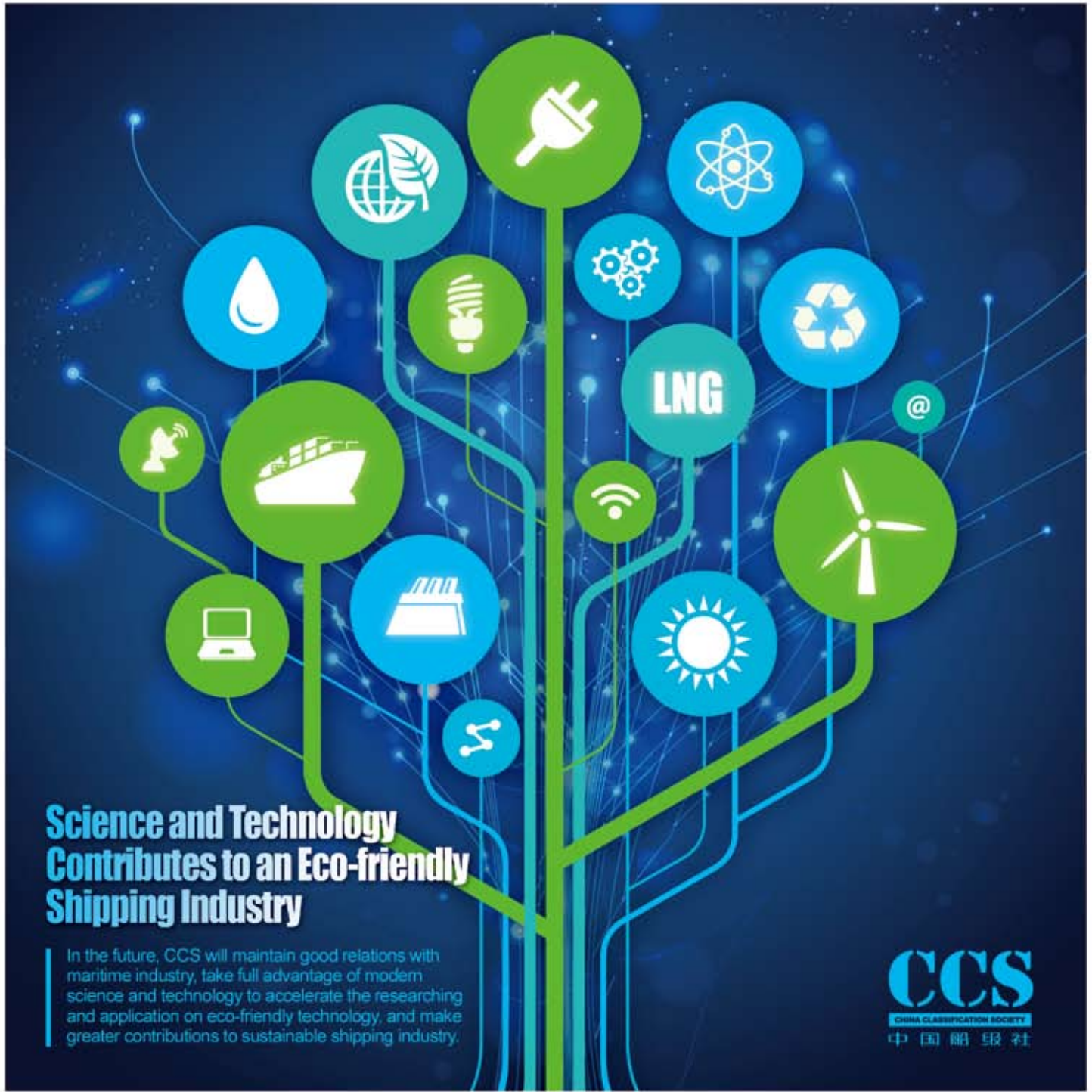


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# Partnership



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## Science and Technology Contributes to an Eco-friendly Shipping Industry

In the future, CCS will maintain good relations with maritime industry, take full advantage of modern science and technology to accelerate the researching and application on eco-friendly technology, and make greater contributions to sustainable shipping industry.

