7

Dalian Shipbuilding Industry Co., Ltd, China

Country : China
ISO member body : Standardization Administration of the People's Republic of China (SAC)
Project team :
Project leader : Mr. Guo Hui, Director General, Department of International Cooperation, SAC
Members – China National Institute for Standardization (CNIS) :
Dr. Wang Yiyi, Director, Sub-Institute of standardization theory and education
Dr. Fu Qiang, Assistant to the Director, Sub-Institute of standardization theory and education
Ms. Wang Lijun, Officer, Sub-Institute of standardization theory and education
Member – Dalian Shipbuilding Industry Corporation :
Mr. Ma Yulong, Chief of Standardization Section, Engineering and Research Institute Co., Ltd.
Members – Standardization Administration of the People's Republic of China :
Mr. Guo Chenguang, Director, International Organizations Division
Mr. Li Dongfang, Standardization officer, International Organizations Division
Ms. Huang Li, Standardization officer, International Organizations Division
ISO Central Secretariat advisor : Reinhard Weissinger, Manager, Research, Education & Strategy
Duration of the study : July 2011 – April 2012

7.1 Objectives, time frame and participants in the pilot project

The objective of this pilot project was to evaluate the economic benefits for a company resulting from the use of standards. "Standards" include international, national, industry and company standards that have been implemented and may apply to all segments of the company, from research and development to production and sales. We have selected the Dalian Shipbuilding Industry Co., Ltd., a company well-known in China, to assess the impact of standards on the shipbuilding industry.

The pilot project began in July 2011 and was concluded in April 2012. The main participants were the Standardization Administration of the People's Republic of China (SAC), the China National Institute of Standardization (CNIS), the No. 704 Institute of the China Shipbuilding Industry Corporation, and the Dalian Shipbuilding Industry Co., Ltd.

7.2 Pilot company

7.2.1 Company name and address

The Dalian Shipbuilding Industry Co., Ltd., is located at No. 1, Yanhai Street, Xigang District, Dalian, Liaoning Province, China.

7.2.2 Company history

The Dalian Shipbuilding Industry Co. was founded in 1898 when Tsar Nicholas II approved the construction of a dockyard – the predecessor of the company. In April 2010, it was restructured and divided into the Dalian Dockyard Co., Ltd., a fully-funded subsidiary of the China Shipbuilding Industry Corporation, and the Dalian Shipbuild-

ing Industry Co., Ltd., a holding subsidiary of the China Shipbuilding Industry Limited Liability Company.

7.2.3 Main products

A flagship of China's shipbuilding industry, the Dalian Shipbuilding Industry Corporation (hereinafter referred to as DSIC) is a modern final assembly company combining five major industries – shipbuilding, defence, ocean engineering, ship repair (including shipbreaking) and heavy industry. The products of the shipbuilding industry branch of DSIC are divided into oil tankers, bulk carriers, container ships and special ships. The production volume and domestic market share in the shipbuilding industry between 2006 and 2010 are given in **Table 1.**

Year	National shipbuilding production volume (in thousand tons)*	DSIC's production volume (in thousand tons)*	Domestic market share (%)
2006	14 520	2 010	13.8
2007	18 930	3 110	16.4
2008	19 940	2 970	14.9
2009	42 430	3 890	9.2
2010	65 600	5 880	9.0
Note : Since 2009, privately owned shipbuilding companies have developed quickly.			

(*) Deadweight tons

Table 1 – DSIC's production volume and domestic market share (2006 – 2010)

7.2.4 Revenue, employees and organizational structure

7.2.4.1 Revenue

Table 2 gives DSIC's total revenue, the revenue from the shipbuilding industry in China, and the revenue of the R&D business function in the shipbuilding industry, based on recent surveys.

