8-28-2016

Comparative study of IGF Code and China's relevant laws and regulations

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COMPARATIVE STUDY OF IGF CODE AND CHINA'S RELEVANT LAWS AND REGULATIONS

By

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The People's Republic of China

A research paper submitted to the World Maritime University in partial Fulfillment of the requirements for the award of the degree of

MASTER OF SCIENCE

(MARITIME SAFETY AND ENVIRONMENT MANAGEMENT)

2016

DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

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ACKNOWLEDGEMENTS

I am sincerely grateful to World Maritime University and Dalian Maritime University for offering me this opportunity to take the MSEM 2016 program. My heartfelt gratitude also goes to Guangdong MSA and Zhuhai MSA where I worked, for supporting me to pursue postgraduate studies in Dalian after I had left college for 6 years, and as well as to all my colleague in Zhuhai MSA for their extra efforts to handle the work used to be done by me.

I am profoundly thankful to my supervisor Prof. Wu Wanqing, for guiding me through this work and providing me with invaluable advices and insight into the subject matter. His rich knowledge and rigorous research attitude will benefit me in my future professional career and whole life.

I also deeply appreciated all the professors and experts who deliver lectures in the MSEM program, which is a great source of inspiration and knowledge accumulation for the completion of my studies.

Last but not least, I am everlastingly grateful to dear wife Liu Cuiqiong who encourages me to pursue the degree of Master of Science when I was hesitating, and strongly supporting my studies in Dalian by taking my duties of caring for the whole family. The success and achievement which I made during my studies would not have come true without her love and never-ending supports.

ABSTRACT

Title of Dissertation: **Comparative Study of IGF Code and China's Relevant Laws and Regulations**

Degree: **MSc**

This research paper is a study of how to implement IGF Code in China and its impacts to LNG fuelled shipping industry.

The requirement for seafarers servicing on LNG fuelled ships in STCW Convention and China's national regulation are introduced, and the detailed technical requirement for LNG fuelled ships in IGF Code and CCS Rule is comparatively studied,

The requirements for LNG fuelled ships in IGF Code mostly are in line with the Chinese existing national regulations, but the differences in their requirements will have significant impacts on the development of LNG fuelled shipping industry in China. Therefore, the way of implementing IGF Code, how to balance different requirements in international and national regulations, and improve the ability of PSCOs are core questions that should be firstly settled, and developing training and certificating regulations for seafarers servicing on LNG fuelled seagoing ships, and amending the CCS Rule applicable to all LNG fuelled seagoing ships would be very helpful to the implementation of IGF Code in China.

KEY WORDS: IGF Code, Regulation, Rule, LNG fuelled ships, China.

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LIST OF ABBREVIATIONS

CCS	China Classification Society
CCS Rule	Rules for Natural Gas Fuelled Ships
IGF Code	International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels
IMO	International Maritime Organization
LNG	Liquefied Natural Gas
MARPOL	International Convention for the Prevention of Pollution from Ships, 1973 as Modified by the Protocol of 1978
MSA	Maritime Safety Administration
SOLAS	International Convention for the Safety of Life at Sea, 1974, As Amended
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as Amended

Chapter 1 Introduction

1.1 Background of the research

There is a well-known thesis in the shipping industry which says fuel consumption is the major cost driver in shipping, and only the most fuel efficient ships will survive in tomorrows' markets (DNV GL, 2015). In recent years, with the sequential coming into force of MARPOL convention annex VI - *Regulations for Prevention of Air Pollution from Ships* –incorporating its amendments, the gas emission from ships is strictly controlled. As shown in Table1, the NOx emission is limited to three tiers based on the three time nodes of ship building date and specific emission limitations required for different revolving speed of the main engine. Apart from the NOx emission control, there are also emission controls for SOx: the mass proportion of sulfur in oil fuel used by ships should not exceed 4.5%, and a stricter 1.5% requirement is requested when ships navigating in SO_2 Emission Control Area (Jiang, 2014). To some extent, the fuel consumption is becoming a more complicated issue. As more extra costs such as emission control cost should be added to it, the increasing emission control standards of ships is a stronger drive for people to find new sources of fuel to replace the traditional oil fuel.

Table 1 IMO NOx emission limits

Date of built	Emission standards	limit value of NOx (g/KW.h)			notes
		n<130rpm	130≤n<2000	n≤2000	
2000.1.1 or later	Tier I	17.0	$45*n^{0.2}$	9.84	
2010.1.1 or later	Tier II	14.36	$45*n^{0.23}$	7.66	
2017.1.1 or later	Tier III	14.36	$44*n^{0.2}$	7.66	Out of ECA
		3.4	$9*n^{0.2}$	2.0	In ECA

Sources: Jiang, Huihua. Study on Emission Characteristics of Marine LNG/Diesel dual-fuel engine

The demand for a drastic reduction in harmful atmospheric emissions, coupled with the regulatory spread of Emission Control Areas has accelerated the search for cleaner and greener marine fuels. LNG seems to tick all the boxes in terms of the cleanliness of its emissions, availability and probable costs looking forward (BIMCO, 2014). LNG has been described as the fuel of the future, being clean burning with most noxious impurities such as sulphur or CO2 removed, leaving mostly liquid methane. It is obtained by cooled to near its boiling point of minus 165℃(BIMCO, 2013). LNG is becoming the hot choice of ship fuel to replace the traditional oil fuel as it can be a better solution to meet the emission control requirement compared with marine oil (Wan & Liao, 2013).

LNG was first utilized as a fuel by LNG carriers in the 1960s. This was to take advantage of the fuel available onboard as boil-off gas and was enabled by virtually zero fuel costs when the vessels were loaded. This contributed significantly towards developing the technology and know-how for utilizing LNG as a fuel. The first LNG-powered vessel (excluding LNG carriers) was a ferry built in Norway in 2000. In the following decade, another 20 LNG-powered ships were built, many of them operating in Norwegian waters. Since 2010, the growth in LNG-powered ships has accelerated, resulting in 59 ships in operation today (April 2015), as well as another 80 under construction, with planned deliveries within 2018. The size of LNG-powered ships has increased with experience gained, and the first orders for two-stroke engines were recently placed. Many of the newly built or projected ships will operate in various locations in Northern Europe and North America, but are also scheduled to operate in China and South America. (Christos & Tobias, 2015)

To regulate the designs and constructions of LNG fuelled ships, the International Maritime Organization (IMO) adopted the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code) on 11 June 2015 by resolution MSC.391(95), and the IGF Code was made mandatory to the contract parties by resolution MSC 392.95/22 which amends the SOLAS convention. The IGF Code was

recognized as a milestone for the control of the future gas fuelled ships by the shipping industry (Liu, 2012)

China is energetically pushing the development of LNG fuelled ship especially the inland ships and also closely catching up with the international paces of making regulations for them. The *Rules for Natural Gas Fuelled Ships* (CCS Rule) made by Chinese Classification Society (CCS) and the *Provisional Regulations for Legal Inspection of Natural Gas Fuelled Inland Ships* made by China Maritime Safety Administration (MSA) have already been in effect since 2013.

The IGF Code, which will come into force on 1st January 2017, will have great effect on the development of China's LNG fuelled shipping industry. However, until now seldom researches are found to study the differences in requirement between IGF Code and those national regulations mentioned above, or to assess the influences on and difficulties in the implementation of IGF Code. This research will mainly focus on the areas mentioned above and will come up with some recommendations for implementing IGF Code in China based on these analyses.

1.2 Research questions

The amendments of SOLAS convention (resolution MSC.392(95)) which makes the IGF Code compulsory and STCW convention (resolution MSC.396(95)) which sets requirements for seafarers are introduced, and then the technical requirement differences between IGF Code and China's national regulations are studied. After that the foreseeable impacts on the development of China's LNG fuelled shipping industry and the difficulties in implementing the Code are identified, and finally based on the above discussion, personal advice on implementing IGF Code is given.

1.3 Methodology

The relevant LNG fuelled ships regulations were widely reviewed beforehand, including IGF Code, CCS's rules, China MSA's regulations. Other literature such as appropriate IMO documents and circulars, international conventions, articles from contemporary journals, books and information from websites is also covered in the reading list. Opinions were exchanged and advice was taken by visiting LNG fuelled ships corporations, Zhuhai MSA's officers and my instructor professor Wu Wanqing.

1.4 Objectives and significance of the research

The primary purpose of this research is to illustrate the requirement differences between IGF Code and CCS Rule. The second objective is to identify the impacts that will bring to China and difficulties that will be faced with on its way of implementing IGF Code. The significance of this research is to give advices to the administration so as to fulfill the requirements of IGF Code and to accelerate the development of LNG fuelled ships.