**CCS**  
CHINA CLASSIFICATION SOCIETY  
中国船级社

**The fifth issue in 2015**  
(The 17<sup>th</sup> issue in total)

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## CCS Granted the First Additional Class Notation of EOM for Ship Energy Efficiency Real Time On-line Monitoring



Recently, CCS granted the first additional class notation of vessel energy efficiency on-line integrated monitoring (EOM) to 40000DWT bulk carrier “Pearl Sea” of COSCO Bulk Carrier, constructed

by Tianjin Xingang shipyard. This is the first time that CCS granted such class notation.

CCS is the first classification society that clearly proposes additional class notation of vessel energy efficiency on-line integrated monitoring (EOM) and solutions related to vessel energy efficiency management. “Vessel energy efficiency on-line intelligent management system” developed by CCS and COSCO Bulk meets the requirements related to CCS issuance of EOM to vessels and is installed for the first time on the new ship. The system has been tested through strict trial voyage and satisfies survey requirements.

Vessel energy efficiency on-line intelligent management system consists

of vessel and shore versions, with functions of energy efficiency management, energy management, energy-consuming equipment condition monitoring, navigational condition monitoring, navigation status analysis, SEEMP management and report management. Through synchronizing data with shore-based systems and selecting vessel terminal data, including general operation parameters of boilers, main and auxiliary engines, data from shaft power meter, anemograph, gradiometer, GPS, log and detecting instruments, the system could monitor and analyze vessel energy consumption, equipment working condition and navigation data through vessel and shore terminals.

With this software system, shipping companies could analyze energy efficiency influencing factors based on real time operating parameters and energy efficiency indexes of vessels, and meet the requirements of vessel energy efficiency management at the same time. This system helps shipping companies to meet requirements of EU MRV and provides data for CCS vessel energy efficiency certification and management system. It also offers data for smart vessel research and promotes development of smart vessel. This system gives guidance for figuring out energy management plan, improving efficiency, looking for fuel saving plan, reducing operating costs and creating profit for shipping companies.

## CCS Cape Town Office was Officially Opened

CCS Cape Town Branch opening ceremony was held successfully on Sep. 4, 2015 in Cape Town, South Africa. More than 50 distinguished guests including officials from the Social Development Department and the Finance Department of the Cape Town Province, the Maritime Safety Administration of the South Africa, the Commercial Section of Chinese Embassy in South Africa, Chinese Consulate General in Cape Town and representatives from COSCO Africa, China Shipping Africa and Johannesburg Branch of Bank of China (BOC), French CMA-CGM Africa, SMIT, UNICORN and some local shipping companies, ship repairing yards and suppliers participated in the opening ceremony.

It is the first branch office of CCS established in the southern part of African continent which will aim at strengthening the Sino-African cooperation

in shipping, shipbuilding and ship repairing services and at expanding our business market in Africa. The establishment of CCS Cape Town Branch is an important step forward of CCS to promote the Chinese Government’s strategic initiative “One Road One Belt” and it will be a powerful support to our clients from the marine and offshore sector in West, East and South Africa.

Up to now, CCS has established more than 80 branches and offices spreading all over Asia, Europe, America, Africa and Oceania and formed up a convenient global service network.



## CCS Passed SGS Management System Audit

On 25<sup>th</sup>~28<sup>th</sup> August, 2015, the third party certification body approved by IACS and QACE conducted IACS and QSCS audit on CCS. In addition, management system of CCS was also audited according to ISO 9001, ISO 14001 and OSHAS 18001. Five auditors made an comprehensive audit to CCS according to audit program to ensure that

CCS management system meets related requirements.

Auditors from IACS operation center QACE observed and assessed the audit. In addition, LISCR of Libya also observed the audit according to flag State instructions.

## CCS Held Marine Engineering Technical Seminar in Houston

On 12 September, 2015, invited by International Association of Ocean Engineering, CCS American Center held marine engineering technical seminar in Houston. General Manager Yang Qi, chief marine engineering representative Li Linbin and R&D manager of marine technical center Doctor Liang Yuanhua attended the seminar. On behalf of CCS, Yang Qi made a speech and systematically introduced development of CCS, especially rapidly developing international services in recent years. Liang Hua gave a speech of *Technology research and development of CCS marine engineering* and introduced CCS mobile platform, FPSO/FLNG structure, underwater production system, drilling system and standard system construction, as well as technical research and development results of special business fields. Li Linbin gave a speech of *Marine environmental conditions in marine engineering structure design* and introduced computational process of design conditions in hurricane/typhoon environment, environmental

parameter selecting principles in different structure designs, as well as special concerns of marine environment in structure design and operation.