Year	Revenue of the whole corporation	Revenue due to Shipbuilding	Revenue of the R & D business function
2006	10 460 000	9 414 000	52 450
2007	14 190 000	12 771 000	85 017
2008	18 000 000	16 200 000	113 120
2009	20 590,000	18 531 000	143 250
2010	22 750,000	20 475 000	150 820

Table 2 – Revenue 2006-2010 (Unit : thousand CNY)

7.2.4.2 Employees

DSIC employed 7598 people in 2010, of which 6 held PhDs, 106 masters degrees, 2067 bachelor degrees, 1930 junior college degrees, and 3495 were graduates from technical secondary school or lower level. In addition, more than 20 000 employees worked in supplier companies.

The Design Institute, the focus of this assessment, had 867 employees, of which three had PhDs, 83 master degrees, 524 bachelor degrees, 202 were junior college graduates and 55 had degrees from technical secondary schools or below.

7.2.5 Main construction parts and materials

Eight main categories of construction parts and materials are used in production – paints, sanitary units, cabin materials, steel doors and windows, main engines, diesel generator sets, boilers, steel plates and sectional materials.

7.2.6 Main customers

DSIC's main customers are ship-owners located in Europe, Asia, America and other regions of the world, and include Maersk of Denmark, TORM of Norway, Singapore Pacific International Lines, the IMC Group and other internationally known shipping companies that have been partners of DSIC for many years.

7.2.7 Main competitors

DSIC's main competitors include Hyundai Heavy Industries, Samsung Heavy Industries, Daewoo Shipbuilding (all from Korea), Tsuneishi, Universal Shipbuilding (from Japan), as well as other Chinese companies such as Shanghai Waigaoqiao Shipbuilding Co., Ltd., Jiangnan Changxing and Hudong Zhonghua.

7.3 Attitude of the company towards standardization

7.3.1 Attitudes of management and employees towards standardization

The company established a standardization committee headed by the vice general manager, with members from all departments. The committee holds a standardization working conference involving the whole corporation every 14 October on the occasion of "World Standards Day".

7.3.2 Participation of the company in the development of international, national and industry standards

DSIC participates in the work of ISO/TC 8/SC 4/ WG 3 *Ships and marine technology – Outfitting and deck machinery – Outfitting*. In order to cope with requirements defined in the Energy Efficiency Design Index (EEDI) of the International Maritime Organization (IMO) and the Marine Environmental Protection Committee (MEPC), the company has participated in the "Expert working group on EEDI indexes for new ship design" since 2009. It has put forward suggestions to solve technical problems in EEDI formulae, and submitted proposals to address problems in the operation and applications of the formulae. It

measures and calculates ship types, has developed a data table for calculation, and made proposals for the development of future ship types and diesel engine manufacturing supported by relevant agencies.

Up to now, DSIC has helped to develop more than 30 Chinese national standards and over 150 Chinese industry standards.

7.3.3 Application of standards in the company

Since the shipbuilding industry uses many different technologies and its processes are very complex, it uses a large number of standards. DSIC uses more than 100 000 Chinese and foreign standards that can be classified as follows:

- General conventions and rules issued by the IMO
- Specifications issued by various major classification societies and the International Association of Classification Societies (IACS)
- International Standards developed by ISO, IEC and ITU
- National and industry standards issued by various countries
- Standards developed by major companies.

According to the ISO methodology, these standards can be divided into three types: product, process, and health, safety and environmental (HSE) standards.

- Product standards cover all classes of ships, ocean engineering equipment, ship support equipment and materials (see **Table 3)** and specify mainly the performance of these products, their design and structure, sizes, and product-related test methods, etc.
- Process standards cover production and processing, management and quality control, and test methods of ships and their support equipment (see **Table 4)**. They include also process, management and quality system standards, and standards for test methods.

- HSE standards – the main standards used are OHSAS 18001 *Occupational health and safety management systems*, and ISO 14001 *Environmental management systems* (see **Table 5)**.

