

CCS SHIP TYPE SERVICE MANUAL OF LIQUEFIED GAS CARRIERS

CCS
CHINA CLASSIFICATION SOCIETY
中国船级社

Overview

By sticking to the policy of "building first-class international classification society with own characteristics and with technology as the foundation and credibility as the cornerstone", CCS improves continuously its image and value of liquefied gas carriers through advanced technology and quality service and is widely and highly recognized by the industry.

Liquefied gas carriers classed with CCS cover ships types such as large membrane tank LNG carriers, type B independent tank, type C independent tank LNG carriers and large type A independent tank LPG carriers (VLGC). Based on the classification service, CCS provides customers with a series of solutions such as LNG fuel tank technology, LNG bunkering technology, LNG power propulsion, Carbon capture and storage system CCUS, intelligentization of ships, vibration and noise assessment, shafting vibration and alignment and energy efficiency of ships.

By committing to the mission of "safety, environmental protection and creating value for clients and society" and based on over 120 offices established across the globe, CCS provides the ship owner with 7 X 24 hours of survey and technical support services. Relying on its highly efficient service system structure, CCS continuously provides comprehensive support for conducting survey activities, safeguarding ship safety and emergency response to accidents. CCS has continuously achieved outstanding performance in three main MoUs and witnessed healthy and steady increase of its fleet size.

The shipping industry is witnessing great transformation against the backdrop of green and environmental protection, reduction of carbon and emission across the globe. Along with the "dual carbon" goal processing, international ship energy efficiency requirements continue to upgrade, as a clean energy source, natural gas continues to play an important and growing role in the global energy structure. Liquefied natural gas (LNG), which is a major part constituting China's import of natural gas, and LNG carriers engaged in the shipping of LNG will also show an optimistic growth prospects in the long run.

CCS fleet of liquefied gas carriers

Over the past decade, CCS has achieved remarkable results in the field of liquefied gas carriers, with a rapid increase in the number of classified fleets. Rich experience in ship classification and ship type approval services has been accumulated. In terms of ship classification and technical capability, CCS has achieved full coverage of different tank types of liquefied gas carriers and transportation of large, middle, small types and different cargo types.

◆ Membrane tank LNG carriers



"DAPENG SUN" membrane tank LNG carrier

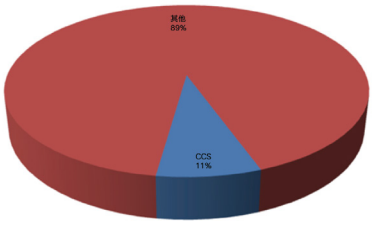


"SHAO LIN" membrane tank LNG carrier



"DAPENG PRINCESS" membrane tank LNG carrier

At present there are 75 CCS classed membrane tank LNG carriers in service and on order, accounting for 11% of large membrane tank LNG carriers of 140,000m^3 above constructed over the past decade. The fleet scale shows a trend of increase on a yearly basis.



Percentage of CCS Classed Membrane Tank LNG Carriers

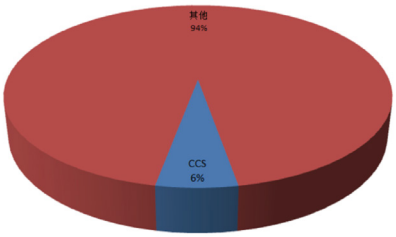
◆ Independent tank liquefied gas carriers

◆ Large Type A independent tank LPG carriers

In the field of large Type A independent tank LPG carriers, at present the number of large Type A independent tank LPG carriers which have been delivered for service in CCS fleet is 8, accounting for 6% of those built at the same period of time, and the size of CCS fleet shows a trend of rapid increase.



"GAS ARIES" 84,000 m3 VLGC



Percentage of CCS Classed Type A independent tank LPG carriers

◆ HuDong Type B independent tank LNG carrier



◆ Type C independent tank LNG carrier

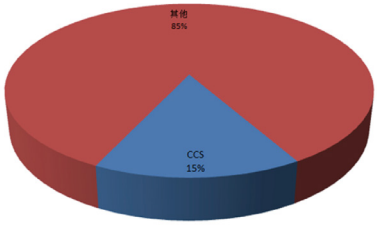
At present, the number of Type C independent tank LNG carriers classed with CCS accounts for 15% of those constructed worldwide since 2010.

In May 2015, "HAI YANG SHI YOU 301", a Type C independent tank LNG carrier with the maximum capacity in the world was classed with CCS and successfully delivered, which demonstrates that CCS has become one of the leading classification societies in the field of large Type C independent tank LNG carriers.

In 2022, the Hangjiaxin 78,900m^3 Type C LNG carrier classed with CCS. After completion, the ship will become the world's



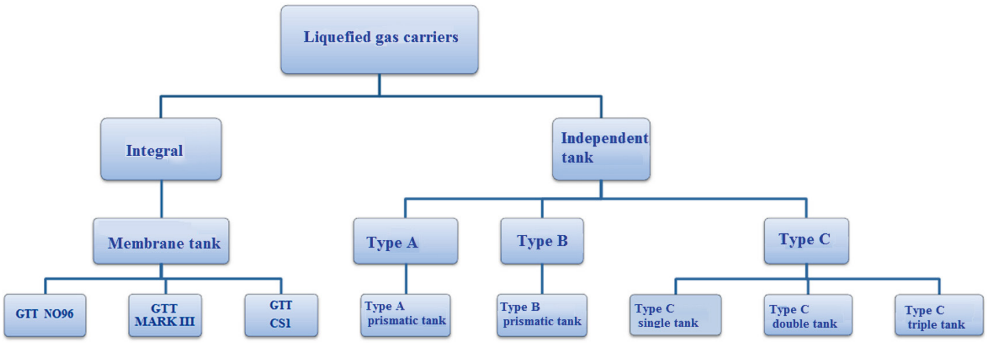
"HAI YANG SHI YOU 301", 30,000 m^3 Type C independent tank LNG carrier



Percentage of CCS Classed Type C independent Tank LNG Carriers

Characteristics of liquefied gas carriers

◆ Coverage of ship types

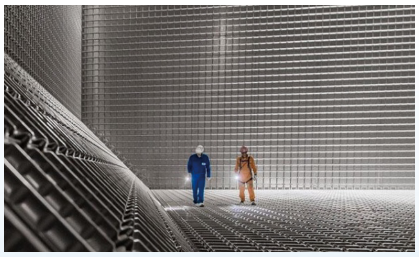


◆ Membrane tank liquefied gas carriers

- double hull, double bottom, double deck, double plate watertight transverse bulkhead;
- Integral cargo tank;
- trunk deck;
- a complete second barrier;
- suitable for large-volume loading.



