CCS PROVIDES SOLUTIONS FOR WATERBORNE LNG CHAIN



CCS
CHINA CLASSIFICATION SOCIETY
中国船级社



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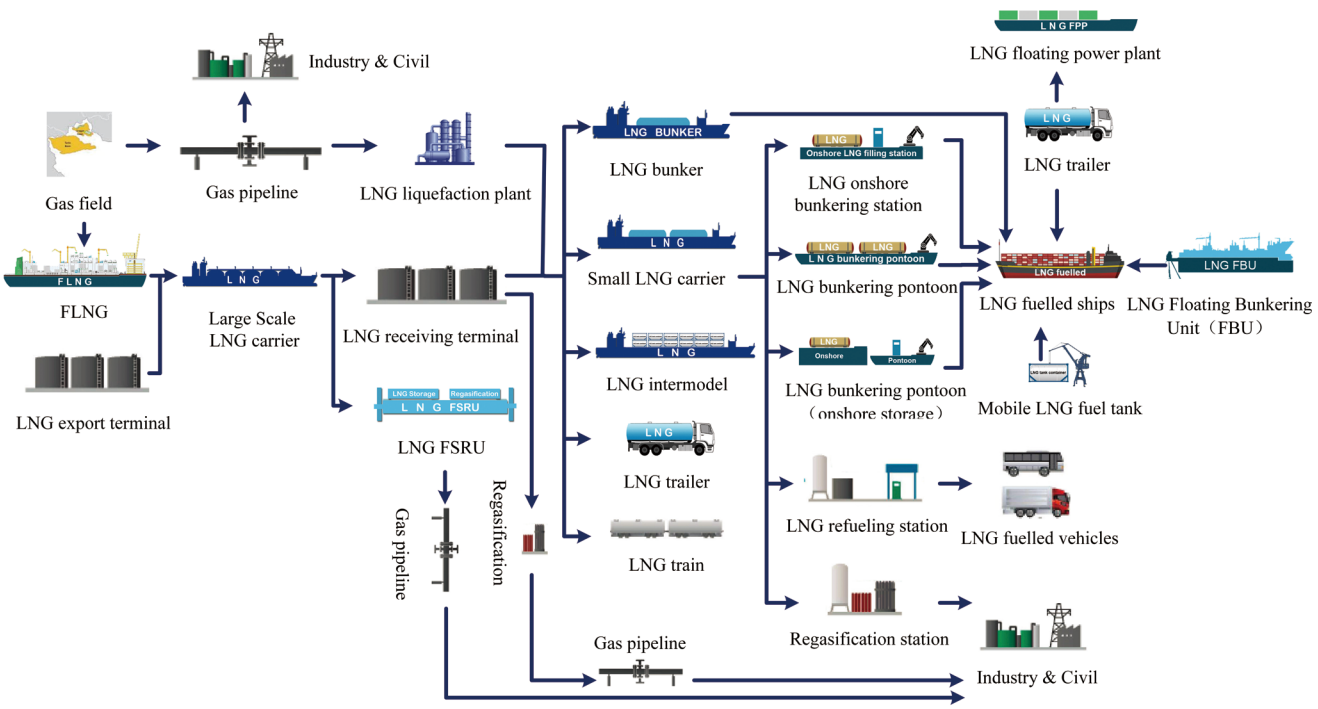
07 Quantitative Risk Assessment (QRA) Service

CCS Provides Solutions for Waterborne LNG Chain

Air pollution prevention requirements are driving the marine industry to seek advanced technologies to reduce the air emissions from ships. LNG used as fuel being a new air emission reduction system has been proven in land based applications, and is now being adapted to the marine environment, which drives the formation of LNG supply chain at sea and river.

LNG fuelled ships are the end-users, bunkering stations layout, including onshore based stations, floating stations(pontoon) ,and bunker vessels will take charge of the mission to ensure fuel supply. Small LNG carriers also play an important role in the chain. New LNG facilities are booming to meet the energy demands, such as FSRUs, FSUs and FRUs.