Category	Field of application	Examples of key standards
Ships	Whole ship, ship structure, ship performance, basic and universal methods, etc. : 165 standards	CB 3181 ~ 3187, *Hull structure series standard*
Ocean engineering equipment	Whole ships and structures, systems and equipment, underwater units, etc. : 8 standards	GB/T 3471, *General provisions for programming, mooring and sea trials of sea going ships* CB/T 3655, *Design regulation for engine control rooms* CB 3371, *Hull node structures for oil hold area of oil tankers*
Ship support equipment	Marine power plant, including marine engine, shafting and gearing : 102 standards	GB/T 2497, *Charge air coolers for marine diesel engines* GB/T 12916, *Specification for metallic marine propellers*
	Marine machinery accessories, including auxiliary engines in cabins and engine room equipment, deck machinery, fire-fighting equipment, environmental protection equipment, pipeline fittings, hydraumatic and pneumatic elements, boilers and pressure vessels, etc. : 560 standards	GB/T 14650, *General specification for marine auxiliary boilers* CB/T 1036, *Marine plate coolers* GB/T 11035, *Marine electric two spindle screw pumps* GB/T 11864, *Marine axial flow fans* GB/T 4447, *Sea-going vessels – Windlasses and anchor capstans* GB/T 584, *Marine cast steel flanged stop valves*
	Ship's electrical systems and equipment, including generating, transformer, distribution, control and measuring equipment, lighting and other electric appliances, electrical installations, etc. : 136 standards	GB/T 3783, *General specification for low-voltage apparatus in ships* GB/T 13603, *Marine battery installation* CB/T 1001, *Marine transformers* CB/T 3871, *General specification for indicator lights in ships* CB 771, *Voltage resistant cable stuffing boxes*

Category	Field of application	Examples of key standards
	Ship navigation, communication, underwater sound equipment, etc. : 72 standards	GB/T 4301, *Marine electromagnetic logs* GB/T 11875, *Marine rate of turn indicators* GB/T 18913, *Marine facsimile receivers for meteorological charts* CB 1218, *Usual piezoceramics element of underwater sound*
	Ship outfitting, including mooring fittings, marine installation, deck fittings, survival equipment, accommodation equipment and interior decoration, marine ventilation accessories, etc. : 323 standards	GB/T 554, *Bollards* GB/T 11577, *Container securing fitting for ships* GB/T 3477, *Marine weathertight single-leaf steel doors* GB 4303, *Marine lifejackets* CB/T 295, *Mushroom ventilators for ships*
Materials	Marine materials and testing methods, etc. : 137 standards	GB/T 22641, *Wrought aluminium alloy sheet and plate for ships* CB/T 3496, *Marine cable coating* GB/T 6748, *Anticorrosive paint for ships* GB/T 7789, *Dynamic test method for performance of marine antifouling paint*

Table 3 – Product standards

Category	Field of application	Examples of key standards
Production machining	Shipbuilding technology and processes : 99 standards	GB/T 13148, *Specification for welding of stainless steel clad plates* CB/T 3190, *Hull structure welding, groove type and size* CB/T 3671, *Integrated arrangement zoning principles and code names*
	Ship manufacturing process equipment : 7 standards	CB/T 3950, *Elevating work platforms for docksides* CB/T 8521, *Design requirements for shipbuilding gantry cranes*

Category	Field of application	Examples of key standards
Test methods	Test methods for ships	CB/T 346, *Open water test methods for model propellers* CB/T 3471, *Testing regulations for floating system models under combined action of wind, waves and currents* CB/Z 215, *Test method for propeller cavitation in uniform flow carried out in a cavitation tunnel*
	Test methods for support equipment	CB/T 3254.1 ~ 3254.3, *Method for marine diesel engine bench testing*
Management and administration	Management requirements and methods : 111 standards	CB/T 14, *Numbering for general drawings and technical documents shipbuilding products* CB/T 3261, *Rules for drafting of marine standard products* CB/T 3824, *Material classification and code for electric wire and cable*
	Information technology and applications : 5 standards	ISO 16155, *Ships and marine technology – Computer applications – Shipboard loading instruments* ISO 7838, *Shipbuilding – Shiplines – Formats and data organization*
Quality control	Quality management systems, quality standards	ISO 9001, *Quality management systems* CB/T 4000, *China shipbuilding quality standard*