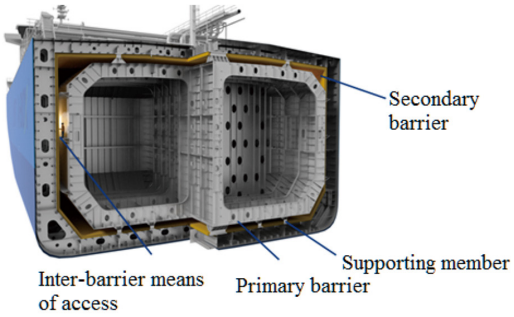
GTT NO96



GTT MARK III

Type A independent tank liquefied gas carriers:

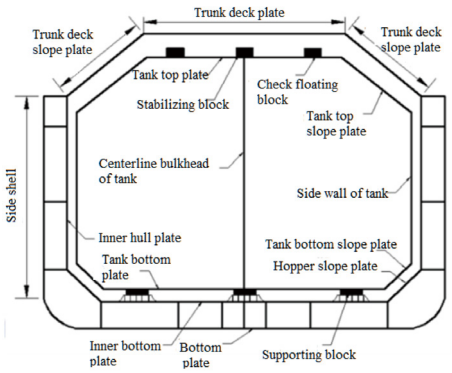
- flat deck arrangement;
- prismatic cargo tank with an independent self-supporting design;
- provision of centerline bulkhead and swash transverse bulkhead (if needed);
- a complete secondary barrier;
- primary and secondary barriers can be accessed, convenient for inspection and maintenance;
- cargo tanks can be constructed concurrently.



LNT A-BOX Type A independent tank liquefied gas carrier

Type B independent tank liquefied gas carriers:

- provision of centerline bulkhead and swash transverse bulkhead (if needed);
- design of plane bulkhead of cargo tank;
- self-supporting cargo tank;
- cargo tanks can be constructed concurrently;
- partial secondary barrier.



Typical section of Type B independent tank liquefied gas carrier

Type C independent tank liquefied gas carriers:

- type C single-tank, bi-lobe tank or muti-lobe tank design is adopted for the cargo tank;
- provision of longitudinal bulkhead and swash transverse bulkhead(if needed);
- self-supporting cargo tank;
- designed based on pressure vessels, pressure resistant structure;
- cargo tanks can be constructed concurrently;
- No need for secondary barrier.

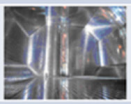
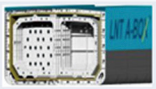


Type C triple-tank model



Lifting of Type C independent tank

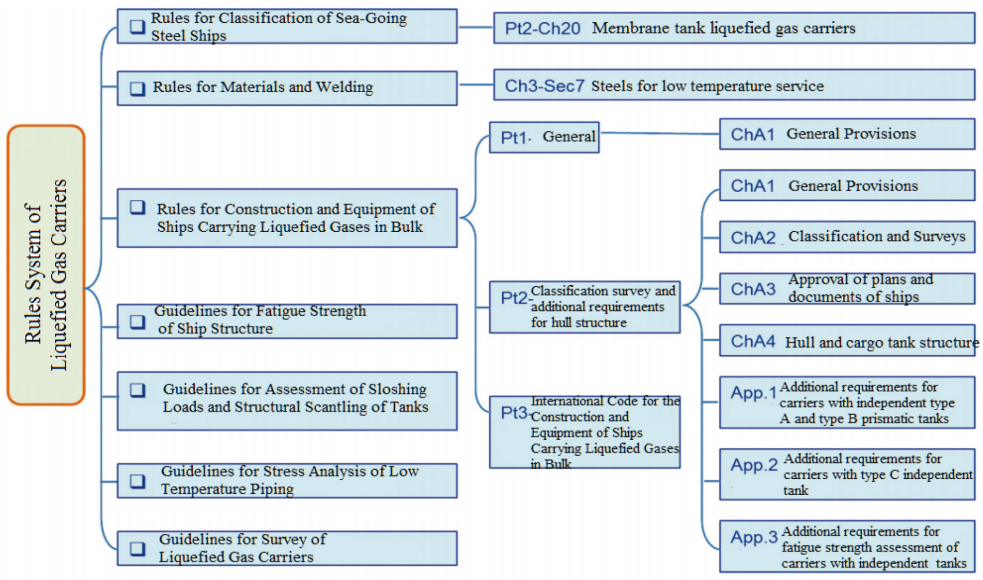
◆ Comparison between cargo tanks of liquefied gas carriers

Containment system	Membrane tank		Independent tank		
			Type A	Type B	Type C
Secondary barrier	Complete secondary barrier		Complete secondary barrier	Partial secondary barrier	Secondary barrier not needed
Design pressure	≤0.025MPa		≤0.07MPa	≤0.07MPa	High pressure (pressure vessel)
Figure					
Primary barrier material	304L stainless steel	Invar steel	Stainless steel/ 9% nickel steel/ low temperature steel	9% nickel steel/ aluminum alloy	5% nickel steel/ 9% nickel steel
Secondary barrier material	"Triplex" material	Invar steel	Aluminum plywood	Polyurethane foam	No secondary barrier
Insulation box material	Polyurethane foam		Polyurethane foam	Polyurethane foam	Polyurethane foam
Cargo pump	Immersed pump + pump tower	Immersed pump + pump tower	Deep well pump	Deep well pump	Deep well pump
Geometry	Prismatic	Prismatic	Prismatic	Prismatic	Single tank, double tank, triple tank



Rules system of liquefied gas carriers

CCS rules and guidelines for liquefied gas carriers fully cover technical requirements for liquefied gas carriers with membrane tank, type A independent tank, type B prismatic independent tank and type C independent tank.