CCS Rules for Natural Gas Fueled Ships have come into force in 1st September 2013, and more than 200 LNG fuelled vessels have been classed with CCS. For expanding services, CCS has established the Technical Solutions Library which has provided a number of excellent solutions for retrofitting and new building projects. CCS Rules for LNG bunkering pontoons and Rules for LNG bunkering ships have come into force in 2014 and 2015 respectively, and more than 10 ships have been classed. In addition, several small LNG carriers have been classed in the past few years. And our FSU service experience gives us the ability to offer complete safe, efficient and green solutions for FSRUs, FSUs, FRUs, etc.



◎ *LNG chain*

LNG Fuelled Ships

CCS is committed to providing optimal solutions for LNG as marine fuel.

Services:

+ Technical feasibility and economical evaluation
+ Design optimization and AiP approval
+ Assessment on the solution for dealing with marine emissions control
+ Emergency plan preparation and evaluation
+ Engine room safety evaluation and simulation
+ Optimization design for escaping gas control
+ Type optimization and selection of fuel containment systems, gas supplying systems and gas consumers
+ Optimum utilization of BOG
+ Test verification of LNG fuelled systems (a LNG system lab is under construction)
+ Equivalent design evaluation
+ Consulting and training

Rules and Guidelines:

+ Guidelines for Survey of Ships Powered by Gas-fuel, 2011
+ Rules for Ships Using Natural Gas Fuels, 2021

Performance:

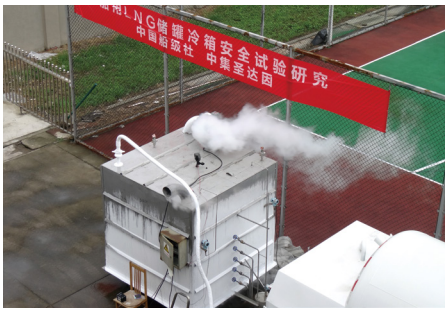
+ More than 200 LNG fueled vessels classed, including inland waterway vessels and seagoing vessels
+ Having jointly developed the safety evaluation system and simulation software for engine rooms
+ Having jointly completed the leakage testing research for tank connection spaces of LNG fuelled ships with CIMC
+ Providing LNG ready solutions for VLCC, VLOC and Mega Container Ship
+ Issuing AiP for high pressure Fuel Gas Supply System (FGSS)
+ Issuing AiP for 20/40 ft Liquid Fuel Gas Container



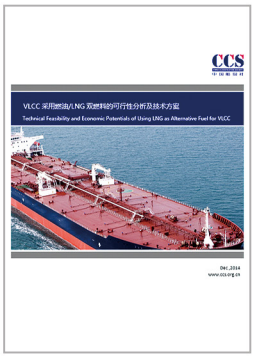
◎ *LNG fuelled tugboats (6500 hp) classed with CCS*