More than 50 representatives from Shell, XOM, CVX and BP, design companies of Technip, FloaTec and Cotec, ABS, DNV-GL as well as TAMU attended the seminar. In addition, more than 20 students majoring in marine engineering from NTNU, Stevens Institute of Technology and TAMU attended the seminar though network broadcast. Speeches of CCS aroused broad interests of participants, they appreciated highly the rapid development and service ability of CCS. This is the first time CCS holds service introduction and technical seminar. In this way, CCS effectively publicized its technical level and service ability, got closer to international marine engineers and technician, further promoted marine research and development, communication and cooperation with international industry.

## CCS Attended South America Maritime Exhibition

In mid-August of 2015, Marintec South America was inaugurated in Rio de Janeiro, Brazil. CCS American center attended the exhibition as representative.

Marintec South America is the grandest and most professional maritime exhibition in the world. It is the only exhibition in the field of ship building and marine technologies, which provides a best business communication platform for service supply chain. Attending the exhibition further raised profile of CCS in Central and South America and laid good

foundation for market development.

CCS introduced its main services, latest research products, latest service capacity, international communication and cooperation and development in maritime engineering field in the exhibition. During the exhibition, CCS visited important clients of banks and ship-owners. CCS had an informal discussion with the chairman of ABDI on the development opportunity, project and problems in this area.

## CCS Hold Technical Seminars in Cyprus and Athens

On 17<sup>th</sup> September 2015, CCS held technical seminars in Cyprus and Athens, this is the first time that CCS hold technical seminars in these two places at the same time. More than 10 top technical managers and technicians from 8 Cyprus shipping companies and 29 top technical managers and technicians from 23 Greek shipping companies of NAVIOS SHIPPING, DIANA SHIPPING, COSTAMARE SHIPPING, MARAN GAS MARITIME etc. attended the seminars.

CCS introduced its general development, technical capacity, Hull Inspection and Maintenance System (HIMS) developed to improve vessel management level, value-added services of OTA and SEEMS, NO<sub>x</sub> and SO<sub>x</sub> emission control research outcome, ballast water treatment system and LNG power system, as well as the concept of smart ship and technique application. Representatives from shipping companies were interested in



above contents and discussed lively with CCS. Some companies paid high attention to value-added services and hoped to know details.

Through the above seminars, CCS showed its technical capacities, value-added services and solutions for hot topics to Cyprus and Greece shipping industries. CCS brand image in Mediterranean was further enhanced.

## CCS Held Seminar on *Sea-river vessel Design Evaluation Standard*

On Sep. 22<sup>nd</sup>~23<sup>rd</sup> of 2015, CCS Rules and Technical Center Zhoushan office held Seminar on Sea-river vessel design evaluation standard. Experts from Zhoushan port authority, China MSA and departments affiliated to it, Zhejiang vessel inspection bureau, Yangtze River ship-owner association, design units, shipping companies, colleges and universities attended the seminar.

In order to support and ensure implementation of the development strategy of “the Belt and the Road”, CCS signed Strategic cooperation agreement with Zhoushan municipal government on Mar. 26<sup>th</sup>. On Jul. 22<sup>nd</sup>, CCS approved the establishment of CCS Rules and Technical Center Zhoushan office and determined its three functions and eight responsibilities, mainly related to research on standard of sea-river vessels. This is the first seminar to show research results CCS achieved in field of developing sea-river vessel standards and regulations. At the seminar, experts discussed Sea-river vessel design evaluation standard and came to a conclusion that the technical line is rigorous and reasonable, data and technical processes are convincing, which fully reflect the work ethos of “Explore fact and create achievement”. The standard was well received by all the experts.

Sea-river vessel design evaluation standard adopts materials of hydrological

conditions, environmental data of winds and waves of coastal waters for the first time. Experts developing the standard forecast, compared and analyzed wave data of sea-river vessels, conducted researches on wind and wave conditions of “certain sea area, certain route and certain ship type” as well as wave load, on the basis of the safety principle of “load being the priority” and the technical line of combing “numerical forecasting, theoretical analysis and experimental verification”, standard compilers conducted researches on vessel wave load, structural strength, stability, load line and equipment, improved requests on wave load, structural strength and steel strength. Compiling works covered examination and certification, load line marks, maneuverability. Technical requirements about marine engines, electrical and ship safety were also improved. In addition, model verification and test onboard are synchronously conducted to verify numerical forecasting and theoretical analysis.

