FSRU Vessel (HP Gas Send-out, FSRU Vessel Process and Non-Process Systems)

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
1. External Hazards	1. Collision of passing vessel, service vessel and support vessel (including refueling barge operation, maintenance barge, supply vessel and tug) with FSRU Vessel	1. Navigational error of the passing vessel	1. Possible loss of LNG/natural gas containment due to breach of cargo, leading to safety impact (fire/explosion) with possible escalation.	1. Enforcement of speed limit
		2. Propulsion or steering equipment failure of the passing vessel	2. Possible loss of LNG/natural gas containment due to unloading arm failure, leading to safety impact (fire/explosion) with possible escalation.	2. Safety zone
		3. Environmental factors (See Subsystem #2 Natural and Environmental Hazards)	3. Possible loss of natural gas containment due to high pressure natural gas arm failure, leading to safety impact (fire/explosion) with possible escalation.	3. Navigation aid system
			4. Possible loss of natural gas containment due to higher pressure natural gas riser failure, leading to safety impact (fire/explosion) with possible escalation.	4. FSRU Vessel will be always manned
				5. Standby tug (with impact characteristic less than the design criteria of LNGC and FSRU Vessel)
				6. Routing of high pressure natural gas pipework above impact elevation for most vessels
				7. Standard SIGTTO ship to shore connections in place
				8. Provision of fenders with considering angled berthing
				9. LNGC cargo area sub-divided
				10. Emergency shutdown system with PERC activation
				11. Shut-off valves on loading arm connections
				12. ISPS (Port Security) Plan
				13. Emergency response plan
	2. Mooring line failure	1. Extreme loads	1. Potential drifting of FSRU Vessel leading to potential grounding, impact on structure, impact with another vessel. Ultimately release of LNG/natural gas and safety impacts.	1. LNGC will only enter HK waters within an agreed weather envelope
		2. Fatigue		2. LNGC will leave HK waters in event of impending bad weather
		3. Corrosion and wear		3. Testing and maintenance program for mooring lines
		4. Improper selection of mooring lines		4. Line tension monitoring
	3. Aircraft crash	1. Similar to System 2 - LNG Carrier Approaching Jetty in HK waters		5. Vetting procedures for LNGC
	4. Helicopter crash	1. Similar to System 2 - LNG Carrier Approaching Jetty in HK waters		6. Ability to start main propulsion system to compensate drifting
	5. Oil or chemical spills in the vicinity	1. No additional concern identified		7. Vetting procedures by supplier
	6. Grounding	1. No additional concern identified		8. Built in redundancy in the mooring configuration
	7. Dropped objects - from crane operation	1. Swinging/dropped objects from crane operation	1. Potential damage to LNG/natural gas pipeworks and process equipment, leading to safety impacts (fire/explosion).	9. Load monitoring and mooring hooks
2. Natural and Environmental Hazards	1. High wind/high sea conditions	1. High wind/high sea conditions	1. Potential sloshing leading to boil off gas through vent. Potential safety impact if ignited.	10. DGPS
			2. Potential sloshing leading to damage to membrane.	11. Standby tug (with impact characteristic less than the design criteria of LNGC and FSRU Vessel)
				12. Emergency response plan
	2. Heavy rainfall and flooding	1. No significant concern identified		
	3. Fog with poor visibility	1. No significant concern identified		
	4. Tidal waves/storm surge	1. Refer to High wind/high sea conditions above		

System: 4. FSRU Vessel (HP Gas Send-out, FSRU Vessel Process and Non-Process Systems)