◎ *The World's First LNG Dual-Fuel VLCC "YUAN RUI YANG"*

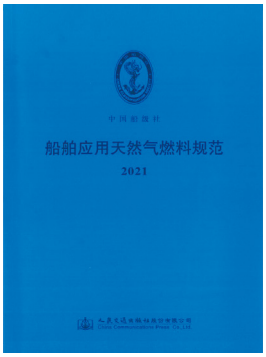


◎ *Experimental study of LNG tank connection space*









◎ *LNG fuel ready study reports*

Table. LNG Fuelled Ships Classed with CCS

Delivery	Name	Amount	Ship Type	New building/ conversion	Operation area
2010	Wutuo 302	1	Tug	Conversion	The Yangtze river
2013	Haichuan NO.3	1	Bulk (3100 dwt)	New building	The Yangtze river
2013	Haichuan NO.2	1	Bulk (3100 dwt)	New building	The Yangtze river
2013	Haiyangshiyou 521	1	Tug (6500 hp)	New building	Zhuhai Gaolan Port area
2013	Haiyangshiyou 522	1	Tug (6500 hp)	New building	Zhuhai Gaolan Port area
2014	Haiyangshiyou 525	1	Tug (6500 hp)	New building	Hainan LNG terminal port
2014	PU Hai 211	1	Containership (48TEU)	New building	China coastal line
2015	Haiyangshiyou 526	1	Tug (6500 hp)	New building	Hainan LNG terminal port
2015	Tai hong No.1	1	sand ship	New building	The Yangtze river
2017	TBN	100	Bulk (600 dwt)	New building	China Inland waterway
2017	TBN	50	Bulk (600 dwt)	New building	China Inland waterway
2017	TBN	50	Bulk (1000 dwt)	New building	China Inland waterway
2018	TBN	200	36 TEU Containership	New building	China Inland waterway
2018	TBN	12	PSV (4×5000 hp, 8×4000 hp)	New building	China Offshore
2022	Yuanruiyang	1	VLCC	New building	International Navigation
2022	TBN	4	Deck carrier (700FEU)	New building	Tiger Gas

LNG Bunkering Infrastructures

We focus on the risk analysis and safety control of LNG bunkering.

Rules and Standards

+ Rules for Liquefied Natural Gas Bunkering Ships, 2015
+ Rules for LNG Bunkering Pontoons, 2021
+ Guidelines for LNG fuel bunkering operation, 2021

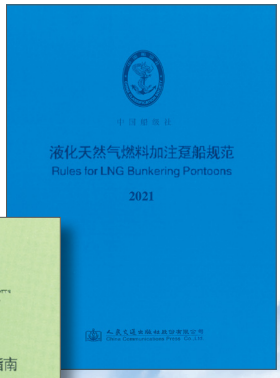
Classification Services:

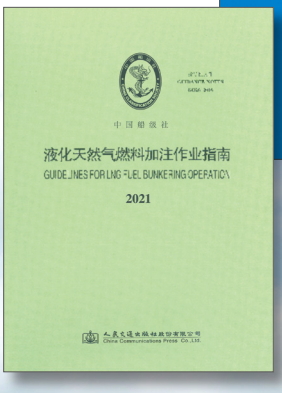
+ More than 10 LNG bunkering pontoons classed
+ One inland waterway LNG bunkering vessel classed
+ Three LNG bunkering ship classed (under construction)

Other Services:

+ Developing guidelines of Ship-to-Ship LNG Bunkering
+ Providing risk assessment for ENN Zhoushan LNG bunkering station
+ Issuing certification of truck-to-ship LNG bunkering procedure
+ Issuing AiP for GTT LNG bunkering system of 10k LNG bunkering vessel







◎ Haigangxing No.01 LNG bunkering pontoon



◎ *Huaqiang LNG bunkering pontoon (under construction)*



◎ *CCBC LNG bunkering pontoon*



◎ *ENN 8500m³ LNG bunkering ship (under construction)*

Table. LNG Bunkering Ships/Pontoons Classed with CCS

Delivery	Owner	Operation area	Oil tank	LNG tank
2013	Jiangsu Overseas group	The Yangtze river	--	2×250m³
2014	Xinjie	The Yangtze river	--	2×250m³
2014	China Changjiang Bunker (Sinopec) Co.,LTD	The Yangtze river	200m³	2×250m³
2014	China Changjiang Bunker (Sinopec) Co.,LTD	The Yangtze river	200m³	2×250m³
2015	ENN	The Pearl river	400tons	200m³
2016	Jiangsu Overseas group	The Yangtze river	--	2×250m³
2016	Anhui Huaqiang	The Yangtze river	2000tons	2×250m³
2016	Anhui Huaqiang	The Yangtze river	2000tons	2×250m³
2016	Anhui Huaqiang	The Yangtze river	2000tons	2×250m³
2016	Anhui Huaqiang	The Yangtze river	2000tons	2×250m³
2018	Zhuhai Gas	The Zhujiang River	4×170m³	2×100m³
2020	ENN	Zhoushan	--	2×4100m³
2021	CNOOC	--	--	2×6000m³

LNG FSU/FSRU

Rules and Guidelines:

+ Guidelines for Liquefied Natural Gas (LNG) Carriers Serving as Floating Storage Units (FSUs), 2016
+ Rules for the construction and equipment of liquefied natural gas floating storage and regasification units, 2018
+ Ship to Ship Transfer Guide, 2019