Chapter 2 Requirement for seafarers servicing on LNG fuelled ships

Equipped with LNG fuel containment system, LNG consumers and other control and safety systems, the LNG fuelled ships are different from traditional oil fuelled ships in many ways, such as bunkering, maintenance, operation and firefighting. These differences bring challenges to the seafarers who work on them, so to ensure that seafarers can safely operate and manage the LNG fuelled ships and limit the hazards to a minimum range, seafarers should be carefully trained on the relevant knowledge before working onboard LNG fuelled ships. In part D of IGF Code, it requires companies to ensure that seafarers on board ships using gases or other low-flashpoint fuels shall have completed training to attain the abilities that are appropriate to the capacity to be filled and duties and responsibilities to be taken up, taking into account the provisions given in the STCW Convention and Code, as amended. Such training for seafarers who service on ships subjected to IGF Code has already been specified in the amendment of STCW convention (resolution MSC.396 (95) and MSC.397 (95)). In China, there is only regulation for crews servicing on the LNG fuelled inland ships, and regulations for seafarers servicing on LNG fuelled seagoing ships haven't been developed till now. In the existing regulation, such training is categorized as special training, and the regulation is named *Regulations on Exam and Certification of Special Training for Inland Ships* which was developed by China MSA.

2.1 Requirement in STCW convention

To incorporate the requirement for seafarers servicing on ships subjected to IGF Code into the STCW convention, IMO amended the STWC convention in the 95th session maritime safety committee. In resolution MSC.396(95) *(Amendments to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978, as Amended*) and resolution MSC.397(95) (*Amendments to Part A of the Seafarers' Training, Certification and Watchkeeping (STCW) Code*), seafarers' trainings are categorized into two types: one is basic training and the other is

advanced training, depending on the different responsibilities they take associated with the care, use or emergency response to the fuel on board.

2.1.1 Basic training

2.1.1.1 Application

Seafarers who service on ships subject to the IGF Code and responsible for designated safety duties associated with the care, use or in emergency response to the fuel on board ships shall hold a certificate in basic training.

2.1.1.2 Equivalence

Seafarers who have been qualified and certified on liquefied gas tankers, are to be considered as having met the requirements for basic training.

2.1.1.3 Training

The minimum standard of competence in basic training is specified in table A-V/3-1 of STCW Code. The main content of the training is to contribute to the safe operation; take precautions to prevent hazards; apply occupational health and safety precautions and measures; carry out firefighting operations; respond to emergencies; and take precautions to prevent pollution of the environment from the release of fuels.

2.1.2 Advanced training

2.1.2.1 Application

Masters, engineer officers and all personnel with immediate responsibility for the care and use of fuels and fuel systems shall hold a certificate in advanced training for service on ships subject to the IGF Code.

A candidate for a certificate in advanced training shall already hold a basic training certificate, and shall complete at least one month of approved seagoing service that

includes a minimum of three bunkering operations on board ships subject to the IGF Code. Two of the three bunkering operations may be replaced by approved simulator training on bunkering operations.

2.1.2.2 Equivalence

In addition to having been qualified and certified according to the standards of competence specified in section A–V/1-2, paragraph 2 for service on liquefied gas tankers, seafarers are considered as having met the advanced training requirements if they finish the basic training or its equivalence, and three bunkering operations on board (Two can be replaced by approved simulator training) or have participated in conducting three cargo operations on board the liquefied gas tanker, and have completed sea going service of three months in IGF Code adopted ships or tankers carrying as cargo which is fuel covered by the IGF Code or ships using gases or low flashpoint fuel as fuel.

2.1.2.3 Training

The minimum standard of competence in advanced training is specified in table A-V/3-2 of STCW Code. The main content of the training are familiarity with physical and chemical properties of fuels; operate controls of fuel related to propulsion plant and engineering systems and services and safety devices; ability to safely perform and monitor all operations related to the fuels; plan and monitor safe bunkering, stowage and securing of the fuel; take precautions to prevent pollution of the environment from the release of fuels; monitor and control compliance with legislative requirements; take precautions to prevent hazards; apply occupational health and safety precautions and measures; and knowledge of the prevention, control and firefighting and extinguishing systems.

2.2 Requirement in China's national regulations

Chinese LNG fuelled ships are mainly developed in inland water areas especially in the Yangtze River area, LNG fuelled seagoing ships in China are relatively rare – only 3 LNG fuelled harbor tugboats which owned by CNOOC (China National Offshore Oil Corporation) are in service, so there is only training regulations for crew service on LNG fuelled inland ships other than seagoing ships. In China, the training for attaining the abilities to take duties and responsibilities of servicing onboard LNG fuelled inland ships is categorized as special training, such special training is regulated in the *Regulations on Exam and Certification of Special Training for Inland Ships* which was newly amended and entered into force in 1st, April, 2015.

2.2.1 Application

Crews servicing on LNG fuelled inland ships shall accomplish the LNG fuelled inland ships special training and hold a certificate in the special training. Different from the requirement of STCW convention, according to the *Regulations on Exam and Certification of Special Training for Inland Ships*, all crews service onboard LNG fuelled inland ships in China shall hold the same Certificate of Proficiency for special training, other than two different levels of certificates based on their responsibilities associated with the care, use or in emergency response to the fuel on board.

2.2.2 Training

The main content of the LNG fuelled inland ships special training is given in the *Regulations on Exam and Certification of Special Training for Inland Ships*. They are basic knowledge of LNG fuelled ships; arrangement and operation of LNG fuel tank; constitution and routine inspection of fuel supply system; knowledge and operation of LNG fuel engine and other auxiliary devices; knowledge of ventilation system and control, monitoring and safety system; procedures of LNG bunkering; knowledge and

procedure of firefighting; safe watchkeeping and emergency operation of LNG fuelled ships; maintaining the electronic and machinery devices related to LNG fuel; knowledge about legal inspection and survey of LNG fuelled ships; practical training for using personal safety devices, oxygen meter and explosion meter, testing the flammable gases detective system, leakage detecting and eliminating, bunkering of LNG fuel, operating and maintaining LNG engine.

Chapter 3 Requirement for LNG fuelled ships

Because of the differences in fuel properties, fuel containment system and bunkering operations between the two types of ships, the LNG fuelled ships face more safety risks compared with the traditional oil fuelled ships. These risks lie in protecting LNG fuel from escaping out of containment system or piping to avoid causing fire, explosion and excessive cooling to ship structures and minimizing the probability of injury to seafarers. To achieve this goal, both international and Chinese national regulations have set new requirements on the ship's arrangement and design, fuel containment system, materials and other aspects, but there are also some differences between them.

3.1 Main regulations for LNG fuelled ships

3.1.1 IGF Code

The IGF Code was given in resolution MSC.391(95) – Adoption of the International Code of Safety For Ships Using Gases or Other Low-Flashpoint Fuels and will enter into force on 1st January 2017. The core concept of this code is to formulate compulsory requirements for the arrangement, installation, monitoring and management of the machinery equipment and systems fuelled by gases or other low-flashpoint fuels, so as finally to reduce the risks faced by the ships, seafarers and environment (Guo, 2014). The IGF Code was intended to take a wide range of ships using gases or other low-flashpoint fuels under its regulating, but right now only the requirements for the LNG fuelled ship is covered in the available version because of time limitation, maybe with the development of shipping technology, requirements for the other fuels such as ethyl alcohol and fuel cell will be added into it.

Different from IMO's former conventions and codes, the IGF Code is established by using the methodology of GBS (Goal Based Standards), rather than stating in prescriptive form of how ships should be built and equipped. The regulation focuses on

the goals, the purpose and what should be achieved, rather than how to achieve it.(Rolf, 2009).

3.1.2 Rules for Natural Gas Fuelled Ships (CCS Rule)

The CCS Rule is the rule for steel ships using natural gas (both CNG and LNG) as fuel which was developed by CCS and entered into force on 1st September 2013. It takes the place of the CCS's *Survey Guidance for Gases Fuelled Ships* (2011) after entering into force. The CCS Rule is developed on the basis of the *Survey Guidance for Gases Fuelled Ships* (2011) and other CCS's important researches such as the *Research on the Key Technology of Natural Gas Fuelled Ship*s and *Research on the Key Technology of Marine LNG Fuel Tanks Structure*, at the same time, the new concept of Goal Based Standard and risk analysis were also taken throughout the whole developing process (CCS, 2013).

Compared with the IGF Code which applies to gases or other low flash-point liquid fuelled ships with the GT (gross tonnage) not less than 500, the CCS Rule applies to steel ships not less than 20 meters long which are equipped with gas fuelled engine (or engines), and the passenger ships and dangerous cargo ships are excluded from this Rule.