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
	5. Lightning	1. Lightning strike	1. Ignition on vent can lead to potential localized safety impact. Potential gas release and possible fire if ignited leading to safety impact.	1. Flame arrestors provided on vents
	6. Earthquakes	1. No significant concern identified		
	7. Landslide	1. No significant concern identified		
	8. Subsidence/ movement	1. No significant concern identified		
	9. Tsunami	1. Tsunami	1. Tsunami impact is expected in the worst case of disconnection of unloading arm. No further impact is envisaged due to sufficient water depth.	
	10. Seawater - seasonal variations in salinity and suspended solids	1. No significant concern identified		
3. Material Hazards	1. LNG/natural gas - Process Equipment	1. Excessive LNGC/FSRU Vessel movement	1. Possible loss of LNG/natural gas containment, leading to safety impact (fire/explosion) with possible fire escalation.	1. Terminal, FSRU Vessel, LNGC ITM
		2. High pressure gas arm connection failure	2. Potential cryogenic impact leading to safety issue. However this will be localized.	2. Operation procedure will be in place
		3. Flange/piping failure	3. Potential rapid phase transition when LNG comes in contact with water.	3. Check valve provided on HP gas send-out line to prevent reverse flow
		4. Valves/seals failure		4. Process control systems and alarms (DCS)
		5. Internal corrosion/ erosion (in vaporizer area and send-out system)		5. Emergency shutdown system to trip the unloading system including pumps shutdown valves to initiate the closing of PERC valves
		6. External corrosion		6. PERC system provided for unloading arms for quick disconnection and isolation, in case of excessive movement
		7. Process upset due to equipment failure/ human error		7. Pressure safety devices
		8. Loss of structural integrity of piping, process equipment support		8. Fire and gas detection with automatic actuation of ESD system
		9. Cargo mismanagement affecting hull integrity		9. LNG spill tray system (cargo area and regasification process area and reliquefyer area)
		10. Excessive vibration (compressor area and pumps)		10. Fire fighting system (hydrants, monitors)
		11. Dropped Objects		11. Standby tug with fire fighting equipment
	2. LNG/natural gas - Storage Containment	1. Flange/piping failure	1. Possible loss of LNG/natural gas containment, leading to safety impact (fire/explosion) with possible escalation.	1. Terminal, FSRU Vessel, LNGC inspection, testing and maintenance (ITM)
		2. External corrosion	2. Possible roll over leading to overpressure and loss of LNG/natural gas containment, leading to safety impact (fire/explosion) with possible escalation.	2. Operation procedure will be in place
		3. Process upset due to equipment failure/ human error	3. Potential cryogenic impact leading to safety issue. However this will be localized.	3. Process control systems and alarms (DCS)
		4. Dropped Objects	4. Potential rapid phase transition when LNG comes in contact with water.	4. LNG eductor system to allow transfer of LNG in case of power failure and emergency condition
		5. Containment failure (membrane)		5. Emergency shutdown system
				6. Pressure safety devices
				7. Fire and gas detection
			8. Secondary barrier for spill containment for full inventory (applicable for each storage compartment)	
			9. Fire fighting system (hydrants, monitors)	
			10. Standby tug with fire fighting equipment	
			11. Emergency response plan	
3. Fuel oil/ lubricating oil/ hydraulic oil	1. Refer to Subsystem 5 Layout Hazard below			
4. Calibration gas for analyzers	1. Only localized hazard envisaged due to small inventory			

System: 4. FSRU Vessel (HP Gas Send-out, FSRU Vessel Process and Non-Process Systems)