Table 4 – Process standards

Category	Field of application	Key standards
Health, safety	–	OHSAS 18001, *Occupational health and safety management systems – Requirements*
Environment	–	ISO 14001, *Environmental management systems*

Table 5 – Health, safety and environmental (HSE) standards

The standards in **Tables 3, 4 and 5** only include national, ship industry and some ISO standards that are applicable to ships, without listing technical standards developed by the company itself. Com-

pany standards play a vital role in facilitating design, and in guiding production and inspection.

7.3.4 Company standards

Among some 1266 company standards, there are 71 basic standards, 433 for design, 300 for process, 99 for testing, 157 for the defence industry, 122 standards for products, ship parts and auxiliary equipment, three for safety, health and environmental protection, and 81 on metering detection and information technology.

7.3.5 Relevant mandatory standards and technical regulations

The company is not only under obligation to comply with mandatory standards and technical regulations, but also with international rules and specifications that are routinely followed by the industry, and which are listed in **Table 6** and **7**.

No. Safety	Document number	Title
1.		Amendment (VI) to the criminal law of the People's Republic of China
2.		Fire control law of the People's Republic of China
3.		Production safety law
4.		Measures for the determination of work-related injuries
5.	Order No. 344 of the State Council	Regulations on safety in the administration of hazardous chemicals
6.	Order No. 493 of the State Council	Bye-law governing reporting, investigation and handling of safety-related accidents in production
7.	Order No. 549 of the State Council	Regulations on safety supervision of special equipment
8.	Order No. 13 of the State Commission of Economy and Trade	Special operations staff security training assessment procedure

No.	Document number	Title
9.	Order No. 1 of the State Administration of Work Safety	Regulations on supervisory management of labour protection articles
10.	Order No. 3 of the State Administration of Work Safety	Regulations on safety training of production and operation entities
11.	Order No. 15 of the State Administration of Work Safety	Administrative penalty method for offences against safe production
12.	Order No. 23 of by the State Administration of Work Safety	Order by the state administration of work safety
13.	Order No. 27 of the State Administration of Work Safety	Order by the state administration of work safety
14.		Regulations of Liaoning province on safe production
15.	No. 31 [2004] issued by Dalian Bureau of Work Safety	Dalian municipal regulations on security management to prevent falling accidents
16.	Order No. 23 of Dalian municipal people's government	Dalian municipal administrative provisions on safety of external labour service personnel
17.	No. 114 [2005] issued by Dalian Bureau of Work Safety	Administrative municipal provisions on enclosed shipbuilding and ship repairing spaces
18.	No. 522 [2002] issued by Dalian Commission of Economy and Trade	Dalian municipal regulations on safety management of ship painting operations
19.	No. 32 [2007] issued by Dalian port	Notice on printing and distributing " Interim Dalian provisions on safe production management for ship repairing and local shipbuilding companies "
20.	GB 6067-1985	Safety rules for lifting appliances
21.	CB/T 3969-2005	Gas safety requirement for metal welding and cutting in cabins
22.	GB 9448-1999	Safety in welding and cutting
23.	CB 3660-1997	Safety procedures for shipyard lifting operation
24.	CB 3785-1997	Safety procedures for height operation in shipyards
25.	CB 3786-1997	Safety procedures for electrical operation in shipyards
26.	CB 3787-1996	Safety procedures for inter-plant handling operations in dockyards
27.	CB 3381-1991	Safety procedures for ship painting operations
28.	CB 3515-1993	Shipbuilding security management
29.	GB 18218-2009	Identification of major hazards for dangerous chemical installations