3.1.3 Provisional Regulations for Legal Inspection of Natural Gas Fuelled Inland Ships

The *Provisional Regulations for Legal Inspection of Natural Gas Fuelled Inland Ships*, developed by China MSA, entered into force on 15th November 2013. It only applies to the inland ships equipped with gas fuelled engine (or engines) with whose length not less than 20 meters, the passenger ships and dangerous cargo ships are also excluded from this regulation. The detailed contents of this regulation all come from the CCS Rule. When involving technical details such as risk analysis and requirement for

specific marine devices, the Provishional Regulation always refers to the CCS Rule, so objectively speaking, the P*rovisional Regulations for Legal Inspection of Natural Gas Fuelled Inland Ships* is a shrunken version of CCS Rule.

3.2 Differences in requirements

In consideration that the P*rovisional Regulations for Legal Inspection of Natural Gas Fuelled Inland Ships* is more or less part of the CCS Rule, precisely speaking, the CCS Rules can better represent China's regulations for the LNG fuelled ships. From this point of view, to get to know the requirement differences between IMO and China, we only need to comparatively study the IGF Code and the CCS Rule.

3.2.1 Goal and Functional Requirements

The goal and functional requirements in chapter 3 of IGF Code and article 1.1.2 CCS Rule are mostly the same, except for some small differences.

Article 3.2.12 of IGF Code states, "Fuel containment system and machinery spaces containing source that might release gas into the space shall be arranged and located such that a fire or explosion in either will not lead to an **unacceptable loss of power** or render equipment in other compartments inoperable". As explains in article 2.2.40, the unacceptable loss of power means "not possible to sustain or restore normal operation of the propulsion machinery in the event of one of the essential auxiliaries becoming inoperative". In the corresponding article of CCS Rule 1.1.2(11), there is no such presentation of **unacceptable loss of power,** but only requires not to render equipment in other compartments loss function. If the fire or explosion seriously damages the space, which results in unacceptable loss of power but not affects equipment in other compartments, this actually meets the CCS Rule's requirement, but will put the ship at risk, so we can conclude that the IGF Code has a stricter requirement than CCS Rule.

3.2.2 General requirements

3.2.2.1 Risk assessment

Article 4.2.2 of IGF Code requires LNG fuelled ships to carry out risk assessment in the following situation: the sufficient capacity of drip trays, the most critical events that airlock not release gas, LNG containment system, additional relevant accidental scenarios for accidental design condition, closed or semi-enclosed bunkering stations, equivalence of alternative ventilation installations in tank connection space, mechanical ventilation for bunkering stations not located on open deck, ventilation inlets to accommodation and machinery spaces to permanently installed gas detectors. It doesn't clarify how to carry out risk assessment but to satisfy the Administration. In article 11.3.4 of CCS Rule, risk analysis is mostly connected with gas fuelled engine such as gas systems or components failure, ignition system failure, air-fuel ratio control system failure, and components failure which will lead to fire, gas combustion failure or abnormal combustion, monitoring or control gas safety system failure of gas engine, gas anomaly in components in or out of gas engine, operational mode changeover for dual-fuel engines. Besides that the CCS Rule also clarifies the methods and procedures of risk analysis in chapter 11 section 3. Objectively speaking, the CCS Rule is a good form to implement the IGF Code, however, more aspects should be added compared with the IGF Code risk assessment scope.

3.2.2.2 Limitation of explosion consequences

The limitation of explosion consequences in article 4.3 of IGF Code is mostly similar to article 2.1.1 of CCS Rule except that the IGF Code requires that an explosion should not prevent person's access to life-saving appliances or impede escape routes while the CCS Rule does not.

3.2.3 Ship design and arrangement

3.2.3.1 Location of fuel storage tanks

In article 5.6.1.5 of CCS Rule, the requirement for minimum distances from fuel storage tanks to the ship side, ship bottom, ship shell plating or aft terminal are the same as the requirement in article 5.3.3 of IGF Code. However, the requirement in IGF Code is universal and does not take the position where the fuel tank is arranged into consideration, while in the CCS Rule, the fuel tanks arranged in the open deck or semi-enclosed space have no specific limitation on the minimum distance to the ship bottom, ship shell plating or aft terminal. Stricter than the CCS Rule, the IGF Code requires greater minimum distance to the ship shell plating or aft terminal which is calculated by a formula when the single capacity is greater than 1000m^3, more than that, a f_{CN} value calculated as $f_{CN}=f_l \times f_t \times f_v$ is given to determine the acceptable location of the fuel tanks, which must be less than 0.02 for passenger ships and less than 0.04 for cargo ships.

3.2.3.2 Regulations for drip trays

The CCS Rule doesn't clarify what capacity each drip tray should have to accommodate the maximum leakage, while in article 5.10.5 of IGF Code, it requires each tray shall have a sufficient capacity according to the risk assessment. In this case, the CCS Rule may face the problem that some drip trays may have the risk of being unable to handle the maximum amount of spill.

3.2.3.3 Regulations for location and protection of fuel piping

Article 5.7.2 of IGF Code requires fuel piping shall not be led directly through accommodation spaces, service spaces, electrical equipment rooms or control stations, while in article 4.4.1.1 of CCS Rule it requires that fuel piping shall not be lead directly

through the accommodation spaces, service spaces or control station, which does not take the electrical equipment rooms into consideration.

3.2.4 Fuel containment system

3.2.4.1 General requirement

In article 6.3.5 of IGF Code, it requires pipe connections to the fuel storage tank shall be mounted above the highest liquid level in the tanks, except for fuel storage tanks of type C, and connections below the highest liquid level may however also be accepted for other tank types after special consideration by the Administration. In article 6.3.9 it requires that the pipe should be protected by a secondary barrier up to the first valve if piping is connected below the liquid level of the tank. However in the CCS Rule, it doesn't have clear requirements for the location and protection of pipe connections.

3.2.4.2 Regulations for liquefied gas fuel containment

The CCS rule doesn't have very detailed technical requirements for fuel tanks like IGF Code, however in article 5.1.1.2, it requires that the membrane tanks, type A independent tanks and type B independent tanks shall correspondingly comply with the requirement for membrane tanks, type A independent tanks and type B independent tanks in the *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*. In this Rule the requirements for these types of tanks are mostly the same as the requirements in the IGF Code, except for the determination of the collision load. In article 6.4.9.5.1of IGF Code, the design acceleration which used to determine the collision load shall be determined by the Ship length (L): when L > 100 m, the design acceleration is 0,5 g(gravitational acceleration); when 60 < L $\leqslant$ 100 m, the design acceleration is$(2-3\frac{L-60}{80})g$; when L $\leqslant$ 60 m, the design acceleration is 2g. However, in article 4.15.1 of the *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*, the design acceleration is 0.5g and has no relationship with the ship length. For ships whose length is greater than 100 meters it

will not cause any trouble, but for ships whose length is less than 100 meters, because the design acceleration is not as big as the IGF required, the ships' structure may not be strong enough following the CCS Rule.

3.2.4.3 Regulations for type C independent tanks

For the type C independent tanks, the CCS Rule has a special annex (annex I) to clarify the requirement for it.

The determination of loads due to ship motion is not clear given in the IGF Code, in article 6.4.9.4.1.1, it only requires that accelerations acting on tanks shall include vertical acceleration, transverse acceleration, and longitudinal acceleration, but detailed value is given. However, in article 2.4 of the annex I of CCS Rule, the detailed acceleration value is given, that is: 2g (g is gravity acceleration) for longitudinal acceleration; 1.5g for transverse acceleration; 1g for upward vertical acceleration and 2g for downward vertical acceleration.

As for the determination of the collision load, different from the requirement in *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*, the annex I of CCS Rule (article 2.12) and the IGF Code have the same requirement.

In article 3.1.5(2) of annex I of CCS Rule, it requires that the Von Mises resulting stress σ of the fuel tank supporting attachments shall not be greater than 0,9Re(yield stress of the fuel tank supporting attachments). In the IGF Code there is no such requirement.

In article 3.2 of annex I of CCS Rule, there is requirement for the maximum distances of the two swash plates in the fuel tanks, and minimum thickness of the fuel tank shell and end socket, while in the IGF Code there is no such requirement for the type C independent tanks.

3.2.4.4 Regulations for the maintaining of fuel storage condition

In article 6.9.1.2 of the IGF Code, it doesn't accept the Venting of fuel vapor for control of the tank pressure except in emergency situations. In the CCS Rule, there is no clear statement that it does not accept control fuel tank pressure by way of venting fuel vapor, while in article 5.2.1.7, it says the CCS accepted ways of controlling tank pressure include thermal isolation, vapors reliquefaction, setting BOG (boil off gas) storage tanks, liquefied gas fuel cooling and setting combustion devices. Although the CCS Rule doesn't keep the way of venting fuel vapor in its acceptable list, to make clear and for the purpose of environment protection, it would be better to clearly state that it does not accept control fuel tank pressure by way of venting fuel vapor.