In recent years, CCS has published relevant rules for LNG carriers, LNG bunkering ships and LNG fuelled ships, covering technical standards of the overall water industrial chain of LNG.

- Rules for Classification of Sea-going Steel Ships
- Rules for Materials and Welding
- Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
- Guidelines for Design and Installation of Gas Fuel Engine Systems of Liquefied Gas Carriers
- Rules for Liquefied Natural Gas Bunkering Vessel
- Rules for Pontoons of LNG bunkering
- Rules for Ships using Natural Gas as Fuel
- Guidelines for LNG Bunkering Operation
- Guidelines for Survey of Liquefied Gas Carriers
- Implementation Guidelines for Liquefied Natural Gas Carriers Adapted for Floating Storage Units
- Guidelines for Division of Dangerous Zones and Electrical Provision of Tankers
- Guidelines for Construction Monitoring of Hull Structures
- Guidelines for Natural Gas Fuel Ready Ships
- Guidelines for Ships Using Alternative Fuel
- Guidelines for Stress Analysis of Low Temperature Pipes
- Guidelines for Assessment of Sloshing Loads and Structural Scantling of Tanks
- Guidelines for Fatigue Strength Assessment of Ship Structure based on Fatigue Spectrum Analysis
- Guidelines for the application of liquefied petroleum gas fuel in ships
- Guidelines for the application of ammonia fuel in ships

Application of LNG fuel tanks

◆ Membrane tank LNG fuel tank

◎ **Advantages such as high utilization ratio of tank volume, small loss of cargo carrying capacity and flexible management of boil-off gas and applicable to the following ship types:**

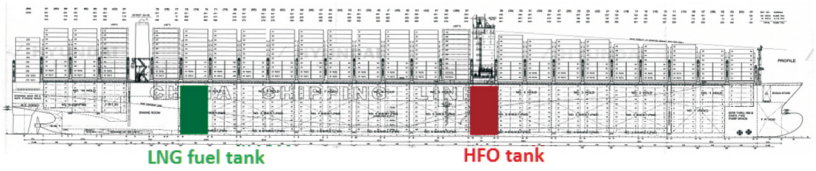
- large, very large container ships
- large, very large ore carriers
- large bulk carriers etc.





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◆ Type A tank LNG fuel tank

◎ **A sound and self-supporting primary barrier and totally independent secondary barrier;**

◎ **Higher safety due to two layers of totally independent barrier systems;**

◎ **Two barrier systems can be accessed, convenient for inspection and maintenance;**

◎ **Construction cost has advantage;**

◎ **Relatively simple construction technique;**

◎ **Prismatic design, higher utilization ratio of tank volume;**

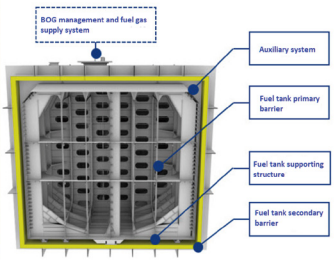
Applicable to:

- large, very large container ships
- large, very large ore carriers
- large bulk carriers etc.



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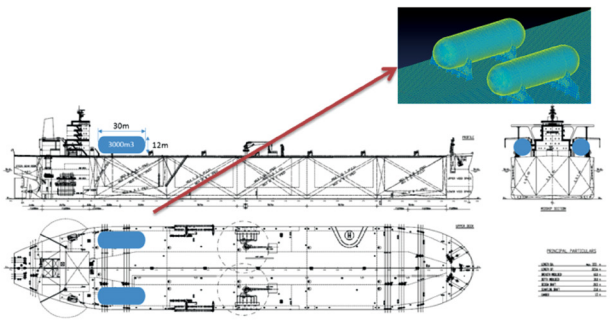
◆ Type B tank LNG fuel tank

◎ **Higher utilization ratio of tank volume;**
◎ **Effective control of sloshing;**
◎ **Partial secondary barrier with good reliability;**
◎ **Relatively simple construction technique;**
◎ **Standardized supporting structure for easy assembly;**
◎ **Secondary barrier is located outside the primary barrier, which can contain leakage of low temperature liquid and reduce accidental risk; Applicable to:**

- large, very large container ships
- large, very large ore carriers
- large bulk carriers etc.

◆ Type C tank LNG fuel tank

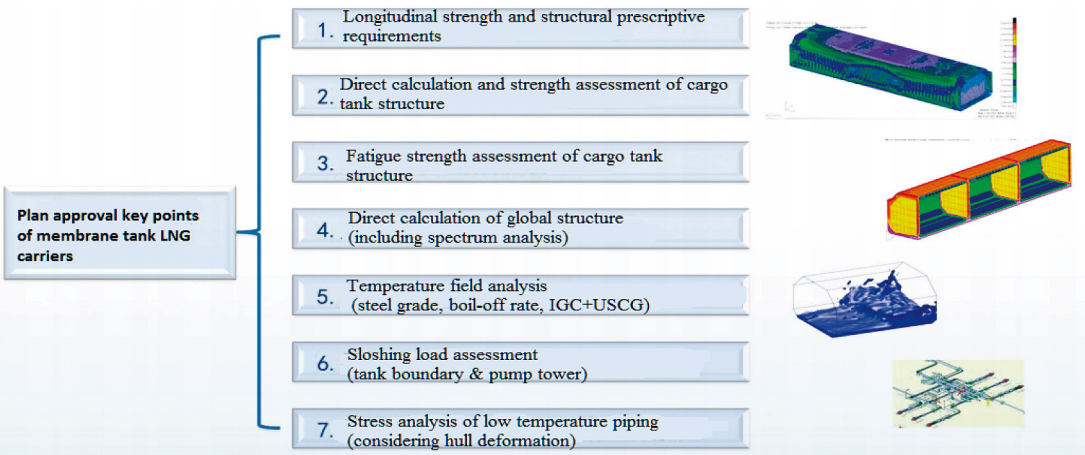
◎ **High pressure resistance capability of fuel tank;**
◎ **Mature design and manufacturing technology;**
◎ **The fuel tank is built concurrently with hull construction so as to shorten the overall construction period.**



Key technologies of ship types

CCS has established a complete rules system for liquefied gas carriers in the field of membrane tank LNG carriers, type C independent tank LNG carriers type C independent tank LNG carriers, type A independent tank LPG carriers, liquefied ethane carriers, liquefied ethylene carriers and small LPG carriers, accumulated rich experience in the real ship plan approval of liquefied gas carriers and construction survey, and mastered key technologies of ship types related to liquefied gas carriers.