No.	Document number	Title
30.	GB/T 18664-2002	Selection, use and maintenance of respiratory protection equipment
Health		
31.		Law of the People's Republic of China on the Prevention and Control of Occupational Diseases
32.	Order No. 27 of the State Administration of Work Safety	Management method for the declaration of occupational hazards in operational fields
33.	No. 63 [2002] issued by health, law and supervision	Classification of occupational disease hazard factors
34.	No. 142 [2003] issued by health, law and supervision	Catalogue of highly toxic substances
35.		Temporary method of Liaoning province on occupational health supervision in operational fields
36.	CB/T 3745-1995	Classification for comprehensive evaluation of degrees of occupational hazard
37.	GBZ 2.1-2007	Occupational exposure limits for hazardous agents in the workplace
38.	GBZ 188-2007	Technical specifications for Occupational Health Surveillance
39.	GBZ/T 194-2007	Hygienic engineering measures for preventing and controlling occupational poisoning in the work place
40.	GB 5044-1985	Classification of hazards of occupational exposure to toxic substances
41.	GBZ/T 193-2007	Criterion of control and prevention of occupational hazards in processing asbestos
42.	GBZ/T 198-2007	Guideline for prevention of occupational hazards in the use of synthetic vitreous fibre insulation
43.	GBZ/T 196-2007	Technical guidelines for pre-assessment of occupational hazards in construction projects
Environment		
44.		Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution
45.	Order No. 475 of the State Council	Administrative Regulation on the Prevention and Control of Pollution Damage to the Marine Environment by Coastal Engineering Construction Projects
46.	Order No. 561 of the State Council	Regulation on the Prevention and Control of Vessel-induced Pollution to the Marine Environment

No.	Document number	Title
47.	Order No. 1 of the Ministry of Environmental Protection and National Development and Reform Commission	National Catalogue of Hazardous Wastes
48.	CB 3769-1996	Regulations on labour health management in the shipbuilding industry
49.	GBZ 1-2002	Regulations on labour protection in workplaces where toxic substances are used
50.	GB 11654 ~ 11666-1989, GB 18068 ~ 18082-2000	Hygiene standards for the Design of Industrial Companies
51.		Health protection zone standards for industrial companies
Other standards		
52.		Labour law of the People's Republic of China
53.		Labour contract law of the People's Republic of China

Table 6 – Mandatory standards and technical regulations

No.	Title
1.	Requirements of the Flag Administration
2.	International Convention for the Safety of Life at Sea, 1974, its Protocol of 1988 (SOLAS) and Amendments
3.	International Convention for the Prevention of Pollution from Ships, 1973 and Protocol of 1978 (MARPOL) and Amendments
4.	International Convention on Load Lines, 1966 and its Protocol 1988 and Amendments
5.	International Convention on Tonnage Measurement of Ships (1969)
6.	Suez Canal Navigation Rules including Tonnage Measurements
7.	Panama Canal Navigation Rules including Tonnage Measurements
8.	International Regulations for Preventing Collision at Sea, 1972 and Amendments
9.	International Telecommunication Convention 1973 and Radio Regulations (Geneva 1982) and Amendments
10.	IMO Resolutions –A468 (XII) – Code on Noise Level on Board Ships, 1982
11.	ILO Convention No. 92 and 133 concerning Crew Accommodation on Board
12.	Maritime Labour Convention, 2006, concerning Crew Accommodation on Board (without certificate nor inspection)

13.	ISO 6954:1984, *Mechanical vibration and shock – Guidelines for the overall evaluation of vibration in merchant ships*
14.	USCG Regulations for foreign-flag ships operating in navigable waters of the United States, CFR Title 33 Part 155, 159 and 164
15.	Australian Maritime Safety Authority Marine Orders Part 32 " Cargo Handling Equipment " Issue 2 (requirements for cargo hold ladders and cranes)
16.	International Maritime Pilot's Association Requirement Concerning Pilot Ladders
17.	The General Harbour (Ship cargo and dock safety) Regulation 1968, amendments No.1 (New Zealand Regulation)
18.	Harbour authority requirements for cargo gear in UK, Canada, India, Pakistan, Australia, New Zealand, USA and China

Table 7 – Rules and regulations applied by the company

7.4 Analysis of the value chain

In the present period of global economic integration, ships have become irreplaceable due to their large transport capacity and low cost.