3.2.5 Material and general pipe design

In article 3.2.1.7 of CCS Rule it requires that all the gas pipes should be identified with the same color, while in article 7.3.1.1 of IGF Code, it requires fuel pipes be color marked according to the "EN ISO 14726:2008 Ships and marine technology – Identification colors for the content of piping systems", in which flammable gas pipe is marked in yellow and liquid gas is marked in yellow-violet-yellow. If fuel pipes are marked according to CCS Rule in the same color, it may face the problem of not complying with IGF Code.

In article 7.3.6.3 of IGF Code, it requires piping system be joined by welding with a minimum of flange connections. Gaskets shall be protected against blow-out, in the CCS Rule there is no special requirement for the gaskets.

3.2.5.1 Regulations for materials

For the plates, pipes and sections used on the fuel tanks, process pressure vessels, fuel and process piping, there are detailed requirements on the chemical composition and

heat treatment, tensile and toughness (impact) test in article 7.4 of IGF Code; however, there is no clear materials requirement in the CCS Rule, but in article 1.1.5, it requires that materials used in fuel tanks, fuel pipes, process pressure vessels, and other components contacted with cryogenic liquid or gases should comply with the chapter 6 of *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*, the chapter 6 of the *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk 2016* (CCS, 2016), whose requirement for materials is the same as article 7.4 of IGF Code, so the requirements for materials are the same in IGF Code and CCS Rule.

3.2.6 Bunkering

3.2.6.1 Ships' fuel hoses

In the IGF Code, article 8.3.2.1 requires fuel hoses should be compatible with the fuel and suitable for the fuel temperature, and article 8.3.2.2 requires hoses subject to tank pressure, or the discharge pressure of pumps or vapor compressors be designed for a bursting pressure not less than five times the maximum pressure the hose can be subjected to during bunkering. In the CCS Rule, there is no such requirement, but article 3.3.1.10 requires hoses used in the fuel system shall comply with the requirement for cargo hoses in the *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.* In article 5.11.7.1 and article 5.11.7.2 of this rule, the requirement is the same as in the IGF Code.

3.2.6.2 Regulations for bunkering manifold

In article 8.4 of IGF Code, it requires the bunkering manifold be designed to withstand the external loads during bunkering. The connections at the bunkering station shall be of dry-disconnect type equipped with additional safety dry break-away coupling/ self-sealing quick release. The couplings shall be of a standard type. There is no detailed requirement for manifold in CCS Rule, which needs special considerations to be taken.

3.2.6.3 Regulations for bunkering system

Article 8.5.5 of IGF Code requires Bunkering lines shall be arranged for inerting and gas freeing. When not engaged in bunkering, the bunkering pipes shall be free of gas, unless the consequences of not gas freeing are evaluated and approved. A corresponding article 5.2.1.6 in CCS Rule requires fuel tanks and their pipes shall be gas freed and inerted, but for the condition of bunkering pipes not in operation there is no specific requirement.

Article 8.5.6 of IGF Code requires bunkering lines shall be ensured by suitable isolation arrangements that no fuel is transferred inadvertently to the ship side not in use when bunkering is arranged with a cross-over. It is a very important measure to eliminate the misoperation of bunkering, but there is no such requirement in the CCS Rule.

3.2.7 Fuel supply to consumers

The requirements for fuel supply to consumers are mostly the same in IGF Code and CCS Rule, except that article 9.9.3 of IGF Code requires that under no circumstances can liquefied gas be introduced in the gas control section or gas-fuelled machinery, unless the machinery is designed to operate with gas in liquid state; in the CCS Rule there is no such requirement.

3.2.8 Power generation including propulsion and other gas consumers

The requirement for power generation in chapter 10 of IGF Code covers three kinds of power plants, which is internal combustion engine, boiler and gas turbine, while in the CCS Rule there is only requirement for internal combustion engine. For the internal combustion engine, the requirements in the CCS Rule are more detailed than in the IGF

Code. These more detailed regulations lie in the arrangement of air inlet pipe for main engine, the protection of crank case and the ignition system for gas-only engines.

3.2.9 Fire safety

3.2.9.1 Regulations for fire protection

The scope of category A machinery space for fire protection purposes is a little different in the two regulations. In the IGF Code (article 11.3.1) any space containing equipment for the fuel preparation such as pumps, compressors, heat exchangers, vaporizers and pressure vessels shall be regarded as a machinery space of category A for fire protection purposes, while in the CCS Rule (article 8.1.1.2) it says the gas compressor room and gas pump room shall be regarded as a category A machinery space for fire protection purposes. That means the scope of category A machinery space for fire protection purposes in the CCS Rule is narrower than in the IGF Code, which will lead to some spaces such as pumps, heat exchangers, vaporizers and pressure vessels not being protected properly.

In article 11.3.2 of IGF Code, it requires any boundary of accommodation spaces, service spaces, control stations, escape routes and machinery spaces, facing fuel tanks on open deck, shall be shielded by A-60 class divisions, while in the corresponding article 8.2.1.1 of CCS Rule the escape route is not covered. In addition, the IGF Code requires fuel tanks shall be segregated from cargo in accordance with the requirements of the International Maritime Dangerous Goods (IMDG) Code where the fuel tanks are regarded as bulk packaging, for the purposes of the stowage and segregation requirements of the IMDG Code, a fuel tank on the open deck shall be considered a class 2.1 package. There is no such requirement in the CCS Rule which maybe mainly because the CCS Rule does not apply to the dangerous cargo ships and passenger ships, so it will not face the problem of segregation with other dangerous cargos, but in the future if the CCS Rule were amended to apply to the dangerous cargo ships and passenger ships, such requirement shall be added into the Rule.

The fire separation for the bunkering station on the open deck in CCS Rule is a little stricter than in IGF Code. In article 8.2.2.2 of CCS Rule, it requires any boundary of accommodation spaces, service spaces, cargo spaces, machinery spaces and control stations, facing bunkering stations on open deck, shall be shielded by A-60 class divisions for at least 10 meters along the right and left side of bunkering stations. In the IGF Code there is no such detailed requirement.

3.2.9.2 Regulations for water spray system

In article 11.5.2 of IGF Code, it requires the water spray system shall also provide coverage for boundaries of the superstructures, compressor rooms, pump-rooms, cargo control rooms, bunkering control stations, bunkering stations and any other normally occupied deck houses that face the storage tank on open decks unless the tank is located 10 meters or more from the boundaries. While in article 8.3.2.1 of CCS Rule, it requires the water spray system shall also provide coverage for boundaries of superstructures and other deck houses that face the fuel tank unless the tank is located 5 meters or more from the boundaries. This is a very clear difference: if the ship is designed under the CCS Rule with water spray system only covering boundaries within 5 meters from the fuel tank, it may be recognized as a big deficiency from the IGF Code's point of view, so it should be amended before the IGF Code enters into force.

In article 11.5.4 of IGF Code, it requires stop valves shall be fitted in the water spray application main supply line(s), at intervals not exceeding 40 meters, while in the corresponding article 8.3.2.3 of CCS Rule, it requires water spray system's main supply line(s) shall be fitted with stop valves at an appropriate intervals, rather than a clear limitation of the intervals. Therefore, in practice the 40 meters should be taken into considerations.

3.2.10 Explosion prevention

There is no special chapter for the explosion prevention in the CCS Rule, but the relevant contents are included in chapter 9, Electrical System. The requirements for the hazardous area zones are mostly the same as in the CCS Rule and IGF Code except for some little differences. In article 12.5.1 of IGF Code, it considers the pipes and equipment containing fuel are hazardous area zones 0, while in article 9.1.1.2 of CCS Rule, it considers the internal spaces of facilities containing fuel are hazardous area zones 0, which is scope differences for the hazardous area zones 0.

In article 12.5.3.2 of IGF Code, it considers the space containing bolted hatch to tank connection space is hazardous area zone 2, which is not included in the CCS Rule, while in article 9.1.1.4 of CCS Rule, it considers the spaces within 2.4 meters surrounding outer surface of single hull fuel tanks located on the open spaces are hazardous area zone 2, which is not included in the IGF Code.

3.2.11 Ventilation

3.2.11.1 Regulations for non-hazardous spaces with entry openings to a hazardous area

In article 13.3.9 of IGF Code, it requires non-hazardous spaces with entry openings to a hazardous area shall be arranged with an airlock and be maintained at overpressure relative to the external hazardous area, and proceeding with purging (at least 5 air changes) and pressurizing the space should be done before initial start-up or after loss of overpressure ventilation, and an audible and visual alarm shall be given at a manned location and automatic or programmed, disconnection of unsafe electrical installations shall be required in the event of failure of the overpressure ventilation. In article 7.5.1.4 of CCS Rule, such requirement is only required in the fuel preparation room where hazards are mainly related to the ventilation, and for the non-hazardous spaces with entry openings to a hazardous area, the CCS Rule only requires it be equipped

with an airlock, which follows the requirement of article 2.4.1. In a word, the IGF Code has a higher requirement for the non-hazardous spaces with entry openings to a hazardous area than the CCS Rule.