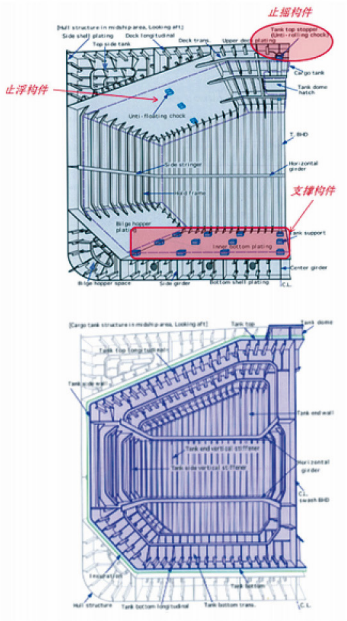
◆ Research on key technologies of membrane tank liquefied gas carriers



◆ Research on key technologies of liquefied gas carriers with independent type A and type B prismatic tanks

Liquefied gas carriers with independent type A and type B prismatic tanks

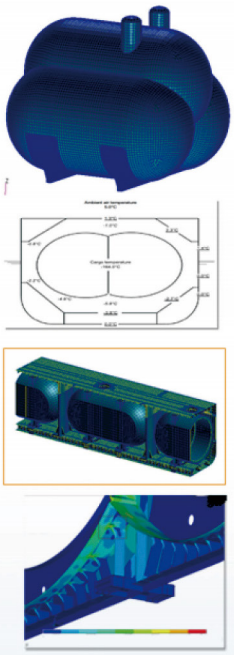
1. Rules check of hull and cargo tank structures
2. Direct calculation and strength assessment
3. Strength analysis of cargo tank supporting structure
4. Sloshing load and strength assessment
5. Temperature field calculation and steel grade selection
6. Fatigue strength assessment of hull and cargo tanks
7. Fatigue crack propagation and leakage analysis of cargo tanks



◆ Research on key technologies of liquefied gas carriers with type C independent tank

Liquefied gas carriers with type C independent tank

1. Rules requirements for hull structure and FE analysis
2. Rules requirements for type C independent tank and FE analysis
3. Strength analysis of independent tank supporting structures (including saddle)
4. Temperature field calculation and steel grade selection
5. Sloshing load and strength assessment



◆ Key technologies of liquefied gas carriers

◎ Structural safety

1) Strength check of hull structures and cargo tank structures based on prescriptive requirements of rules;

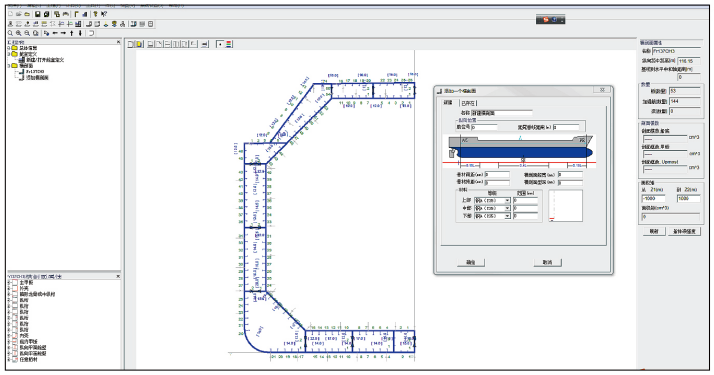


Figure: Check of scantling requirements of rules

2) Direct calculation and analysis of hull structures and cargo tank structures;

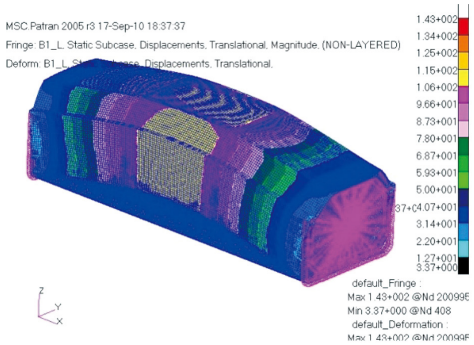


Figure: Direct calculation and analysis of membrane tank LNG carriers

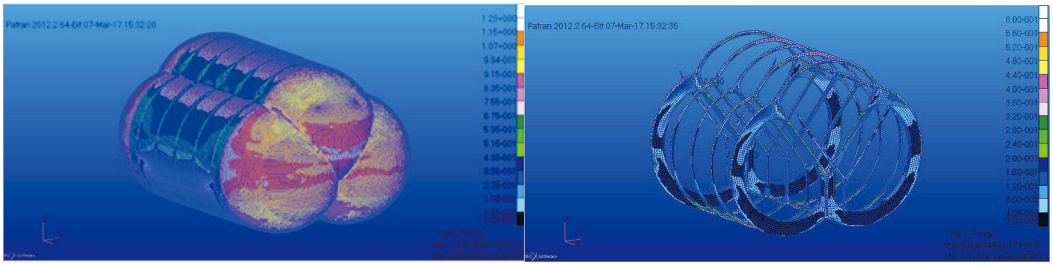


Figure: Direct calculation and analysis of cargo tank of type C independent tank LNG carriers