Service capabilities:

+ Structure strength analysis
+ Tank sloshing analysis
+ Anchoring and mooring analysis
+ Seakeeping performance analysis
+ Relative motion analysis for FSRU/LNGC
+ LNG cargo handling system
+ LNG cargo containment system
+ LNG loading/unloading
+ Optimization for topside (analyzing the fire and explosion risk based on 3D CFD software)
+ Certification for regasification facilities

Case of LNG FSU:

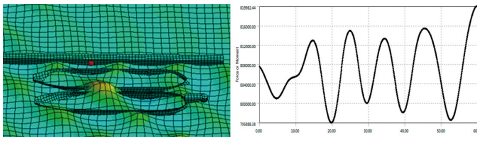
HAIYANGSHIYOU 301 was deliveried to JSK Company used as a floating storage unit (FSU) in the Benoa port of Indonesia in 2016, for which CCS provided the solutions.

Service contents:

+ Compatibility analysis of ship to ship transfer operation on waters
+ Analysis of long-term mooring options to jetty
+ Equipment management and personnel allocation
+ Analysis of key technologies in cargo handling
+ Risk analysis and the countermeasures



◎ 27,000-cbm FSRU design approval by CCS



◎ Ship to ship mooring analysis



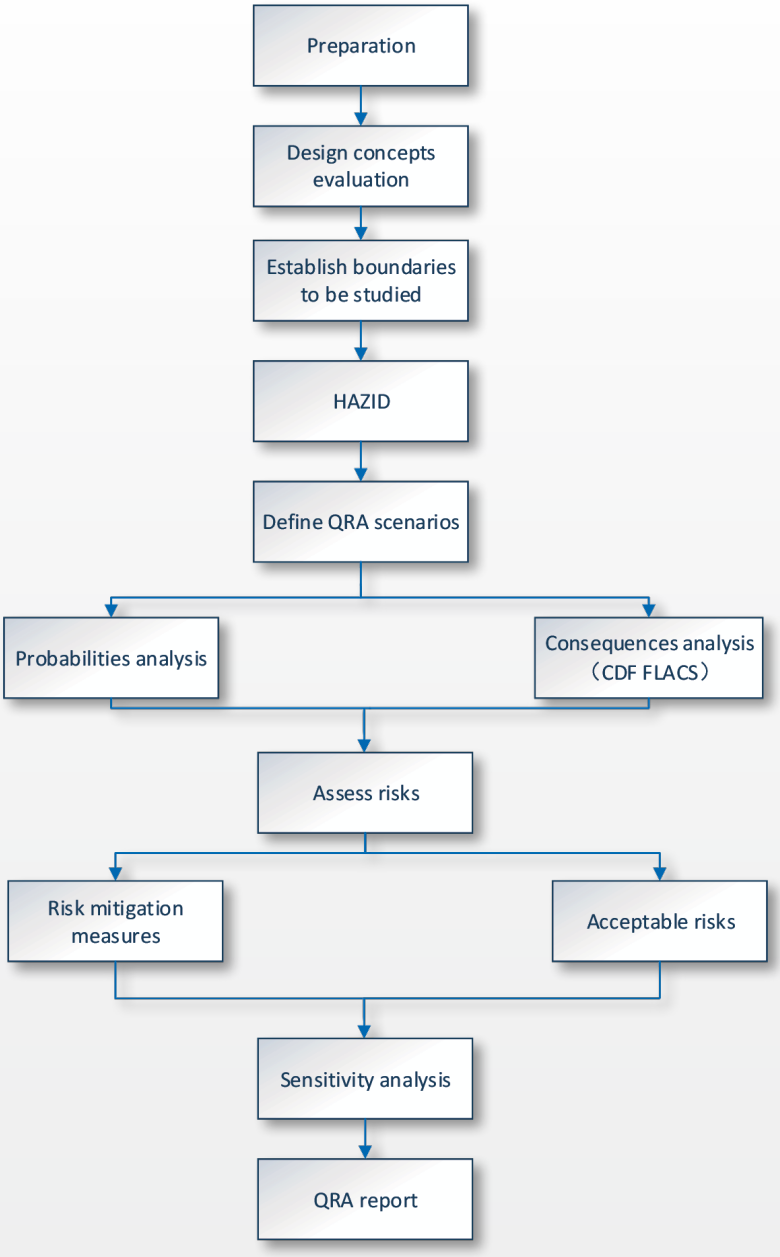
◎ Layout of FSU



◎ Haiyangshiyou 301

Quantitative Risk Assessment (QRA) Service

CCS QRA service provides highly transparent and readily understandable results. Probabilities and consequences are explicit inputs. The effect of risk mitigation measures is also modeled.
The work procedures see below figure:



Step 1 Preparation

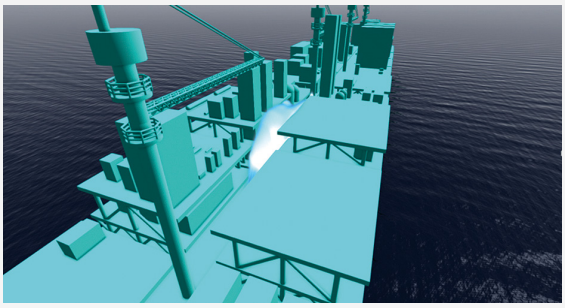
+ To set up a QRA team,
+ To make preliminary QRA plan according to project background.

Step 2 Design concepts evaluation