3.2.11.2 Regulations for ESD protected machinery spaces

In article 13.5.2 of IGF Code, it provides an alternative to the requirement that the ESD protected machinery spaces shall have ventilation with a capacity of at least 30 air changes per hour, which is: arrangements whereby under normal operation the machinery spaces are ventilated with at least 15 air changes an hour is acceptable provided that, if gas is detected in the machinery space, the number of air changes will automatically be increased to 30 an hour. While in the CCS Rule, there is no such alternative, it requires the ESD protected machinery spaces shall be fitted with effective underpressure mechanical ventilation system whose capacity shall not be less than 30 air changes per hour.

3.2.11.3 Regulations for safety enhanced machinery spaces

The concept of safety enhanced machinery spaces is only given in the CCS Rule, in the IGF Code there is no such space. The ventilation requirement for the safety enhanced machinery spaces in the CCS Rule is stricter than in the ESD protected machinery spaces. In article 7.3.3.3 of CCS Rule, in the case of one of the group of fans is inoperable, it requires the capacity of ventilation fans for safety enhanced machinery spaces can also fulfill the ventilation requirement, other than capacity is not reduced by more than 50%.

For the safety enhanced machinery spaces, there is another requirement in article 7.3.3.4 of CCS Rule which is not included in the IGF Code. It requires the ventilation system shall be interlocked with the gas engine, which is the gas engine shall not be running in gas fuel mode unless the ventilation system has been started for at least 10

minutes. When the ventilation system is inoperable, the gas engine shall automatically changeover to the oil fuel mode.

In a word, the requirement for the ventilation system for the safety enhanced machinery spaces in the CCS Rule is stricter than in the IGF Code.

3.2.12 Electrical installations

In article 14.3.5 of IGF Code, it requires the lighting system in hazardous areas shall be divided between at least two branch circuits, and switches and protective devices shall interrupt all poles or phases and shall be located in a non-hazardous area. While in the CCS Rule there is no such requirement for the lighting system, so this requirement should be added into it in order to avoid the inconformity of ships.

In article 14.3.8 of IGF Code, it requires fuel pump motors shall be capable of being isolated from their electrical supply during gas-freeing operations if the submerged fuel pump motors and their supply cables are fitted in liquefied gas fuel containment systems. In article 9.1.2.1(1)d of CCS Rule, it requires the structure and installment of submerged fuel pump shall not allow it to connect to the power grid when the pump is unsubmerged or exposed to the air. Although the presentations of the two are different, during gas-freeing operations, the submerged fuel pump undoubtedly is unsubmerged or exposed to the air, so the requirement in CCS Rule is still in line with the IGF Code pertains to the submerged fuel pump.

In article 9.2.1 of CCS Rule, it requires the gas engine control system and gas fuel control system shall have two circuits of power supply, one circuit is from the main switchboard and the other is from storage battery, in the case of the main switchboard circuit is power off, the design shall automatically changeover to the storage battery circuit. In the IGF Code there is no clear requirement for the power supply of the gas engine control system and gas fuel control system.

3.2.13 Control, monitoring and safety systems

3.2.13.1 Regulations for portable fuel tanks

In article 15.3.3 of IGF Code, it requires that if tanks are not permanently installed in the ship, a monitoring system shall be provided for permanently installed tanks. While in the CCS Rule, article 5.1.1.7 requires when using portable tanks to store fuel, the design of fuel containment system shall be the same as permanent tanks. However, in part 2 of chapter 5, which is about the LNG fuel containment system, there is no clear requirement for the monitoring system. So the CCS Rule has no clear requirement for the monitoring system of portable fuel tanks, which should be amended.

3.2.13.2 Functional requirement for safety system

In article 15.2(4) of IGF Code, it requires safety functions shall be arranged in a dedicated gas safety system that is independent of the gas control system in order to avoid possible common cause failures which include power supplies and input and output signal, and in article 15.2(5) and 15.2(6), it also require the safety systems including the field instrumentation shall be arranged to avoid spurious shutdown, and where two or more gas supply systems are required to meet the regulations, each system shall be fitted with its own set of independent gas control and gas safety systems. In the CCS Rule there is no such requirement for the safety system.

3.2.13.3 Regulations for liquefied gas fuel tank monitoring

In article 15.4.1 of IGF Code, it says the liquefied gas fuel tank liquid level gauges may be of the indirect devices type and closed devices type (not penetrate the liquefied gas fuel tank), while in article 10.2.1.1 of CCS Rule, it requires the liquid level monitoring and overflow control of fuel tank shall comply with the *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.* However, this Rule (2016, PP:

211) not only allows the above mentioned two types of liquid level gauges to be used, but also accepts the closed devices type (penetrate the liquefied gas fuel tank) and restricted device type, and both the two types must penetrate the liquefied gas fuel tank, if ships use these types of liquid level gauges, they may face the problem of not complying with the IGF Code.

In article 15.4.11 of IGF Code, it requires each fuel tank (except for independent tanks of type C supplied with vacuum insulation system and pressure build-up fuel discharge unit) shall be provided with devices to measure and indicate the temperature of the fuel in at least three locations; at the bottom and middle of the tank as well as the top of the tank below the highest allowable liquid level. However, in the CCS Rule there is no clear requirement for the temperature monitoring of fuel tanks, even in the *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*, though the CCS Rule doesn't directly refer to it, it only requires at least two locations to measure and indicate the fuel temperature, one at the bottom and the other at the top of the tank below the highest allowable liquid level. This is a clear requirement differences. If three temperature measure devices are not provided as required by the CCS Rule, it undoubtedly will not comply with the IGF Code, so this should be amended.

3.2.13.4 Regulations for gas compressor monitoring

In article 15.6.2 of IGF Code, it requires temperature monitoring for the bulkhead shaft glands and bearings of the gas compressor, and automatically give a continuous audible and visual alarm on the navigation bridge or in a continuously manned central control station in case of high temperature. While in chapter 10 of CCS Rule, regulation for the control, monitoring and safety systems, there is no clear requirement for the temperature monitoring for gas compressor. However, in article 2.2.4.2, regulation for the arrangement of gas compressor, it requires the prime motor of gas compressor shall be arranged in the adjacent gas safety spaces, the area where the transmission shaft running through the bulkhead shall be gastight and be temperature monitored.

Comparing the two statements of IGF Code and CCS Rule, we can get the idea that the temperature monitoring is required by both, but the CCS Rule should take audible and visual alarm system into consideration in the ship survey practice.

3.2.13.5 Regulations for gas detection

In article 15.8.7 of IGF Code, it requires the alarm limit be set to 30% LEL（lower explosive limit） for ventilated ducts around gas pipes in the machinery spaces containing gas-fuelled engines, and the safety system shall be activated at 60% of LEL at two detectors, while in article 10.3.1.1(2) of CCS Rule, it requires the safety system be activated at 40% of LEL. From this point of view the requirement for the safety system activation is in CCS Rule is stricter than in the IGF Code.

In article 15.11 table 1 of IGF code, when fire is detected in fuel storage hold space, it requires that the alarm system be activated, however, in the table 10.4.1.1(2) of CCS Rule, when fire is detected in fuel storage hold space, it requires not only to activate the alarm system but also to automatically shut down the tank valve. More than that, the CCS Rule contains monitoring of bunkering system which is not included in the IGF Code, and the requirement for the monitoring of gas supply system to engines is more detailed than in the IGF Code. In a word, the requirement is stricter than the IGF Code.

3.2.14 Standard for the use of limit state methodologies in the design of fuel containment systems of novel configuration

The Standard for the Use of Limit State Methodologies in the Design of Fuel Containment Systems of Novel Configuration is an annex of IGF Code, which provides procedures and relevant design parameters of limit state design of fuel containment systems of a novel configuration. In the CCS Rule, there is no such chapter or annex. However, in article 5.1.1.2 of CCS Rule, it requires the membrane tanks, type A independent tanks and type B independent tanks shall correspondingly comply with the

requirement of membrane tanks, type A independent tanks and type B independent tanks in the *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*, in this Rule there is an annex which is the same as the one mentioned above, so this means the requirement in the IGF Code and CCS Rule have no differences.

3.2.15 Manufacture, workmanship and testing

The manufacture, workmanship and testing which is part B of the IGF Code, is mainly about the welding of metallic materials and non-destructive testing for the fuel containment system, other regulations for construction in metallic materials, testing, welding post-weld heat treatment and non-destructive testing, and testing regulations. In the CCS Rule, there is no one specific chapter for such aspects, however in article 1.1.5.1, it requires the materials for fuel tanks, fuel pipes, process pressure vessels, and other components contacted with cryogenic liquid or gases should comply with the requirement in chapter 6 of *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*, and in article 3.2.3.4, it requires the type testing for the valves and attachments in the piping system shall be carried out in accordance with the requirement in the *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*. In chapter 5 and 6 of the Rule, the contents about manufacture, workmanship and testing which in part B of the IGF Code are all covered, so from this point of view, the requirements in IGF Code and CCS Rule are the same.