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
	5. Hydrogen	1. No significant hazard envisaged, considering the small quantity of hydrogen generated, which will be diluted before venting to the atmosphere		
	6. Urea	1. No significant hazard envisaged, considering the small quantity of urea generated		
	7. Nitrogen	1. Potential asphyxiation hazard, no off-site impact is expected.		
	8. CO <sub>2</sub> - inert gas	1. Potential asphyxiation hazard, no off-site impact is expected.		
	9. Sodium Hypochlorite	1. Sodium Hypochlorite	1. Release of chlorine if subjected to fire. However, no significant hazard is envisaged given the limited quantity of generated chlorine expected.	
	10. Water Glycol	1. No significant issue		
	11. Pressurized air	1. No significant concern identified		
4. Loss of Utilities	1. Loss of power supply	1. Power failure	1. Potential warm up of LNG within pipeworks leading to overpressure and release of LNG/natural gas.	1. Operating procedures
			2. Potential overpressure of storage system.	2. Ability to vent pressure manually
				3. DCS system with alarm (provided with UPS)
				4. Emergency power generator available
				5. Pressure relief device provided at suitable locations
	2. Loss of hydraulic system	1. Unable to operate unloading arms. No significant concern identified		
	3. Loss of instrument air supply	1. Instrument air compressor failure	1. Potential warm up of LNG within pipeworks leading to overpressure and release of LNG/natural gas.	1. Operating procedures
				2. DCS system with alarm (provided with UPS)
				3. Redundant instrument air system available
				4. Thermal relief valves provided at suitable locations
	4. Loss of nitrogen	1. Loss of nitrogen for prolonged duration	1. Potential impact on unloading arm joints leading to minor leakage of LNG/natural gas.	1. Redundant compressor system
			2. Potential impact on compressor seals leading to minor leakage of gas.	2. High reliability of nitrogen generation package (membrane type)
			3. Loss of nitrogen will lead to potential vacuum in the inter space between the membranes. This will lead to air ingress with moisture ingress. Moisture can freeze leading to potential loss of mechanical integrity of the membranes.	3. FSRU Vessel tanks can tolerate days without any impact in case of loss of nitrogen
5. Loss of fuel gas supply	1. Refer to Loss of Power Supply above			
6. Loss of fuel oil supply	1. Refer to Loss of Power Supply above			
7. Loss of fresh water supply	1. No significant hazard identified			
5. Layout Hazard	1. Escalation of Engine Room Fire	1. Escalation of Engine Room Fire	1. Potential fire escalation to other areas.	1. Engine room separated from cargo storage area and process equipment to prevent fire propagation
				2. Engine room designed to Class rules to minimize likelihood of fire and provide adequate fire-fighting and containment
	2. Escalation of Accommodation Fire	1. Escalation of Accommodation Fire	1. Potential fire escalation to other areas.	1. Accommodation separated from cargo storage area and process equipment to prevent fire propagation
				2. Accommodation designed to Class rules to minimize likelihood of fire and provide adequate fire-fighting and containment
	3. Escalation of Terminal fire	1. Handling of LNG and high pressure gas	1. Possible loss of LNG containment leading to greater fire and resulting in further fatalities to people in the vicinity.	1. Shut-off valves on loading connections.
2. FSRU Vessel/LNGC can move away from jetty (subject to MD approval)				
3. Emergency response plan				
6. Interface with Existing Facility	1. Not applicable			

System: 5. Two Subsea Pipelines to BPPS & LPS

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
1. External Hazards	1. Aircraft crash	1. No significant concern identified		
	2. Helicopter crash	1. No significant concern identified		
	3. Anchor Drag/ Drop from third party vessels onto new pipelines	1. Emergency anchoring for vessel underway due to loss of steerage, power or control, either due to mechanical problems or due to collision events	1. Possibility of damage to external coating, damage to pipe requiring remedial action.	1. Engineered rock protection with respect to anchor size of different vessel types
		2. Drag from anchorage areas	2. Potential loss of containment leading to natural gas release. Impact on passing vessels and shore population. Vessel involved in the incidents may sink due to loss of buoyancy cause by the gas bubbling.	2. Depth of cover
			3. Disturbance to the rock cover protection. Possible exposure of the pipe.	3. Route avoiding anchorage areas
	4. Anchor Drag/ Drop from construction vessels near the landing point onto existing CLP pipelines	1. Emergency anchoring for vessel underway due to loss of steerage, power or control, either due to mechanical problems or due to collision events	1. Possibility of damage to external coating, damage to pipe requiring remedial action.	4. Concrete external coating
				5. Marking marine charts of the pipeline route
		2. Drag from anchorage areas	2. Potential loss of containment leading to gas release. Impact on passing vessels and shore population. Vessel involved in the incidents may sink due to loss of buoyancy cause by the gas bubbling.	1. Engineered rock protection for existing pipelines with respect to anchor size of different vessel types
	5. Anchor Drag/ Drop from construction vessels near the landing point onto existing HKE pipelines	1. Emergency anchoring for vessel underway due to loss of steerage, power or control, either due to mechanical problems or due to collision events	1. Possibility of damage to external coating, damage to pipe requiring remedial action.	2. Proper anchoring procedures during construction
				3. Anchor position monitoring
		2. Drag from anchorage areas	3. Disturbance to the rock cover protection. Possible exposure of the pipe.	4. Cofferdam near the shore to further protect the existing pipelines
	6. Dropped Object	1. Emergency anchoring for vessel underway due to loss of steerage, power or control, either due to mechanical problems or due to collision events	1. Possibility of damage to external coating, damage to pipe requiring remedial action.	1. Engineered rock protection with respect to anchor size of different vessel types
				2. Proper anchoring and construction procedures during construction
		2. Drag from anchorage areas	2. Potential loss of containment leading to natural gas release. Impact on passing vessels and shore population. Vessel involved in the incidents may sink due to loss of buoyancy cause by the gas bubbling.	3. Anchor position monitoring
	7. Dumping	1. Emergency anchoring for vessel underway due to loss of steerage, power or control, either due to mechanical problems or due to collision events	1. Possibility of damage to external coating, damage to pipe requiring remedial action.	4. Cofferdam near the shore to further protect the existing pipelines, or tie-in with existing pre-installed section of the pipe
		2. Drag from anchorage areas	2. Potential loss of containment leading to natural gas release. Impact on passing vessels and shore population. Vessel involved in the incidents may sink due to loss of buoyancy cause by the gas bubbling.	
	8. Grounding	1. Navigation error, loss of control due to mechanical or adverse weather	1. Same as consequence 1,2 & 3 of anchor drag hazard.	1. Engineered rock protection with respect to anchor size of different vessel types
			2. Displacement of the pipeline leading to exposure.	2. Depth of cover
				3. Concrete external coating
	9. Vessel Sinking	1. Vessel Sinking	1. Same as consequence 1, 2 & 3 of anchor drag hazard but less severe.	1. Burial depth appropriate to the type of shipping activities based on Marine Department and CEDD guidelines
				2. Pipeline is buried below the seabed with rock cover flush with seabed
				1. Depth of cover
	10. Fishing & Trawling	1. Operation of trawl board and other fishing/trawl gear	1. No damage to the pipeline.	2. Concrete external coating
				3. Burial depth appropriate to the type of shipping activities based on Marine Department and CEDD guidelines
				1. Pipeline is buried below the seabed with rock cover flush with seabed
	11. Dredging	1. Impact from dredge bucket or drag head	1. Same as consequence 1, 2 & 3 of anchor drag hazard but less severe.	1. Burial depth appropriate to the type of shipping activities based on Marine Department and CEDD guidelines
				2. Engineered rock protection with respect to anchor size of different vessel types
				3. Depth of cover