To identify risk challenges for the design. If there are different design concepts, to identify risk challenges for the different design concepts.

More details as follows:

+ Identifying potential showstoppers for concepts and risk challenges for any of the concepts under evaluation. i.e. evaluate if it is likely that the authority and acceptance criteria for any of the concepts cannot be met
+ Describing all risks that are significant for the facility, in order to assist the concept selection
+ Identifying possible significant risk reducing measures, so that safer, more environment friendly, more cost effective design and/or inherently safe options can be adopted
+ Providing a risk ranking of the proposed concepts
+ Evaluating the robustness and uncertainties of the proposed concepts with respect to possible changes during design development
+ Identifying need for any further risk assessments or detailed studies that should be performed
+ Identifying need and scope for further risk assessments during the next phase
+ Evaluating the layout of main areas



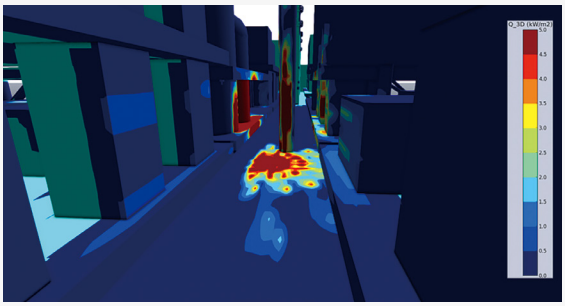
FLNG gas dispersion

Step 3 Establishing boundaries

To establish QRA boundaries according to the agreement among the parties to the contract.

Step 4 HAZID

HAZID is team based brainstorming analysis. HAZID work includes identifying identify causes, consequences and note safeguards, making recommendations to reduce risk, and providing QRA scenarios suggestion.



FLNG fire analysis

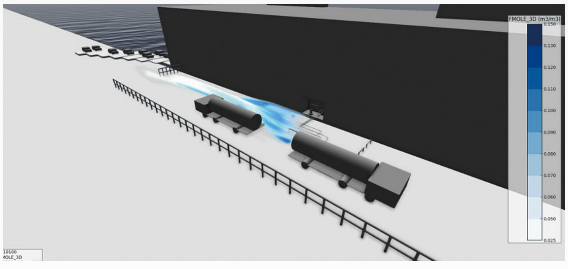
Step 5 Defining QRA scenarios

To define QRA scenarios according to Step 4.