3.2.16 Drills and emergency exercises

The IGF Code and CCS Rule all require drills and emergency exercises on board shall be conducted at regular intervals, more than that, the CCS Rule requires the LNG fuelled ships shall have an exercise plan.

3.2.17 Operation

The regulations for bunkering operations (article 18.4), regulations for enclosed space entry (article 18.5), regulations for inerting and purging of fuel systems (article 18.6), regulations for hot work on or near fuel systems (article 18.7) which covered in the IGF Code are not included in the CCS Rule.

3.3 Summary

Based on the above chapter by chapter comparative study between IGF Code and CCS Rule, we can get a clear idea that the two regulations are mostly in line with each other, both in structures and contents. The detailed requirements for LNG fuelled ships of the two regulation also have some differences: there are some aspects that the IGF Code has stricter requirement or not covered by the CCS Rule, while in some other aspects the CCS Rule has additional and more detailed requirement.

The IGF Code has stricter requirements than CCS Rule in the following aspects including: fire and explosion, scope of risk analysis, limitation of explosion consequences, location of fuel storage tanks, capacity of drip tray, location and protection of fuel piping, location and protection of pipe connections to the fuel storage tank, determination of the collision load for the tanks except type C independent tank, limitation of venting of fuel vapor for control of the tank pressure, color mark for the gas pipes, anti-blow-out for the gaskets, connections at the bunkering station, gas free of bunkering pipes, isolation arrangements for bunkering arranged with a cross-over, scope of category A machinery space for fire protection purposes, coverage scope of water spray system, scope of the hazardous area zones 0, protection for non-hazardous spaces with entry openings to a hazardous area, lighting system in hazardous areas, power supply for gas engine control system and gas fuel control system, monitoring system for potable fuel tanks, safety system, type and arrangement of level gauges, high temperature alarm system for the bulkhead shaft glands and bearings of the gas compressor, bunkering operations, entering enclosed space, inerting and purging of fuel system, and hot work on or near fuel systems.

The CCS Rule has additional and/or more detailed requirement in the aspects including: determination of loads due to ship motion, arrangement of air inlet pipe for main engine, protection of crank case and the ignition system for gas-only engines, fire separation for the bunkering station on the open deck, scope of hazardous area zone 2, ventilation in ESD protected machinery spaces, protection for the safety enhanced machinery spaces, alarm limit for ventilated ducts around gas pipes in the machinery spaces containing gas-fuelled engines, response to fire in fuel storage hold space, and exercise plan.

Chapter 4 Impacts and difficulties for implementing IGF Code in China

The IGF Code is the first international document that clarifies the comprehensive safety standards for LNG fuelled ships, this unified regulation unquestionably will accelerate the development of the ING fuelled ship all over the world, of course including China. However, based on the analysis in chapter 3, the implementation of IGF Code at the same time will bring new requirements for LNG fuelled ships, which will also exert influences on the development of LNG fuelled ships, and some difficulties may also appear in the process of implementing this Code.

4.1 Impacts on LNG fuelled shipping industry in China

4.1.1 Promoting the development of LNG fuelled passenger ships, dangerous cargo ships and seagoing ships

The present Chinese regulations for LNG fuelled ships, including CCS Rule and the *Provisional Regulations for Legal Inspection of Natural Gas Fuelled Inland Ships*, all exclude the passenger ships and dangerous cargo ships from their coverages, which obviously will restrict the development of such ships, and now that no LNG fuelled passenger ships and dangerous cargo ships exist in China is the best evidence. Based on the analysis in chapter 3, it is clear that the IGF Code and CCS Rule don't have many irreconcilable differences, however the IGF Code doesn't exclude the passenger ships and dangerous cargo ships from its coverage, so with the implementation of IGF Code in China, the maritime administrations certainly will realize this problem, and that passenger ships and dangerous cargo ships will be allowed to use LNG fuel is only a matter of time sooner or later.

To be realistic, the passenger ships, especially ferries are more suitable for using LNG fuel. Because of the cryogenic and volatile characters of LNG, the fuel tank and fuel containment system for LNG fuelled ships take much more room compared with traditional ships. In other words, the LNG fuelled ships will take less fuel in their fuel

tanks, for most ships this will cause big problem of reducing their maximum navigating range which finally will affect their competitiveness in commercial transportation, but ferries will not be affected because their navigating ranges usually are not very long and they are mostly operating in fixed lanes from home port to destination port and back to home port. The existing LNG fuelled ships commendably prove this argument: from figure 1 we can see that in the whole 162 LNG fuelled ships (both in operation and on order) the car/passenger ferry takes the biggest part among all other types. If we add the cruise ship into it, the percentage of passenger ship will be 25.9%. Meanwhile, the dangerous cargo ship also takes a big part in the LNG fuelled fleet, whose percentage is 19.8% (both gas carrier and oil/chemical tanker), not taking into consideration the container ship which in most cases can carry dangerous cargoes. So in the situation that nearly half of the world LNG fuelled fleet are passenger ships and dangerous cargo ships, there is no reason for China continually to keep the passenger and dangerous cargo ship out of affairs. The growing trend of LNG fuelled fleet in the next several years which is shown in figure 2 also indicates the number of LNG fuelled passenger ship and dangerous cargo ship will continually increase in future, and the DNV GL (2016) statistics also shows approximately 60% of LNG fuelled ships are now operating in Asia & Pacific area, so from the global trend, the development of LNG fuelled passenger ship and dangerous cargo ship will be greatly boosted.