System: 5. Two Subsea Pipelines to BPPS & LPS

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
	12. Service crossing or other services in the vicinity	1. Cable crossing - repair of cables potentially impacting pipeline	1. Potential loss of containment leading to natural gas release. Impact on passing vessels and shore population. Vessel involved in the incidents may sink due to loss of buoyancy cause by the gas bubbling.	1. Utility crossing agreement (between pipeline operator and utility supplier) ensures that there is an adequate mechanism to prevent damage to the pipelines in case of repair activities and the risk is acceptable
	13. HV cables	1. No significant concern identified		
	14. Oil or chemical spills in the vicinity	1. No significant concern identified		
2. Natural and Environmental Hazards	1. Scouring	1. Current and wave actions	1. Possible reduction of cover.	1. Pipeline is buried below the seabed with rock cover flush with seabed 2. Engineered rock cover
	2. High wind and typhoon	1. No significant concern identified		
	3. Heavy rainfall and flooding	1. Not applicable		
	4. Fog with poor visibility	1. Not applicable		
	5. Lightning	1. No significant concern identified		
	6. Earthquakes	1. No significant concern identified considering the pipelines are located in low seismic activity area		
	7. Landslide	1. Not applicable		
	8. Subsidence/ movement	1. No significant concern identified		
	9. Tsunami	1. No significant concern identified		
	10. Seawater - seasonal variations in salinity and suspended solids	1. No significant concern identified		
	11. Tidal waves	1. No significant concern identified		
3. Material Hazards	1. Internal corrosion	1. No issue for non corrosive, clean and dry gas		
	2. External corrosion	1. Sea-water; corrosive environment	1. Loss of wall thickness leading to potential leak.	1. Coating system 2. Sacrificial anode system 3. Designed for intelligent pigging
	3. Pressure cycling	1. Pipeline pressure will vary with time of day, loads etc.	1. Metal fatigue leading to crack.	1. Design will consider pressure cycles
	4. Material defect/ construction defect	1. Material defect/ construction defect	1. Possible leaks.	1. Quality control during manufacture and construction
4. Loss of Utilities	1. Loss of power supply	1. No concern identified		
	2. Loss of instrument air supply	1. No concern identified		
	3. Loss of nitrogen	1. No concern identified		
	4. Loss of fuel gas supply	1. No concern identified		
	5. Loss of diesel supply	1. No concern identified		
5. Layout Hazard	1. Refer to Subsystem #1 - External Hazard above			
6. Interface with Existing Facility	1. Refer to Subsystem #1 - External Hazard above			