3) Strength analysis of supporting structures of independent cargo tanks

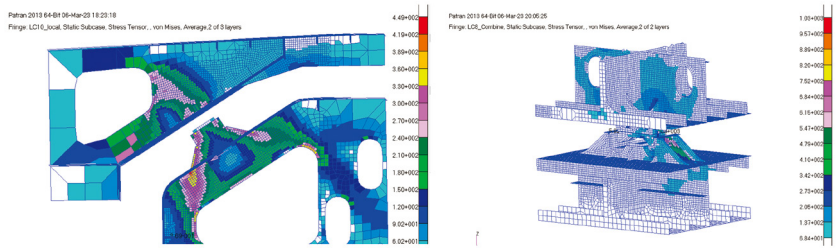


Figure: Strength analysis of supporting structures of type B independent tanks

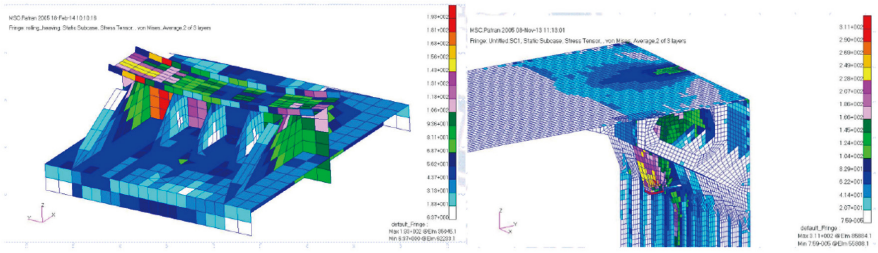


Figure: Strength analysis of supporting structures of type C independent tanks

4) Fatigue analysis of Y-shape weld joints of type C independent tanks

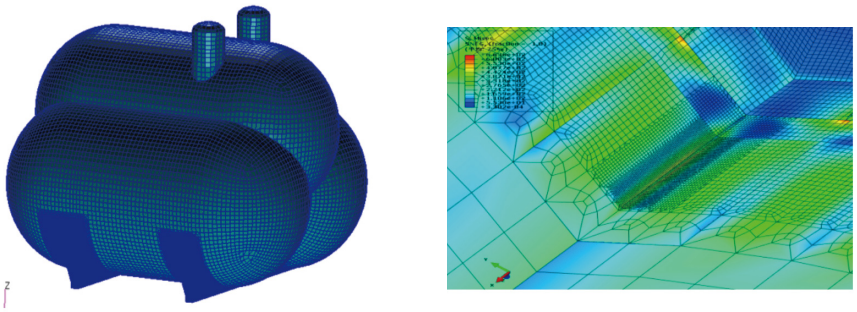


Figure: Fatigue analysis of Y-shape weld joints of type C independent tanks

5) Finite element analysis of whole ship

Dynamic Load Approach (DLA) is based on the most severe conditions during the operation of LNG carriers obtained by hydrodynamic analysis and calculation. By means of finite element analysis of whole ship, structural strength assessment is carried out to each primary structure of ship in terms of three failure modes, i.e. buckling, yielding/ultimate strength and fatigue.

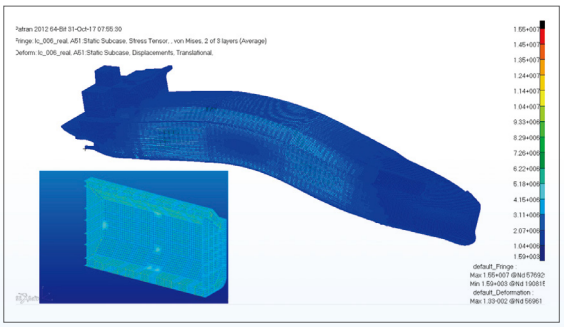
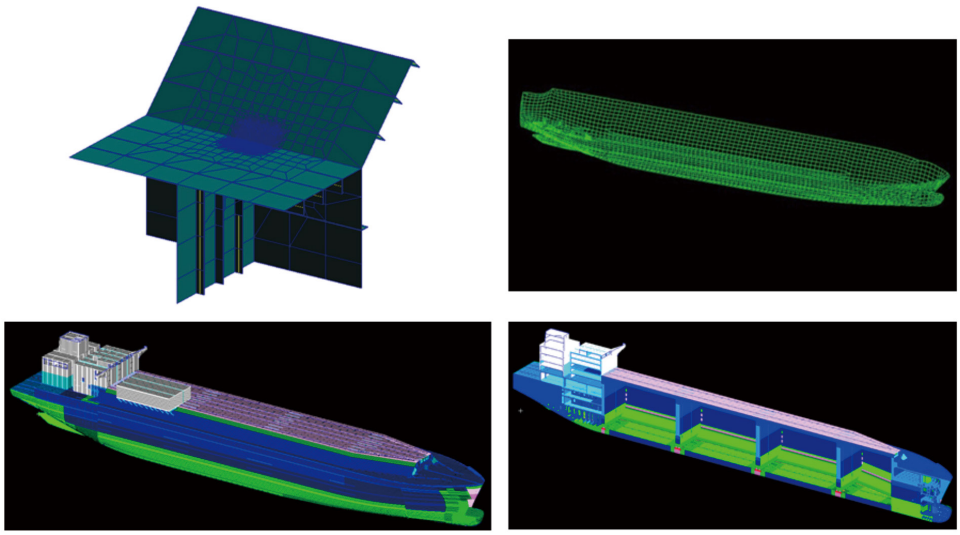


Figure: Finite element analysis of whole ship of membrane tank LNG carriers

6) Fatigue strength assessment of hull structure based on spectrum analysis



◎ **Cargo containment system**

1) Temperature Field Calculation and Analysis

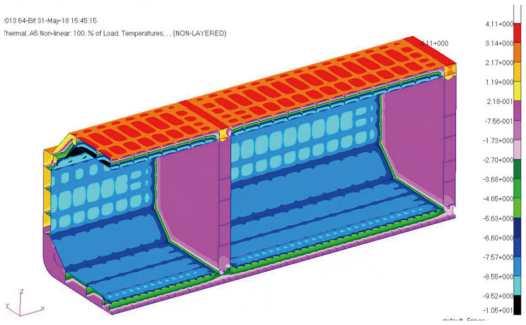


Figure: Prediction and calculation results based on USCG

2) Calculation and analysis of sloshing loads;