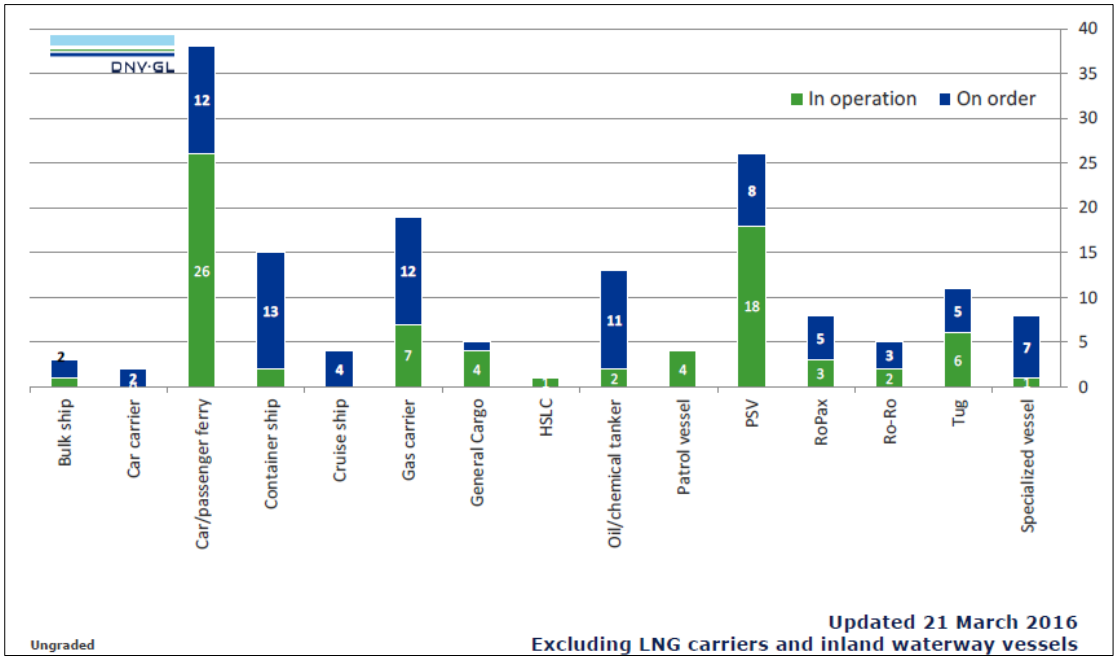

Figure 1: Number of LNG fuelled ships in different types

Source: DNV GL, Ship list – Vessels in operation and vessels on order

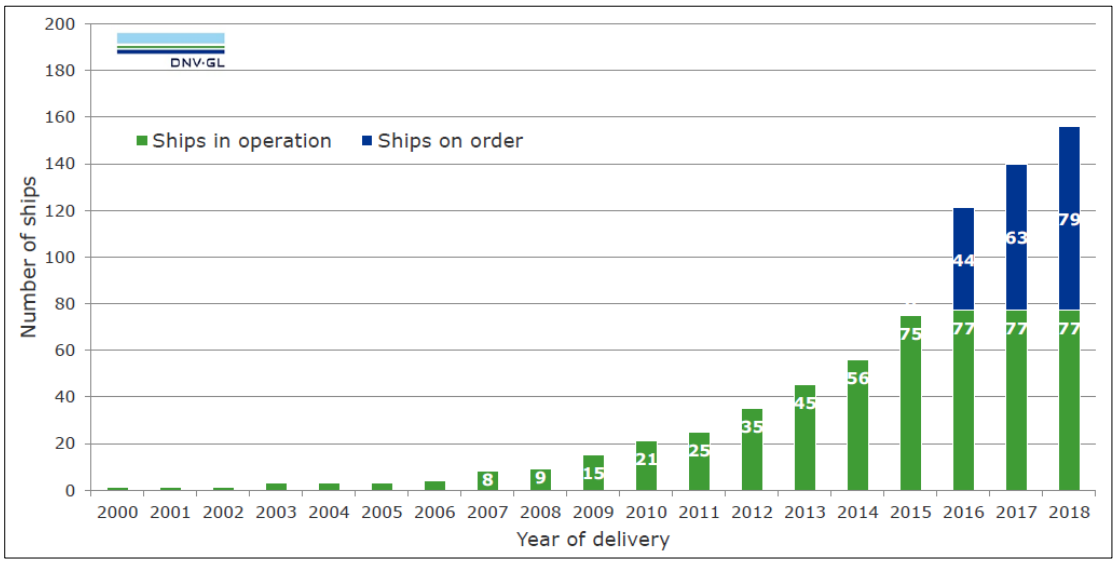

Figure 2: Year of delivery for LNG fuelled ships

Source: DNV GL, Ship list – Vessels in operation and vessels on order

4.1.2 Changing the developing mode of LNG fuelled inland ships from refitting to new building

According to Xu (2016), the approximate number of LNG fuelled ships in China is 118, including the ships in operation and on order. Different from the world fleet list (DNV GL, 2016), which only covers the seagoing ships, the LNG fuelled ships in China mainly are inland ships which as figure 3 shows take 97.5% of the total number. There are two modes of developing the LNG fuelled ships, one is refitting and the other is new building. Most of the world fleet of LNG fuelled seagoing ships are new building, however for Chinese LNG fuelled inland ships the refitting mode is extensively adopted and the percentage of inland ships is nearly 94.1% as shown in figure 3. As stated by Guo (2015), the refitting mode is in the condition of not change the ship's main engines, additionally installing the LNG fuel tank, LNG containment system and piping, automatic control system and safety system on the ship, to inject LNG into the

combustion chamber from the air inlet manifold or inlet valve to burn together with oil fuel, so as to enable the engine to operate in the oil and LNG dual fuel condition and can also be changed over between the two fuels.

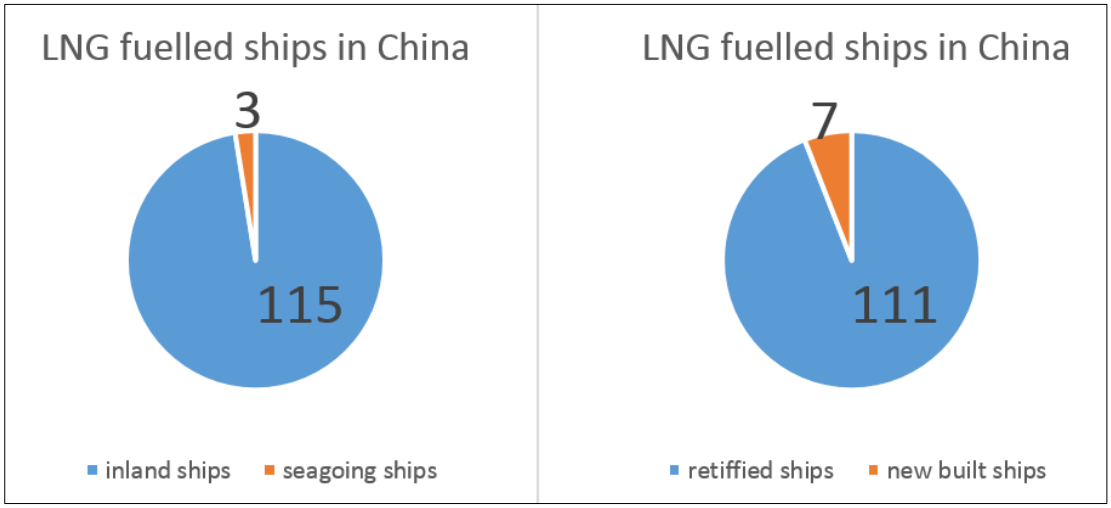

Figure 3: LNG fuelled ships in China

Source: Xu Jian, Discussion on the Special Training for Crews Servicing on LNG fuelled Inland Ships

Although the refitting mode can save a large amount of money compared with new building, the problems faced in the way of refitting really hurt the development of LNG fuelled ships in China, and the most serious problem is emission of methane from the exhaust gas which is caused by the unscientific way of LNG injection. Which totally deviates from the initial purpose of protecting air environment. With the implementation of IGF Code in China, it can be predicted that refitted ships can hardly or in another word are very costly to fulfill the requirement of IGF Code. Although the IGF Code will not be applied to the inland ships, from past experiences, the safety standard of seagoing ships will gradually affect the inland ships, which means the developing mode of LNG fuelled inland ships will gradually change over to new building from refitting. A clear evidence for this argument is the Chinese Ministry of Finance (2014) changed its subsidy policy for LNG fuelled inland ships, in article 19 of its *Administrative Measures for the Subsidy of Inland Ships' Type Standardization,*

whereby the refitted LNG fuelled inland ships have been excluded form compensation objects and only the new built ships can get the subsidy.

4.2 Difficulties in implementing IGF Code in China

4.2.1 Balancing the requirement differences for LNG fuelled ships

Based on the analysis in chapter 3, there are some clear differences between IGF Code and CCS Rule, such as the minimum distance from fuel tank to the ship bottom (IGF requires the greater of B/15 or 2m, while CCS has no limitations for fuel tanks arranged on open deck or semi-closed space), the cover range of water spray system (IGF Code requires 10m while CCS Rule requires 5m), the number of level gauge for fuel tank (IGF Code requires 3 while CCS Rule requires 2). There are other requirements in the IGF Code that are not included in the CCS Rule. For example, an explosion should not prevent person's access to life-saving appliances or impede escape routes, the determination of each drip tray's capacity, the requirement for bunkering manifold and bunkering station. To implement the IGF Code we must totally fulfill its requirements, which means the CCS Rule must be amended. It will cause chain reaction to the *Provisional Regulations for Legal Inspection of Natural Gas fuelled Inland Ships.* The IGF Code will come into force on 1st January 2017, which doesn't leave much time for amending the national regulations.

4.2.2 Implementing IGF Code in proper ways

The IGF Code becomes compulsory by means of SOLAS, and the SOLAS doesn't incorporate any IGF Code's detailed technical requirements, but only gives an index to the IGF Code when involving LNG fuelled ships. In China the SOLAS is implemented through China MSA's *Technical Regulation for Statutory Survey of Seagoing Ships*. Normally such amendment of SOLAS should be implemented through this Technical Regulation. Should we absorb all IGF Code to the Technical Regulation or give an index to an external Code just like SOLAS does? And if we choose the second way,

should China MSA develop its own Code based on IGF Code or just give index to the CCS Rule? These basic questions have great effect on the later work of implementing IGF Code.

4.2.3 Challenges to PSCOs (Port State Control Officers)

Different from most former international documents, the IGF Code is a production of GBS (goal based standards) which focuses on the goals, the purpose and what should be achieved, rather than how to achieve it. For the former conventions, there are all very detailed requirements ships should fulfill, and the PSCOs only need to inspect the ships article by article according to the convention when carrying out the PSC (Port State Control). However, in the IGF Code, it's difficult for PSCOs to verify whether the ship complies with the IGF Code or not because the Code mainly focuses on the safety standards but not always gives detailed measures to achieve them. For example, in article 9.6.2 of IGF Code, it requires "if gas is supplied into the air inlet directly on each individual cylinder during air intake to the cylinder on a low pressure engine, such that a single failure will not lead to release of fuel gas into the machinery space, double ducting may be omitted on the air inlet pipe". Gan (2015) thinks the safety standard "single failure will not lead to release of fuel gas into the machinery space" can be achieved by installing a flammable gas detector above the engine and connecting it to the safety system, but whether other arrangements such as the detector not connected to safety system fulfill the requirement or not really needs the PSCOs to have very professional knowledge to determine. Therefore, this will bring many challenges to the PSCOs when carrying out ship inspections, and more professional training should be given to them, also some guidelines for inspecting shall be made beforehand.