System: 6. Gas Receiving Station (GRS) at BPPS and LPS

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
1. External Hazards	1. Aircraft crash	1. During take-off / landing / approach	1. Damage to the facility and fire/explosion hazard.	1. BPPS and LPS site not directly under the flight path
	2. Helicopter crash	1. Helipad at BPPS and at the radar station	1. Damage to the facility and fire/explosion hazard.	1. Helipad at the radar station near BPPS used for specific purpose and not frequent (about once per week)
				2. Helipad about 500 meter away from the BPPS GRS
	3. Dropped objects	1. Lifting of objects over operational equipment	1. Damage to existing equipment. Potential fire/explosion hazard.	1. Lifting plans need to comply with operating plant procedures and guidelines (e.g. weight limits for lifting over operational plant)
				2. Procedures (Brownfield and constructability workshops)
	4. Neighbouring facilities - Existing GRS at BPPS	1. Gas leak from nearby existing GRS and BPPS	1. Potential domino impacts leading to fire escalation.	1. Fire and gas detection system
				2. Emergency shutdown system
				3. Fire fighting system
	5. Neighbouring facilities - Existing GRS at LPS	1. Gas leak from nearby existing GRS and LPS	1. Potential domino impacts leading to fire escalation.	1. Sufficient separation distance of about 60 meters away from existing GRS
				2. Fire and gas detection system
				3. Emergency shutdown system
				4. Fire fighting system
	6. Neighbouring facilities - BPPS	1. Gas leak at BPPS	1. Potential escalation to the new GRS facility leading fire/explosion. Impact on new GRS facility is considered less likely due to the separation distance of more than 200 meter.	1. Fire and gas detection
		2. Fuel oil fire at BPPS		2. Fire fighting system
		3. Hydrogen fire/explosion at BPPS		
	7. Neighbouring facilities - ash lagoon	1. Ash lagoon to be developed in future (landfill site). Any development at this site has to take into account the risk to the existing facilities at BPPS/GRS		
	8. Neighbouring facilities - Yacheng system	1. Gas leak from the Yacheng system	1. Fire and /or explosion; possible escalation to BPPS GRS/Yacheng.	1. Blast wall
		2. Gas leak from the GRS impacting Yacheng		2. Fire and gas detection
	9. HV cables	1. No significant issue identified		
	10. Fuel oil spills in the vicinity (BPPS)	1. Leakage of fuel from diesel tank system	1. Potential fire and fire escalation.	1. Bund wall provided
				2. Fire detection system
	11. Fuel oil spills in the vicinity (LPS)	1. Leakage of fuel from diesel tank system	1. Potential fire and fire escalation.	3. Fire fighting system
				1. Bund wall provided
				2. Fire detection system
				3. Fire fighting system
	12. Hikers in the vicinity	1. No issue identified		
2. Natural and Environmental Hazards	1. High wind and typhoon	1. No significant issue identified		
	2. Lightning	1. Lightning strike on piping and equipment	1. Damage to equipment and fire/explosion.	1. Lightning conductors
			2. Ignition of fugitive emission.	2. Fire and gas detection
				3. Flame arrestor/snuffing system on vents
				4. Fire fighting system
	3. Earthquakes	1. Seismic activity	1. Damage to equipment and fire/explosion.	1. Area of low seismic activity
				2. Design basis in compliance with local regulation for seismic activity
				3. Fire and gas detection
				4. Fire fighting system
	4. Heavy rainfall and flooding	1. Heavy rainfall and flooding	1. Damage to equipment.	1. Storm water drainage system
	5. Fog with poor visibility	1. No significant issue identified		2. Site at a minimum of +6 mPD
	6. Landslide	1. Slope failure at BPPS	1. No consequence expected on GRS given the slope is located far away from GRS.	