After lively and practical discussion, experts agreed that Sea-river vessel design evaluation standard meets requirements of Zhoushan Sea-river service center. Experts also made suggestions about ship supervision and supporting system constructions, which provided powerful support to development of sea-river cargo vessels.

# Advantages of Lithium-ion Battery Set

By Ma Jilin

Lead-acid battery is widely used on ships for communication, illumination and starting the engine. It can also be used as power battery, such as diesel-electric engine submarine and inland craft. SONY invented a kind of lithium-ion battery, with carbon used as the negative electrode, and lithium-ion chemical compound used as positive electrode. When charged, the positive electrode generates lithium ion which was transferred to the negative electrode through electrolyte.

Positive electrode of lithium-ion battery is generally made of active lithium compounds, the negative electrode is carbon compound with specific molecular structure. Common positive electrode material is  $\text{LiCoO}_2$ . When charged, the electric potential makes the positive electrode to release lithium-ions and then these lithium-ions will be inlaid into lamellar structure carbon of the negative electrode. When discharged, the lithium-ions separate out from the lamellar structure carbon and combine with chemical compound of the positive electrode. Movement of lithium-ions generate the current.

Lithium-ion battery mainly constitutes with positive electrode, negative electrode, separator and electrolyte. Cost of positive electrode material generally comes to 30% of the total cost. Therefore the lithium battery is generally named after the material of the positive electrode. At present, lithium cobalt oxides, lithium nickel oxides, lithium manganese oxide,  $\text{LiMn}_{1-x}\text{Ni}_x\text{Co}_y\text{O}_2$  positive electrode materials of lithium batteries. Among all the positive electrode materials,  $\text{LiFePO}_4$  is the cheapest one and it is also an environmental protection material. In addition,  $\text{LiFePO}_4$  is of excellent performances of high current discharge(5-10C

discharge), stable discharge voltage, security and lifetime than other materials. It is generally recognized as the most suitable battery for power. At present, the  $\text{LiFePO}_4$  has been developed into uniform nanometer-scale particles, dramatically increased superficial area further improves discharge power and stability of the battery.

## Requests on storage battery in CCS standards

CCS makes requests on storage batteries, but mainly on lead-acid batteries. As for the batteries that charging power is greater than 2 kW: the battery should be placed in isolated cabin or bin on open deck, atmospheric conditions are also regulated;

Charging equipment: Charging time should be less than 10h. Short-circuit protection is necessary, safeguard relay should be installed near the battery pack. Each charger should protect the batteries when the charger is under poor charging condition or the battery is discharging due to some failures. The charger should not be installed in the battery cabin, unless antiknock devices are installed.

Then battery should not be installed in living rooms, except the battery that would not produce noxious gas when charged, would not leak when inclined at  $40^\circ$ . In addition, the battery should be acid and alkali mists proofing, be lighted than 100kg and be appropriate for marine swing environment.

Evaluation indexes of batteries for communication and illumination mentioned in Marine Equipment Standards mainly include: appearance inspection (including contour dimension inspection and terminal inspection), electrode inspection, gas

tightness inspection, sealing material, insulation resistance, capacity (startup ability and reserve capacity), maximum discharge current at the inclination angle of 22.5°, resistance to overcharging, sealing reaction efficiency, overcharging lifetime(batteries for communication and illumination), charge holding facility, anti-knock quality, acid mist resistance, incline resistance, swing resistance and antiknock resistance.

Above all, neither specifications nor the vessel standards make request on safety performance of the lithium battery, such as thermal stability. In fact, lithium-ion battery performance tests listed in vessel standards are insufficient. Main evaluation indexes of lithium ion are based on IEC61960-2011, safety indicators are mainly based on UL-1642.

### ■ Type test determination

The primary task of lithium-ion battery approving process is to verifying whether it can be used on ships. The tests were determined

on basis of multi-aspect information, according to CCS standards, international standards and product technical standards proposed by manufactories, as well as marine environment characteristics.