4.2.4 No regulations for seafarers training

The requirement for seafarers servicing on LNG fuelled ships is specified in the STCW convention. However, until now there is no corresponding national regulation or rule to

regulate the training and certification of seafarers in China. The information from Zhuhai branch of CNOOC who holds 2 LNG fuelled seagoing tugs shows that the seafarers are trained by themselves and no official certificates are issued. After the coming into force of IGF Code, if the seafarers servicing on LNG fuelled ships don't hold a Certificate of Proficiency in basic/advanced training, they may be recognized as incompetent because of not meeting the requirement of STCW convention. If seafarers have no means of participating in training and getting a Certificate of Proficiency in advanced /basic training, then who will operate the LNG fuelled ships? So it is urgent to develop China's national regulations to clarify training and certification for seafarers, and the qualification for training institutions and instructors should also be clarified.

Chapter 5 Recommendations for implementing IGF Code in China

From the above discussion we know that some difficulties still should be settled when implementing the IGF Code, meanwhile how to take the opportunity of implementing IGF Code to accelerate the development of LNG fuelled shipping industry in China is another thing the administration should take into consideration. There are some recommendations which are worth considering and putting into practice.

5.1 Making CCS Rule applicable to all LNG fuelled seagoing ships

Until now the China MSA hasn't developed any laws or regulations for the LNG fuelled seagoing ships, although we have a very important classification Rule (CCS Rule) and it has been in effect for about 3 years. However, the CCS Rule itself is not applicable to all seagoing ships. According to article 13 of the *Inspection Regulations for Ships and Offshore Facilities of the People's Republic of China* (Chinas State Council, 1993), ships on international voyages shall apply CCS's society classification survey, which means seagoing ships on domestic voyages are not covered and these ships can voluntarily registry in CCS. It may face the problem of incompliance in the IMO mandatory audit if there is no mandatory regulation for ships on domestic voyages. Two ways can solve this problem: one is developing national regulation for ships on domestic voyages, and the other is making the CCS Rule applicable to all LNG fuelled seagoing ships by administrative order.

For the way of developing new regulation, the first problem is that there is not much time left before the IGF Code comes into force on 1st January 2017 as developing new regulation is a time consuming work; another problem is that if the China MSA develops its own regulation, it means these LNG fuelled ships will be surveyed and certificated by the ship survey department in China MSA, because these ship survey departments do not have much knowledge and experience in LNG fuelled ships compared with CCS who has been researching and participating in such work for many

years, so the surveyors in China MSA's ship survey departments may have difficulties in surveying at the early stage; balancing the requirement in the new developed regulation and CCS Rule is another big problem. If the new developed regulation has the same requirement with CCS Rule, why we waste time to develop it, and if we lower down the safety standard for ships on domestic voyages, it may face the safety problem and not achieve the goal of air pollution protection, which will follow the same old disastrous road of refitting LNG fuelled inland ships.

For the way of making the CCS Rule applicable to all LNG fuelled seagoing ships by administrative order, it's a very easy way which doesn't need much extra work. As all LNG fuelled seagoing ships use the same safety standard, it makes it easier for the administrations to control these ships, and can also promote the development of LNG fuelled shipping industry in a safe and healthy mode. For another thing, it is reasonable to request all LNG fuelled seagoing ships registry in CCS, in China all roro ships, liquid gas carriers and chemical bulk carriers must registry in CCS (Chinas State Council, 1993). The safety standard of LNG fuelled ships usually is thought to be equal to LNG carriers', that's why many of the requirements for LNG fuelled ships in the IGF Code are the same as LNG carriers', so making the CCS Rule applicable to all LNG fuelled seagoing ships is in line with the practice of LNG carriers. The China MSA (2014) requires the new building experimental LNG fuelled seagoing ships shall refer to the requirement of CCS Rule is a good example for this recommendation.

5.2 Amending the CCS Rule

Right now the IGF Code only has requirements for LNG fuelled ships, but in the future the requirement for ships using other gases or low-flashpoint liquid such as fuel cell and low-flashpoint diesel oil will be added into the IGF Code (Guo, 2014). Considering this, to implement the IGF Code we'd better put these requirements together into one regulation just like IGF Code does, so we should do some amendments to the CCS Rule

to get it ready for being a mother regulation to cover more aspects, so that we can catch up with the pace of IGF Code easily.

More urgently, some requirements that are not in line with the IGF Code which have been discussed in chapter 3 should be modified as soon as possible, such as the minimum distance from fuel tank to the ship bottom, the cover range of water spray system, the number of level gauge for fuel tank, the area of hazardous area zones 0 and 2, the protection of non-hazardous spaces with entry openings to a hazardous area, type of liquefied gas fuel tank liquid level gauges, and the determination of the collision load for the tanks except type C independent tank. Some other requirements in the IGF Code that are not covered in CCS Rule, which have been clearly stated in chapter 3, should also be added into it.

Another important aspect that should be amended in the CCS Rule is that it should be made applicable to the passenger ships and dangerous cargo ships. As have been discussed, the requirements for LNG fuelled passenger ships and dangerous cargo ships do not have very special technical difficulties, and nearly half of the existing LNG fuelled ships (both in operation and on order) are passenger ships and dangerous cargo ships. In order to accelerate Chinese LNG fuelled shipping industry, the passenger ships and dangerous cargo ships cannot be prohibited to use LNG fuel any more.

5.3 Developing training and certificating regulations for seafarers servicing on LNG fuelled seagoing ships

The amendment to STCW convention (MSC 95/22/Add.2) requires the administrations shall ensure that a Certificate of Proficiency is issued to the qualified seafarers who are servicing on ships subjected to the IGF Code. To fulfill the requirement of STCW, we must develop our national regulations to regulate the training and certification of seafarers servicing on ships subjected to IGF Code. The *Administrative Measures for Training and Certification of Seafarers of the People's Republic of China* (Ministry of

Transport, 2011) which is one of the most important regulations to regulate certification for seafarers, till now doesn't cover the Certificate of Proficiency for seafarers servicing on LNG fuelled ships, so the first step is to modify this Administrative Measures to incorporate the requirements for seafarers servicing on LNG fuelled ships, the Certificate of Proficiency for basic training and advanced training, the application limitations, and the definition of LNG fuelled ships shall be added into this Administrative Measures. Another important aspect that should be covered is the detailed requirements for training, in China the training for seafarers right now is all carried out by social training institutions which have no direct relation to China MSA, and these social training institutions do their training totally according to the training syllabus which is developed by China MSA, so in order to guide the training work for social training institutions the training syllabus should be amended. The detailed training syllabus for seafarers servicing on LNG fuelled ships can be developed from the specification of minimum standard of competence in basic/advanced training for LNG fuelled ships in STCW convention.

Chapter 6 Conclusion

The IGF Code is a milestone of the control of LNG fuelled ships, to ensure seafarers servicing on LNG fuelled ships have completed training to attain the abilities that are appropriate to the capacity to be filled and duties and responsibilities to be taken up. The STCW amendment (MSC 95/22/Add.2) clearly states the requirement for training and certification of these seafarers, and a Certificate of Proficiency for basic training or advanced training should be held depending on the seafarers' responsibilities onboard ships. China only has regulation for training and certification of crews servicing on LNG fuelled inland ships, and such training is categorized as special training in the *Regulations on Exam and Certification of Special Training for Inland Ships* which was developed by China MSA.

The most important regulations for LNG fuelled ships in China are CCS Rule and China MSA's *Provisional Regulations for Legal Inspection of Natural Gas Fuelled Inland Ships*, and the Provisional Regulations to some extend can be recognized as a shrunken version of CCS Rule. The detailed technical requirements comparison between IGF Code and CCS Rule reveals that they are mostly in line with each other even though on some aspects the IGF Code has stricter requirements and vice versa. Obviously, the areas where the CCS Rule doesn't reach the standard of IGF Code or even not cover should be paid special attention to.

The implementing of IGF Code in China will promote the development of LNG fuelled passenger ships, dangerous cargo ships and seagoing ships, which now are not covered in the national regulation, and meanwhile the developing mode of LNG fuelled inland ships will slowly be changed over from refitting to new building as influenced by the higher safety standard of seagoing ships. To fully implement the IGF Code and lead the Chinese LNG fuelled shipping industry to a healthy and fast developing mode, there are still difficulties that should be solved, including balancing the different requirement

for LNG fuelled ships, choosing a proper way of implementing the IGF Code, improving the knowledge and practices of LNG fuelled ships for PSCOs, and normalizing the training and certification of seafarers form the regulative layer.

Some personal recommendations for implementing IGF Code in China which are worth considering and putting into practice including making CCS Rule applicable to all LNG fuelled seagoing ships, amending the CCS Rule to totally keep it in line with the IGF Code and make it applicable to passenger ships and dangerous cargo ships, and developing the national training and certificating regulations for seafarers servicing on LNG fuelled seagoing ships.

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