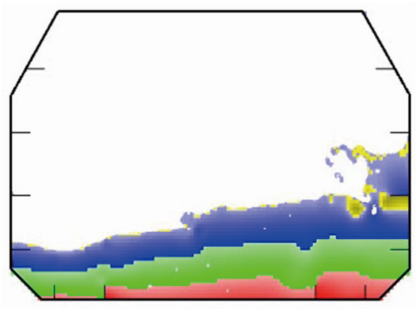


Figure: Sloshing load simulation and sloshing test

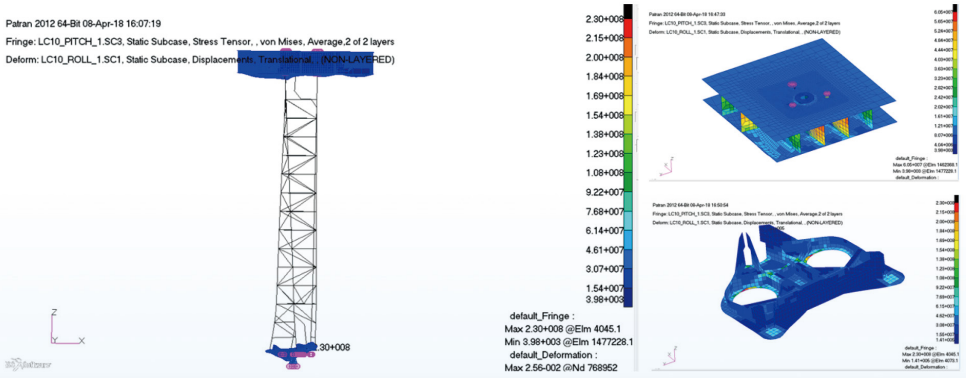
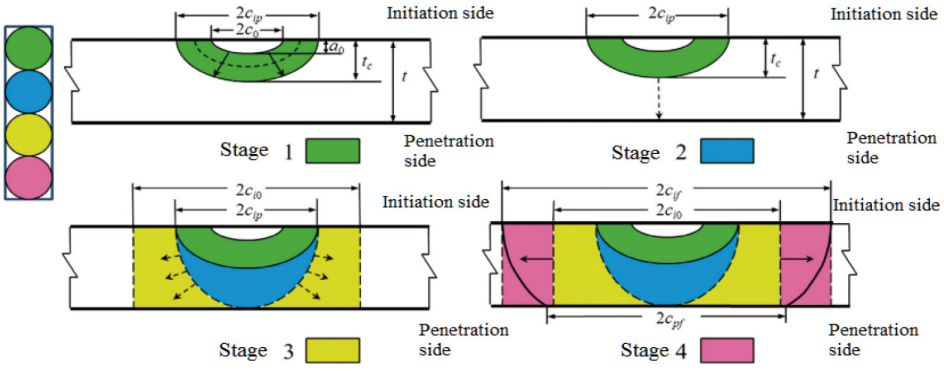
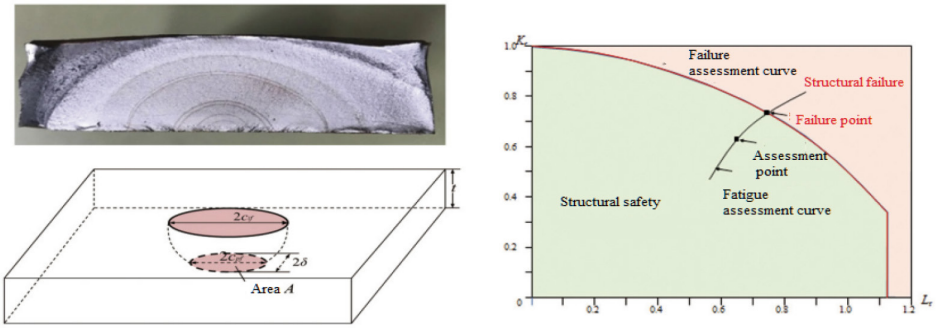


Figure: Pump tower strength analysis

3) Fatigue crack propagation and leakage analysis for type B tanks

Based on the theory of fracture mechanics, the crack propagation analysis of the type B tank is carried out to ensure the integrity of the primary barrier within the design life; the size of assumed through thickness crack after 15 days/3 times the survey period is predicted, so as to determine the leakage amount of the cargo tank. The above calculation and analysis methods have been integrated into CCS custom-developed software.





◎ **Special technology**

1) Stress analysis of low temperature pipes

Assessment and analysis of total stress due to pipe weight (including inertia force), pressure in the pipe, thermal contraction and all load effects caused by hogging and sagging, taking into account thermal expansion values and matching with installation technique.

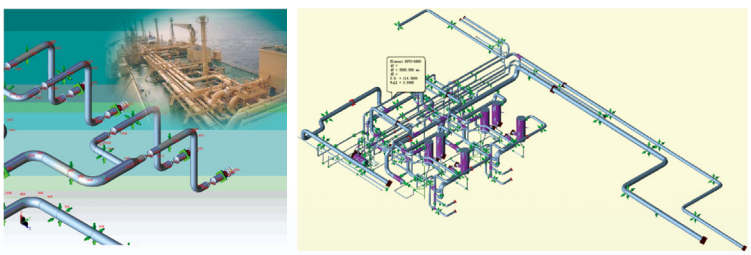
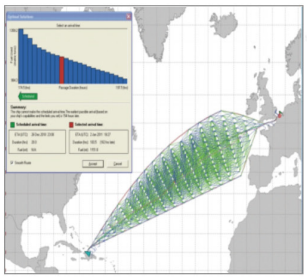
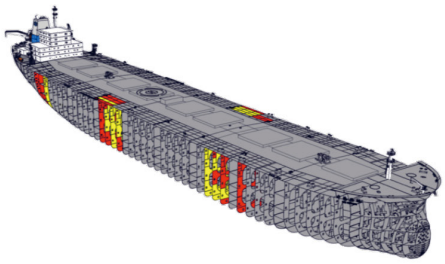