The ship industry comprises four main sections – design, manufacture, transport and auxiliary equipment.

In the last century, the world shipbuilding center shifted from Europe to Japan, Korea, and then to China. Marine technology evolves continuously and is now developing towards safer, more environmentally-friendly and energy-saving ships. In terms of manufacturing models, the industry has moved from the " integral manufacturing mode ", to a " segmented manufacturing mode ", to a " production line manufacturing mode " and finally to an " integrated manufacturing mode ". The current trend is towards a high degree of mechanization, automation, integration and modularization.

Standardization has played, and continues to play, a vital role in the shift of the centre of worldwide shipbuilding and in the progressive development of shipbuilding technology. Analyzing the characteristics

of the industry is very helpful in identifying the value drivers in the industry value chain, and in understanding the benefits generated by standards.

The shipbuilding industry has three main characteristics:

1. Many product types, fast development

Modern ships can be divided into the following types, including oil tankers, bulk carriers, container ships, special vessels (such as dredgers, chemical cargo ships, liquefied petroleum gas (LPG) and liquefied natural gas (LNG) carriers), cruise ships, ferryboats and large-scale yachts. Oil tankers, bulk carriers and container ships account for 70 % to 80 % of the world's transport vessels. For this reason, these are also called the three "mainstream ship types". In addition, the so-called "three high" ship types are characterized by high-tech content, high manufacturing difficulty and high value-added design, but account for only a small share of world markets.

In order to win markets, shipbuilding companies compete by increasing their investment in R&D. They continue to develop new ship types, optimize existing types and improve ship performance resulting in an unprecedented speed in production of new ships.

Korean shipbuilders optimize and innovate in almost all ship types in order to satisfy new maritime regulations. Japan performs advanced research into LNG, container, cruise and many other design concepts. The latest ships tend to be larger in scale, have many more safety features, a greater degree of environmental protection, are also highly automated and more energy efficient.

2. Production of single units, small volumes, long manufacturing periods

Because markets change quickly and customer demands are diverse, it is a characteristic of the shipbuilding industry that orders are received before production is started. A product is in most cases a single unit.

The industry is also characterized by the development of large ships, the focus of much of the innovation. This trend is driven by economies of scale because large-scale ships reduce the per-unit costs of the goods being transported. For example, the per ton cost of transporting oil in a 250 000 ton oil tanker is 40 % less than that for a 25 000 tanker. When the capacity of a container ship increases from 4 000 TEU (twenty-foot equivalent unit) to 8 000 TEU, transport costs per case decrease typically by 15 %. Such economics drive increases in the size of hulls and more complicated structures.

Ship building is complex, demanding many materials of construction, extensive precision instrumentation and systems, leading to higher prices and increasing time taken in manufacture. Using the three mainstream ship types as an example, the average shipbuilding process for a 170 000 ton bulk carrier from docking to delivery is around half a year, around 385 days for a 76 000 ton oil product carrier, and about 320 days for a 4250 TEU container ship.

3. High technical requirements, complex management challenges

The shipbuilding industry involves many different technologies and processes. The technical requirements are high, whether in initial drawing design, process selection or specialized machine operation. In addition, ship structures and technologies are complicated and subject to frequent changes in the manufacturing process. Repeated operations are infrequent, which makes it difficult to adopt streamlined processes or specialized tools and equipment throughout production. Shipbuilding therefore relies heavily on the professional capabilities of engineers, technical staff and workers, all of whom are of key importance.

The company management of DSIC is involved in the control of design, costs, materials, components, production, personnel and other aspects which all require solutions to complex management challenges. A

shipbuilding company needs strong management capabilities and senior managers familiar with the whole shipbuilding process and its associated technologies.