The tests of lithium-ion battery set which are composed of battery cells focus on whether the battery can be appropriate for marine environment. Therefore marine environment tests such as inclination, swing, vibration and flame retarding tests are necessary, according to IEC60945-2002. In addition, lithium-ion battery is equipped with self-protection circuit board to avoid over-charge and short circuit. Tests on PCB are also necessary, mainly refer to electrostatic discharge tests.

It is observed that no matter from the aspect of performance tests or the aspect of safety tests, requests on lithium-ion battery is more strict than the tests on lead-acid battery.

### ■ The possibility to replace lead-acid battery

At present, requests on marine products mainly focus on

Table 1: Performance tests of lithium-ion battery

Test number	Test name	Test requirements
①	Rated capacity	Not less than rated value provided by manufacturer;
②	-20°C Discharging capacity	Discharging capacity should be no less than 30% of rated capacity;
③	55°C Discharging capacity	Discharging capacity should be no less than 95% of rated capacity.
④	20°C High multiplying power discharging capacity	Discharging capacity should be no less than 90% of rated capacity
⑤	Vibration	No bleed, No fire, No Explosion
⑥	Cycle life	Battery cycle life should be no less than: 2000 weeks
⑦	Charge holding and recovering capacities under normal temperature	Battery charge retention rate should not be less than 90% of rated capacity under normal temperature and high temperature, capacity recovering capacity should not be less than 95% of rated capacity.
⑧	Charge holding and recovering capacities under high temperature	

Table 2: Safety indicator tests of lithium-ion battery cell

Test number	Test name	Test requirements
A	High-altitude simulation	NO quality loss, No leakage, No short circuit, No break, No explosion, No fire
B	Temperature cycle	No quality loss, No leakage, No short circuit, No break, No explosion, No fire
C	Over discharging	No overheat, No leakage, No bleed, No short circuit, No break, No explosion, No fire
D	Over charging	No overheat , No short circuit, No explosion, No fire
E	External short circuit	No break, No explosion, No fire, Battery temperature should be no more than 150°C
F	Fall	No bleed, No explosion, No fire
G	Heated	No explosion, No fire
H	Extruded	No explosion, No fire
I	Reverse charge	No explosion, No fire
J	Collision	No explosion, No fire
K	Impact	No quality loss, No leakage, No bleed, No short circuit, No break, No explosion, No fire
L	Pierced	No explosion, no fire

improved performance. At the same time, the industry makes more and more requests on safety, environmental protection, economy and some other aspects. As a kind of traditional energies, lead-acid battery is restricted by environmental protection(lead), working conditions(ventilation and anti-explosion), inefficiency and many other factors. Therefore, research on new energy to replace lead-acid battery is of great practical significance. This paper analyses performance indexes of lithium-ion battery and points out that lithium-ion battery can be used to replace lead-acid battery.

In the first place, battery room and ventilation equipments are not necessary any more. According to CCS regulations, battery on ship for communication and illumination, which charging power is more than 2kW should be installed in isolated room and be equipped with ventilation devices. Lithium-ion battery would not produce flammable and explosive gases. In addition, due to large energy density, lithium-ion battery is more smaller and lighter than general battery with same capacity. Is can be installed flexibly and it is more space saving.

In the second place, lithium-ion battery can be repeatedly used for more than 500 weeks, far more than lead-acid battery. Although one-time investment of lithium-ion battery is more, comprehensive cost is lower and it is of great maintainability.

Thirdly, it is of greater safety. Type tests in this paper indicate that lithium iron phosphate battery would not explode under conditions of high temperature(100°C), dropping, thermal shock, short circuit, reverse charging, acupuncture and some other extreme conditions that may result in fire and explosion. It is of great safety.

In the end, it is of greater environmental protection performance. During processes of manufacturing, using and recycling lithium iron phosphate battery, there would be no hazardous substance. At present, some manufacturers had obtained RoHS authentication. Under background of more and more requests on environmental protection, lithium iron phosphate battery is of great advantages.

In conclusion, lithium-ion battery used on ships is of great significance.