Figure: Stress of low temperature pipes

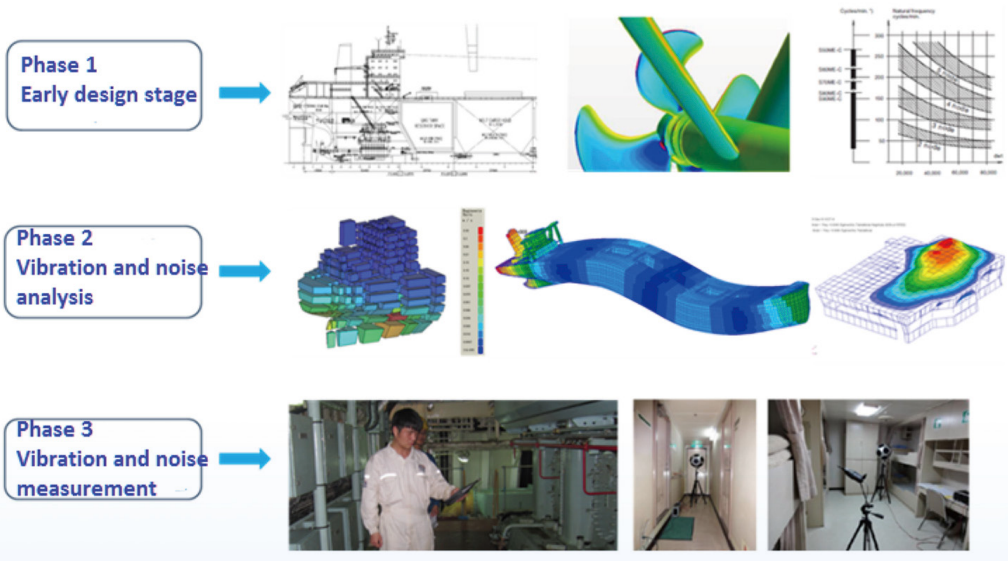
2) Intelligentization

CCS can provide shipowners with intelligent technology application service in 8 categories, i.e. intelligent cargo management, route optimization, hull structure full-life-cycle management, condition monitoring of engine room equipment and assistant decisionmaking, energy efficiency parameter monitoring and assistant decision-making, ship speed optimization, optimal trim and stowage, intelligent integration platform.

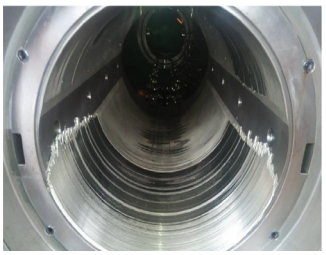

3) Vibration and noise assessment

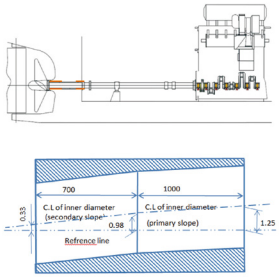
CCS can provide customers with vibration and noise assessment service. Measures to reduce vibration and noise are proposed in accordance with the analysis results of vibration and noise, so that it is easier for ships to satisfaty the requirements of conventions and codes. For harmful vibration and noise on the ship, the cause is analyzed and solutions are provided to reduce vibration and noise.



4) Shafting vibration and alignment

By means of analysis and assessment of shafting vibration and alignment characteristics, CCS provides technical support to construction technique plan of shafting arrangement and alignment, which can effectively avoid shafting damage and over-heating. CCS can provide cause analysis of failure and put forward solutions





◎ **Survey during construction**

1) Survey technology during construction of LNG carriers

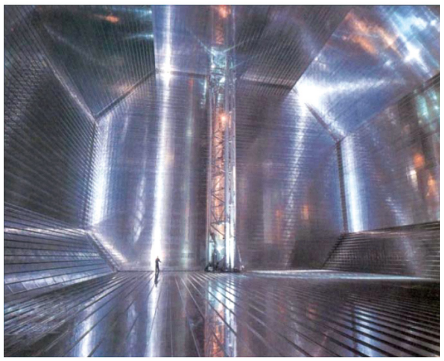
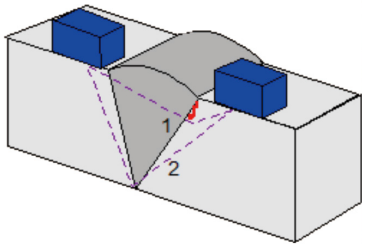




Figure: Survey of membrane tank LNG carriers and type C tank LNG carriers

2) Advanced NDT technology



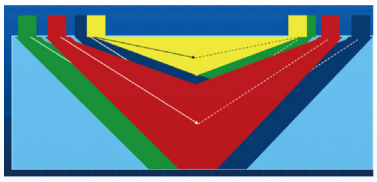


Figure: TOFD Time-of-Flight Diffraction (TOFD) Technique



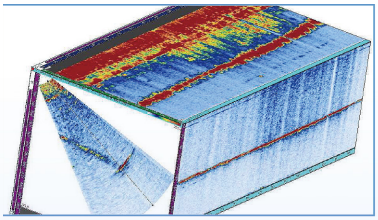


Figure: Phased Array Ultrasonic Testing (PAUT) Technique

CCS characters of classification and class notations for liquefied gas carriers

◆ Typical characters of classification and class notations for membrane tank LNG carriers

★ CSA LNG Carrier, Type 2G, Membrane Tanks; Max. Cargo Density 0.50t/m^3, Max. Vapour Pressure 0.035MPa; Min. Cargo Temperature -163 ° C; CM; COMPASS(R,D,F) SFA(WW, 40); FL(40); Loading Computer(S,I,D); Emergency Towing Arrangements; i-Ship(Ai, Ri, Nx, Hx, Mx, Ex, Cx, I); PSPC(B); In-Water Survey; ERS; EPC1

★ CSM AUT-0; DFD; OMBO; SCM; G-ECO(BWM(T), VIBx, NOIx); G-EP(OIL1, NEC2, INC, AFS, GPR)

◆ Typical characters of classification and class notations for type B tank ethane carriers (VLEC)

★ CSA Liquefied Gas Carrier for Ethane, Type 2G, Type B Independent Tank; Max. Cargo Density 0.61t/m^3; Max. Vapour Pressure 0.025MPa; Min. Cargo Temperature -90 ° C; CM; COMPASS(R,D,F); PSPC(B); FL(25); loading Computer(S,I,D); In-Water Survey; ERS

★ CSM AUT-0; SCM; BWMS

◆ Typical characters of classification and class notations for type A tank LPG carriers (VLGC)

★ CSA Liquefied Gas Carrier for Butane, Butane-Propane, Type 2G, Type A Independent Tank; Max. Cargo Density 0.6t/m^3, Max.Vapour Pressure 0.025Mpa, Min. Cargo Temperature -50 ° C; CM; COMPASS(R,D,F); PSPC(B); FL(25); loading Computer(S,I,D); In-Water Survey; ERS