7.4.1 Industry value chain

The shipbuilding industry can be sub-divided into the following segments (see **Figure 1)**:

- An upstream segment that includes iron and steel and various raw materials, and the manufacture of assorted products, components and parts
- A midstream segment that includes ship design and manufacture
- A downstream segment that includes the shipping industry, the repair service industry, ship disassembly and recycling, the leisure and entertainment industry, and exploration of ocean resources.

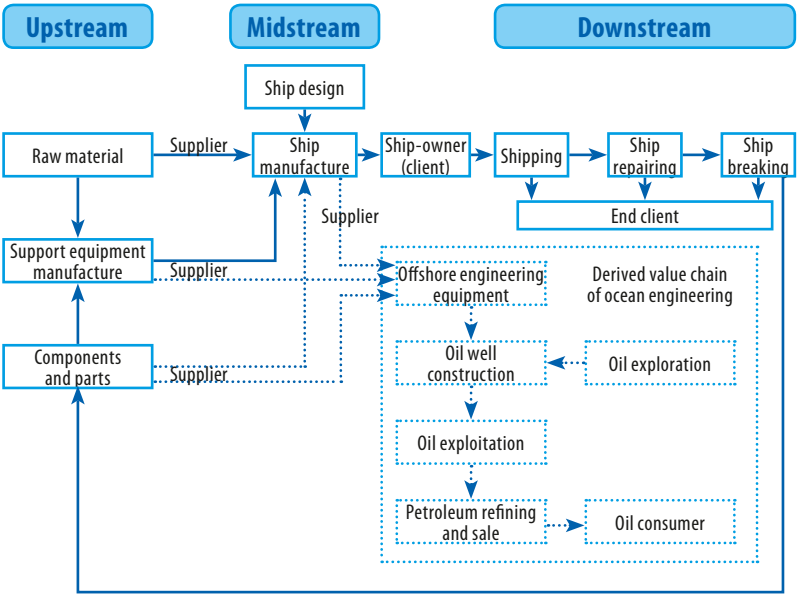

Figure 1 – Shipbuilding industry value chain

7.4.2 Position of DSIC in the shipbuilding industry value chain

Being one of the most important shipbuilding companies in China, DSIC operates across virtually the whole industry value chain. It attaches special importance to its activities in the mid- and downstream segments of the value chain in order to provide services that cover the whole life cycle of ships from development and design to construction, and eventually to repair, refitment and disassembly.

1. **Midstream segment of the value chain – ship design and manufacture**

In line with the company's overall development, its products evolved from foreign designs through joint-design to autonomous design, and increasingly towards large-scale, high-tech, high value-added products. Its output of ordinary bulk carriers, multi-purpose freight ships, medium-size and large oil tankers, ultra-large tankers and container ships has undergone continuous improvement and upgrading. Currently, DSIC puts major efforts into the development of multi-level VLCC (very large crude carriers), LNG ships and other high-end products. The company is improving its technical level in construction and has evolved the "five shipbuilding ideas" – digital, green, lean, standard and final assembly shipbuilding.

2. **Downstream segment of the value chain – repair and shipbreaking**

DSIC's repair/shipbreaking installation under construction at Changxing Island, Dalian, will become the biggest in the world with an annual average dismounting capacity of up to 75 ships of 50 000 to 300 000 tons. Costing some CNY 3 billion and with a floor space of approximately 100 hectares, the ship repair and green shipbreaking base is expected to go into production in 2013. It will operate on a green environmental protection system by channeling scrap steel

from shipbreaking to steelworks to make new steel products for the construction and repair of new ships. Strategic alliances between companies in the upstream and downstream segments of the industry value chain will further promote the cyclical re-use of materials.

3. Extended value chain – offshore engineering equipment

Besides shipbuilding itself, China leads in ocean engineering manufacturing. DSIC has designed and constructed the "Dajiao III" drilling platform, gas cushion and self-elevating drilling platforms, bathypelagic semisubmersible drilling platforms, upper modular structures for ocean engineering, floating production storage offloading vessels, launching barges, ocean integrated detection ships, and anchor handling tug supply vessels, for customers in China and abroad.