# The Entry-into-force of Maritime Labor Convention, 2006 in China Formally Entered the Countdown

**O**n August 29, 2015, the 16<sup>th</sup> meeting of the standing committee of the national people's congress passed the decision of the approval of Maritime Labor Convention, 2006, ratifying Maritime Labor Convention, 2006 which was approved by International Labor Organization on February 23, 2006 at the 94<sup>th</sup> international labor conference in Geneva. This convention is called the human rights code of seafarers, which will play a huge role in promoting Chinese crew to have decent work, living conditions, and health professional development, and will have a profound impact on the healthy and sustainable development of shipping industry. It clearly explicated that based on paragraph 10, Standard A4.5 of Maritime Labor Convention, 2006, social security categories applicable to China respectively are old-age benefit, medical care, employment injury benefit, unemployment benefit and maternity benefit. The convention will take into effect in China one year after international labor organization registered China's ratification book.

As China's only one recognized organization meeting the international maritime organization IMO A. 739 (18) resolution and A. 789 (19) resolution, China classification society (CCS) has now obtained the authorization for inspection and certification of maritime labor from 31 countries such as Panama, Marshall, Liberia, Bahamas, Singapore, Hong Kong (China). From the initial drafting stage of maritime labor convention, CCS was a member of the delegation of the Chinese government to provide ship related technical support. After the Maritime Labor Convention, 2006 was adopted officially on

August 20, 2013, CCS worked more actively together with the flag State administrations, shipping companies, steadily pushed forward related implementation work. So far we have issued and maintained effective 1776 copies of maritime labor certificates/document of compliance (all flags, including document of maritime labor compliance of Chinese flag).

During one year transition period since China formally approved the Maritime Labor Convention, 2006 until the convention comes into force, CCS suggested owners pay attention to the following content:

## ■ **First, the maritime labor certificate and declaration of maritime labor compliance (DMLC) part I, part II:**

Starting from the date of the convention coming into force for ships flying Chinese flag, ships of 500 gross tonnage and above and engaged on international voyages must hold a maritime labor certificate, the declaration of maritime labor compliance (DMLC) part I issued by the competent authority of and the declaration of maritime labor compliance part II established by owners on the basis of DMLC part I, the document of maritime labor compliance of Chinese flag will no longer be valid.

For ships below 500 gross tonnage and engaged on international voyages, the convention does not require the ship to hold the maritime labor certificate, but these ships are still required to meet the Maritime Labor Convention, 2006, and subject to

one maritime labor inspection every three year. Maritime labor inspection report can be used as the documentary evidence of compliance with the convention.

### ■ Second, the accommodation and recreational facilities on board

The existing related certificates and documents of accommodation should be retained on the ship, any substantial changes in accommodation and recreational facilities of existing ship shall meet the requirements of Maritime Labor Convention 2006.

The accommodation and recreational facilities of new ships the keel of which is laid after the convention formally takes into effect for China, shall comply with the relevant requirements of

the Maritime Labor Convention, 2006.

### ■ Third, pay attention to the related legislation file of competent authority:

Owner shall timely carry out the gap analysis to the company policies and regulations in accordance with the relevant legislative document published by the competent authority (including DMLC part I), and revise DMLC part II when necessary.

This article only gives some advices for the impact the convention brings when it takes into effect. If this article has some difference with specific requirements published by the competent authority in the future, please refer to the competent authority requirements.

If you have any questions, please contact [sm@ccs.org.cn](mailto:sm@ccs.org.cn), we are always at your service.

## CCS “Rules for Construction of Inland Waterways Steel Ships” ( New Version) Will be Released at the End of the Year

**O**n September 1, 2015, Rules for Construction of Inland Waterways Steel Ships (new version) was passed by industrial experts review meeting, and is due to be officially released at the end of this year.

The research and development of Rules for Construction of Inland Waterways Steel Ships (new version), is closely around the development demand of user and the shipping market, taking the safety, application, science and rationality as the general target, through the theoretical analysis and evaluation, combined with

the verification and comparison between real ships and the rules, to carry out twenty five items monographic study with regard to five aspects including the safety technical differentiation, load and structure, provision of equipment, materials and welding, ship type supplement requirements, and based on the special subject research and the previous research results, combined with the user views and method conducted the main revision work as follows:

Elaborated the key structures’ node requirements, including the structure transition, connections and perforation;

Revised the wave additional load, the longitudinal bending strength and buckling strength criterion;

Revised the equipment requirements of outfit and machinery and electrical installations;

Added part 7 on materials and welding;

Perfect technical requirements for ship types such as the petroleum asphalt tanker, bulk cement carrier, pontoon engineering ship and slot type engineering ship.