Step 6 Probability calculation

To select databases recognized by the parties to the contract and calculate the probability based on databases.
Database including:

+ Leak probability
+ Ignition probability
+ Explosion probability
+ Injury and death probability

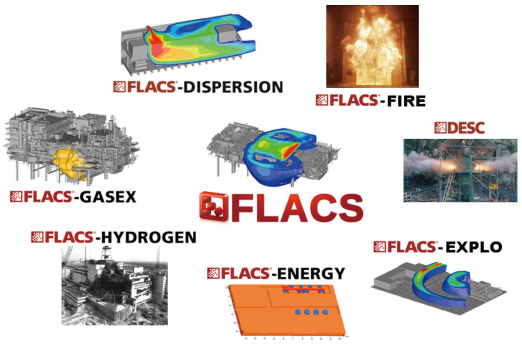


QRA for LNG bunkering to a 3800 PCTC

Step 7 Consequence calculation

To calculate consequences (leakage, dispersion, fire, explosion) using CFD software FLACS.

(FLACS is a leading CFD modeling software in gas & petrochemical industry. FLACS is the required explosion modeling tool by many oil and gas companies for their explosion hazard assessments. Furthermore, the requirements in the oil and gas industry by standards such as ISO 13702, NORSOK Z-013, ISO/DIS 19901-3 are difficult to fulfill without a tool having similar capabilities as FLACS. FLACS has received approval from the US Pipeline and Hazardous Materials Safety Administration (PHMSA) for LNG vapor dispersion modeling scenarios according to federal regulations (49 CFR 193.2059).)



Step 8 Risk results & evaluation

To assess individual & society risks according to acceptable individual risk criteria and F-N curve.

Step 9 Risk mitigation measures

If the risk cannot be accepted, it is necessary to provide the risk mitigation measures to reduce the risk, and to reevaluate the risk.

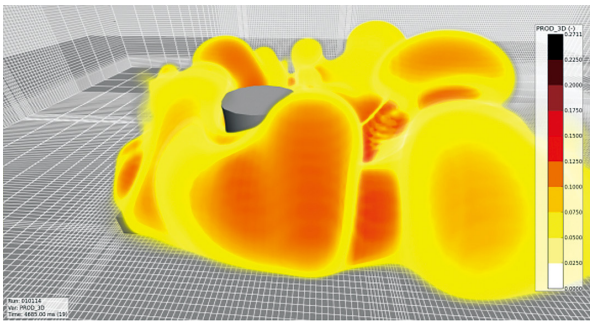
Step 10 Sensitivity analysis

Sensitivity studies could be claimed to be the main purpose of most QRA studies if the overall objective of the work is the comparison of alternative solutions or identification of risk reducing measures.
The main targets of sensitivity studies are:

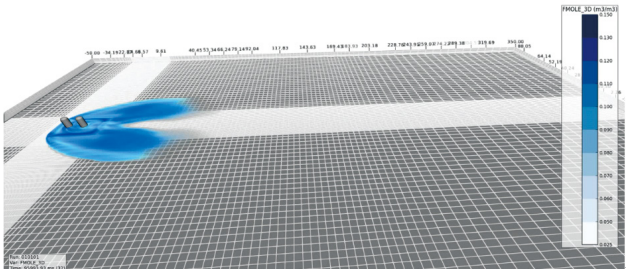
+ To illustrate the effect of variations in various parameters in the risk model
+ To illustrate the effect of introducing risk mitigation measures

Step 11 QRA report

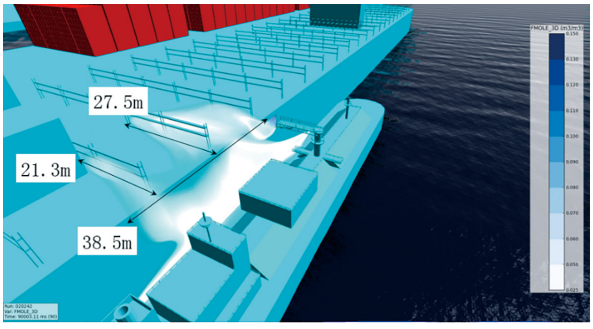
To complete the report.



◎ *LNG pool fire analysis*



◎ *LNG dispersion analysis for a LNG plant*



◎ *Safety distance analysis for LNG bunkering*

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