System: 6. Gas Receiving Station (GRS) at BPPS and LPS

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
	7. Boulders	1. No significant issue identified	1. No consequence expected on GRS given the boulders are located far away from GRS.	
	8. Subsidence/ movement	1. Subsidence/ movement	1. Damage to equipment and fire/explosion.	1. Design basis in compliance with local regulation for subsidence
				2. Fire and gas detection
				3. Fire fighting system
	9. Tsunami	1. Waves higher than predicted	1. Possible damage to structures / facilities due to high wave and associated flooding.	1. Black Point not susceptible to tsunami
				2. LPS site not susceptible to tsunami
	10. Tidal waves	1. Same as Tsunami above		3. Site at a minimum of +6 mPD
	11. Seawater - seasonal variations in salinity and suspended solids	1. No significant issue identified		
	12. Hill fire	1. Hill fire	1. Potential fire escalation.	1. Vegetation control to prevent hill fire escalation
3. Material Hazards	1. Leak from tapings, flanges, valves and piping	1. Corrosion, mechanical failure, etc.	1. Potential loss of containment leading to fire/explosion.	1. Operating and maintenance procedures
		2. Misoperation		2. Area classification
		3. Maintenance error (including dropped object and pigging)		3. Fire and gas detection
	2. Fugitive emission	1. Leaks from seals / valves / analysers, operational losses	1. Environmental emission, potential ignition and fire	4. Shutdown system
				5. Fire fighting system
				1. Well ventilated area
				2. Area classification
	3. Overpressure downstream of letdown valve	1. Control valve malfunction	1. Potential overpressurization and loss of containment leading to fire/explosion.	3. Fire and gas detection
				4. Shutdown system
				5. Fire fighting system
				1. Active/monitor and slam shut system
				2. HIPPS provided
	4. Pigging operations	1. PIG stuck in the pipeline	1. Operational interruption. 2. Possible damage to facility.	3. Fire and gas detection
				4. Shutdown system
				5. Fire fighting system
				1. Operating procedures
	5. Ignition of gases from vent / PSVs	1. Lightning strike	1. Fire/explosion.	2. Pigging is not a frequent operation, 1 in 5 years
		2. Sparks / static / smoking	2. Potential thermal radiation effects on adjoining equipment.	1. Stack height will be determined based on thermal radiation threshold on adjoining equipment
				2. Snuffing system
				3. Area classification
				4. Enforcement of protocol (no smoking on site)
	6. Metering section including Gas Analyzer	1. Regular discharge of small quantity of gas	1. Potential localized fire. No offsite consequence possible.	5. All PSV releases are routed to vent stack
				1. Area classification
				2. Well ventilated area
				3. Piping design vent to safe locations / vent header
				4. Fire and gas detection
	7. Calibration gas	1. Leakage	1. Potential localized fire. No offsite consequence possible.	5. Fire fighting system
	8. Carrier gas	1. Leakage	1. Potential localized fire. No offsite consequence possible.	
	9. Nitrogen	1. No significant hazard identified		
	10. CO <sub>2</sub>	1. No significant hazard identified		
	11. Corrosion Inhibitor (minor quantity)	1. Use of corrosion inhibitor in BPPS GRS (water bath heater)	1. Potential localized fire. No offsite consequence possible.	
	12. Pressurized air	1. No significant hazard identified		

System: 6. Gas Receiving Station (GRS) at BPPS and LPS

Subsystem	Hazards/ Keywords	Description/ Causes	Consequences	Safeguards
	13. Dry chemical powders	1. No significant hazard identified		
4. Loss of Utilities	1. Loss of Power supply	1. No significant concern identified, since all systems will revert to safe conditions.		
	2. Loss of Instrument air supply	1. No significant concern identified, since all systems will revert to safe conditions.		
	3. Loss of nitrogen	1. No significant hazard identified		
	4. Loss of fuel gas supply	1. No significant hazard identified		
	5. Loss of diesel supply	1. No significant hazard identified		
	6. Loss of fresh water supply	1. No significant hazard identified		
5. Layout Hazard	1. Layout	1. No significant hazard identified.		
6. Interface with Existing Facility	1. Tie-ins	1. Unplanned events during tie-in	1. Loss of containment leading to fire/explosion.	1. Procedures and emergency response plan (Brownfield and constructability review)
	2. Access for installation / construction/ Brownfield activities/ General construction hazards	1. Possible interference with existing equipment	1. Damage to existing equipment. Potential leaks and fire/explosion.	1. Procedures (Brownfield and constructability review) 2. Permit to work, procedures need to comply with operating plant procedures and guidelines (e.g. weight limits for lifting over operational plant) 3. Construction safety plan (PPE, training, briefings, etc.)
	3. Dropped objects	1. Lifting of objects over operational equipment	1. Damage to existing equipment. Potential fire/explosion.	1. Procedures (Brownfield and constructability review)