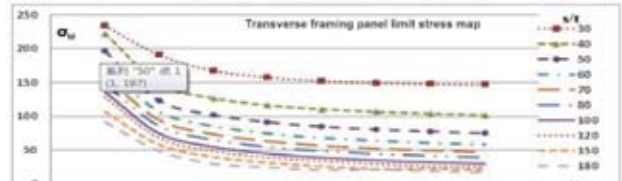
Based on comprehensive carding and evaluation of structure arrangement and node, structure failure control, and provision of machinery and electrical installations, the adaptability of rules for different sizes of vessels and different types of ships is improved.

Combined with bulk carrier of 5000 ton in Yangtze River and container ship of 330 teu to make real ship test and verify, presents a new rules calculation formula of wave bending moment, wave shear force and wave torsional moment.

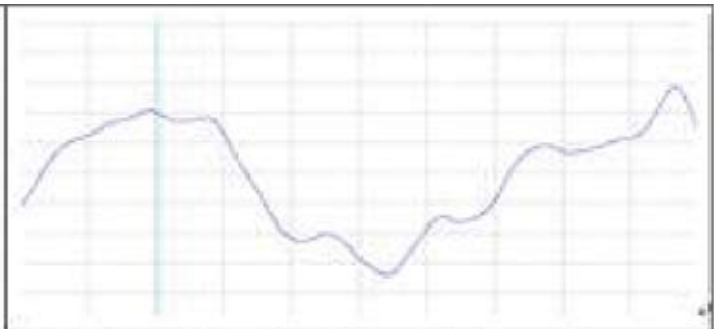
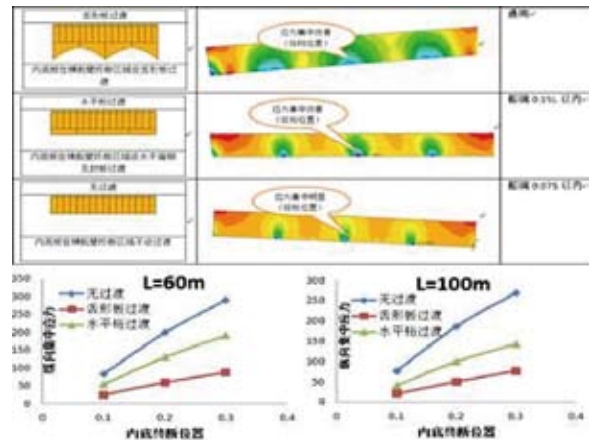
With regard to transverse frame structure problem users are concern with, especially in the application of side, based on the stability study of stiffened plate of inland waterways ship hull, combined with the verification of real ship, the transverse frame plate type criterion based on the ultimate strength is added in the rules.

With regard to double bottom transition problem which user reflect more, through the three-dimensional finite element of typical ship, carrying out detailed qualitative and quantitative comparative

analysis of three schemes including tongue plate transition (the current requirements of rules), horizontal truss transition and no transition, a variety of transition plans are provided.



The project achievements of “Rules for Construction of Inland Waterways Steel Ships” (new version) adapt to the current development of demand of the inland waterways ships (including export ships), provides strong technical support for the healthy development of inland waterways ships.



The Yangtze River of 5000 ton bulk carrier real ship testing spot and the typical wave diagram

# Retention and Reject of CTOD and PWHT During Construction of Large Offshore Structures

By Wang Rong

As the marine oil production gradually develops to the deep sea, there are more and more large offshore jacket units, which also brings us some new topics. During the construction of the offshore jacket unit of China's first deep water project, there are a large number of bars using the technique of post welding heat treatment (PWHT). In the process of the implementation of the technique, many problems are also exposed. The superiority of the crack tip opening (CTOD) has gradually emerged.

This deep water gas field is the first deep water gas development project of the South China Sea, which is currently China's largest and deepest offshore gas field. Located in the pearl river mouth basin of east South China Sea, it is about 250 km off southeast of Hong Kong, about 300 kilometers away from Zhuhai, with the depth of water of about 1350 meters to 1500 meters, which is jointly explored and discovered by China National Offshore Oil Corporation and husky oil company. The project is mainly composed of three parts, i.e. the deep, shallow water, and land terminal. The deep part of the works shall be the responsibility of the husky oil company, shallow part and land terminal facilities are by CNOOC. The unit mentioned by this article is located in shallow part with the water depth of 190 meters, which is Asia's largest platform under construction and also the world's fourth largest monomer steel jacket unit. The total weight of jacket after completion is about 32,000 tons and the upper block weighs about 36,000 tons, bearing heavy responsibilities of processing, pressurization, transfer, etc. of natural gas in surrounding gas fields production.