★ CSM AUT-0; SCM; BWMS

◆ Typical characters of classification and class notations for type C tank LNG carriers

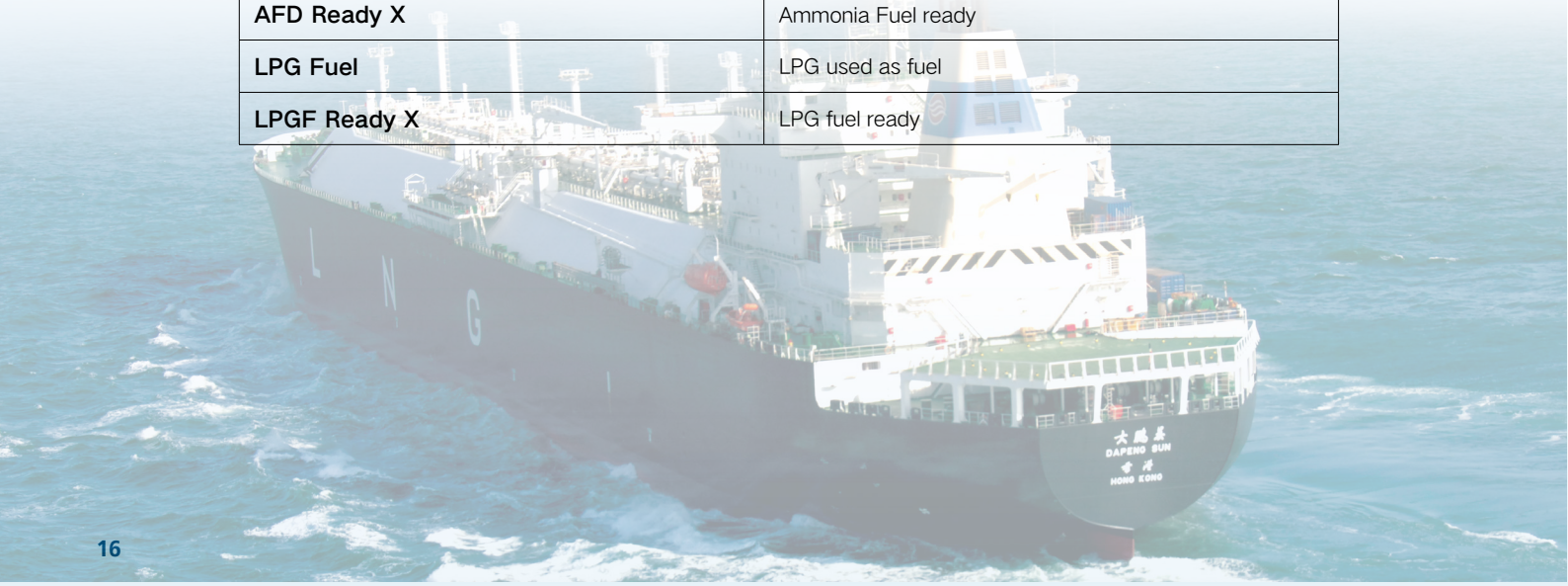
★ CSA LNG Carrier, Type 2G, Type C Independent Tank; Max. Cargo Density 0.5t/m^3, Max.Vapour Pressure 0.35MPa, Min. Cargo Temperature -163 ° C; CM; COMPASS(R,D,F); PSPC(B); FL(25); loading Computer(S,I,D); In-Water Survey; ERS

★ CSM AUT-0; SCM; BWMS



Main class notations for liquefied gas carriers

Class notation	Description
Liquefied Gas Carrier	Liquefied gas carrier
LNG Carrier	LNG carrier
Liquefied Gas Carrier for Butane, Butane-propane mixture	Liquefied gas carrier for butane-butane-propane mixture
Liquefied Gas Carrier for Ethane	Liquefied gas carrier for Ethane
Max. Vapour Pressure xxx Mpa	Maximum vapour pressure
Min. Cargo Temperature xxx ℃	Minimum cargo temperature
Max. Cargo Density xxx t/m3	Maximum cargo density
Natural Gas Fuel	Natural gas used as fuel
LPG Fuel System	LPG used as fuel
Type 1G	Type 1G
Type 2G	Type 2G
Type 2PG	Type 2PG
Type 3G	Type 3G
Membrane Tank	Membrane tank
Type A Independent Tank	Type A independent tank
Type B Independent Tank	Type B independent tank
Type C Independent Tank	Type C independent tank
Electrical Propulsion System	Electrical propulsion system
Ammonia Fuel	Ammonia used as fuel
AFD Ready X	Ammonia Fuel ready
LPG Fuel	LPG used as fuel
LPGF Ready X	LPG fuel ready



Ship type service:

◆ Joint development of ship type

Ship type is jointly developed in conjunction with the shipyard and designer. By making use of CCS advantage in information and technology, based on comprehensive information such as route, port and channel and by means of advanced technical rules, technical economic analysis and structural and performance calculation analysis, effective technical solutions are provided in order to jointly develop top quality ship type.

◆ Optimization and upgrading of ship type

Reliable structural optimization and upgrading solutions are provided by means of scientifically reasonable quantitative and qualitative research and analysis based on current characteristics of ship type, so as to provide strong support for ship type upgrading, making the ship safer, more environmentally friendly, more economical and more efficient.

◆ Approval of ship type

Compliance evaluation is carried out on ship types provided by the shipyards and designers in accordance with agreed rules and conventions, and ship type approval certificate is issued to lay the foundation for ship type promotion and plan approval in the future.

◆ Recommendation of ship type

Excellent and reliable ship type is recommended to industry in accordance with the basic needs of the clients and based on CCS ship type performance accumulation and advantage in technical experience, covering principle particulars, structural arrangement, and model selection of main engine, energy efficiency indicator, emission scheme and intelligentizing scheme.

◆ Technical training of clients

Based on the needs of the clients, CCS can provide comprehensive and customized technical training service related to rules, software and technical solutions.

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CHINA CLASSIFICATION SOCIETY
中国船级社

Contact information:

Technical support: Yang Yan
Tel: 021-61089274
E-mail: yangyan@ccs.org.cn

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