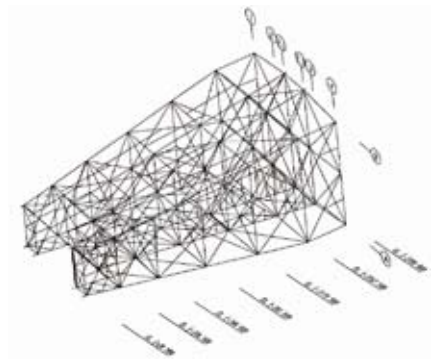


Figure 1: the offshore jacket diagram

The offshore jacket has 8 legs and 16 piles, and the penetration depth of pile foundation design is 135 meters. External four catheters are double dip, each with four skirt pile socket, a total of 7 layers horizontal slices. In the middle four catheters are single tilting, and with the tie bar compose the water truss. Led tube diameter is respectively 4200 mm, 3600 mm, 3500 mm, 3400 mm, 3200 mm, 2900 mm, 2600 mm, 2500 mm, sleeve skirt pile diameter is 2985 mm. Catheters, bracing tube involves two materials, which are D36, D36- Z35. According to the rules and design requirements, for the structure section welding line thickness of more than 50 mm, two kinds of techniques for controlling stress concentration are mainly adopted, namely post welding heat treatment (PWHT) and CTOD (CRACK TIP OPENING).

PWHT's main purpose is to reduce the welding residual stress and improve welding joint organization and performance. If heat treatment is immediately conducted after welding, it is conducive to

releasing the hydrogen in the weld metal in order to prevent welded joints from producing cold crack. For austenitic stainless steels for which heat treatment must be conducted and there are intercrystalline corrosion resistance requirements, the solid solution treatment or stabilization can be conducted, otherwise the post welding heat treatment is generally not carried out.

CTOD, is the abbreviation of CRACK TIP OPENING. For component having certain cracks, when the load increases gradually, the original crack tip opening displacement gradually increases. When the crack opening displacement reaches certain threshold, the crack will extend and crack.

In the process of post welding heat treatment, if processing is bad, it will give rise to many problems and hidden dangers. During heat treatment process, the rate of heating and cooling control range is the key control points of heat treatment. The problems mainly exist in the process of post welding heat treatment in the reinforcement ring. For the deep water jacket project, A2.1, A2.3 intraductal alone has 146 reinforcement rings, a total of 438 pieces with total weight of about 221.588 tons. The requirements of the position error is less than or equal to 3mm or  $t/10A$ . Due to the presence of large amounts of reinforcement ring with thickness of 60-75 mm, and welding requirements for the form of ring strengthen is full penetration, part of the catheter within the length of five meters is five reinforcement rings, welding quantity is very large. The post welding heat treatment capacity needed is very big, and because in the thick section of the pipe joint, the reinforcement



rings are more, the space is narrow, winter temperature difference is big, cooling rate is normal after heat preservation. With the decrease of summer temperature difference, the temperature drop has been postponed, leading to the individual weld cooling rate exceeding the requirements.

CTOD welding technology is located in the preparation work before welding, the latter will not result in a waste of bar. Its difficulty lies in the rigor evaluation standard, the test cycle is long. Both the advantages and disadvantages are shown as the table below:

CTOD and PWHT are the treatment methods for welding joint of greater than 50 mm thickness and complex pipe node under complex force and the decision on which one is superior cannot be based on simple judgment. Selection should be based on the different project conditions in construction, or both methods can be chosen, so as to guarantee the safety of offshore engineering structures.

Table 1 CTOD compared with PWHT

	previous preparation	construction phase	cost
<b>CTOD</b>	preparation for a long time, test for a long time	according to the welding technology to construct	cost is higher, a lot of nodes needed to deal with, lower cost than PWHT
<b>PWHT</b>	preparation time is shorter, only need procedures of PWHT examination and approval documents	input resources is large, PWHT is more difficult in densely populated area	high cost, a few nodes are needed to deal with, cost is lower than CTOD