The company has also enjoyed successful growth in the ocean engineering refitment and repair market, and now refits all drilling platforms in China. In addition, the JU2000 self-elevating drilling platform capable of operating at a maximum water depth of 400 ft was constructed by DSIC. It is the largest platform of its type and offers the highest degree of automation. JU2000 was also the first in China to reach an international advanced level.

7.4.3 Company value chain

By applying the value chain analysis developed by Michael Porter to the specifics of DSIC's business structure, the core activities and support activities can be described as follows:

1. Core activities

Inbound logistics: This business function covers activities related to reception, storage and distribution, such as transport, warehousing, inventory control, dispatch of vehicles and return of goods to suppliers.

Production/operation: This business function covers various activities through which inputs are transformed into final products, such as cutting, welding, sub-assembly, joining of hulls and installation, up to the handover and final acceptance by the customer.

2. **Support activities**

Management and administration: This business function covers company accounting, handling of tax payments, finance, administration, human resource management, information technology, etc.

R&D: This business function includes technical studies, product development, contract design, detailed design, production and process design, and represents a core competitiveness of the company.

Procurement: This business function includes the purchase of raw materials and equipment including steel plates, cables, outfitting items, R&D and production equipment as well as the purchase of materials. More than 60 % of company costs are incurred in this area.

7.4.4 Main value drivers

As explained earlier, the main features characterizing the shipbuilding industry are the high number of product types and their rapid development, the single unit and small scale production volumes, the long manufacturing periods, the sophisticated technical requirements and highly complex management structures. A company can improve its competitiveness by:

- Raising the level of technological R&D and expediting the development of new products
- Improving the technical qualification and work efficiency of employees, and by shortening the manufacturing period
- Improving the quality of management

Standards and standardization activities can help a company to form a competitive advantage in the following areas:

1. **Management**: A company can improve product quality and work efficiency by implementing a quality management system and product standards. In human resource management, training periods can be shortened, training efficiency can be increased and the technical qualification of employees can be improved by applying a general operations guide book, and by following the specifications of the classification societies in the conduct of training in manufacturing operations.
2. **Research and Development**: Design and R&D are key factors in company competitiveness. Only with the design of high tech and high value added products can the company be successful on the market. Implementing standards and applying the specifications and regulations of classification societies will enable a company to improve the speed of its design and development, and reduce design costs.
3. **Procurement**: This is a key area that impacts product costs and quality, and offers opportunities for reducing procurement costs and boosting competitiveness.
4. **Inbound logistics**: Through the use of component standards, it is possible to limit the variety of purchased parts, and consequently reduce expenditure and the complexity of warehouse management.
5. **Production/operation**: This is a key area with high manpower costs. Even the best design can only be transformed into products through careful organization of production. Through the application of product and process standards as well as operation guide books, it is possible to improve employee work efficiency, shorten manufacturing time and streamline production of finished products.

7.5 Scope of the pilot project assessment

The scope of the assessment is the R&D business function for shipbuilding products, with a focus on DSIC's Design Institute. As a core unit of the company, the Design Institute has one of the strongest R&D capacities in China and has been assigned the status of a "Company technical competence centre" at the national level.

It undertakes R&D, design, and development of products for the defence industry, ships for civil use, ocean engineering and non-ship products; research projects financed by state ministries and commissions as well as scientific research trial-manufacture projects for national defence. In addition, it is responsible for integrated management of vessel construction design, technology and material quotas; collection, application, formulation and revision of vessel standards; application and development of computer software for the shipbuilding industry; provision of high-quality support and services for the production and construction departments, as well as for the production control department.

The Institute employs nearly one thousand designers and assistants, with more than 700 directly engaged in engineering design. The technical performance of the products it develops directly affect the competitiveness of the whole company and has therefore a major function in its future.

The Design Institute covers 11 areas with an organizational unit for each, (see **Figure 2.**)

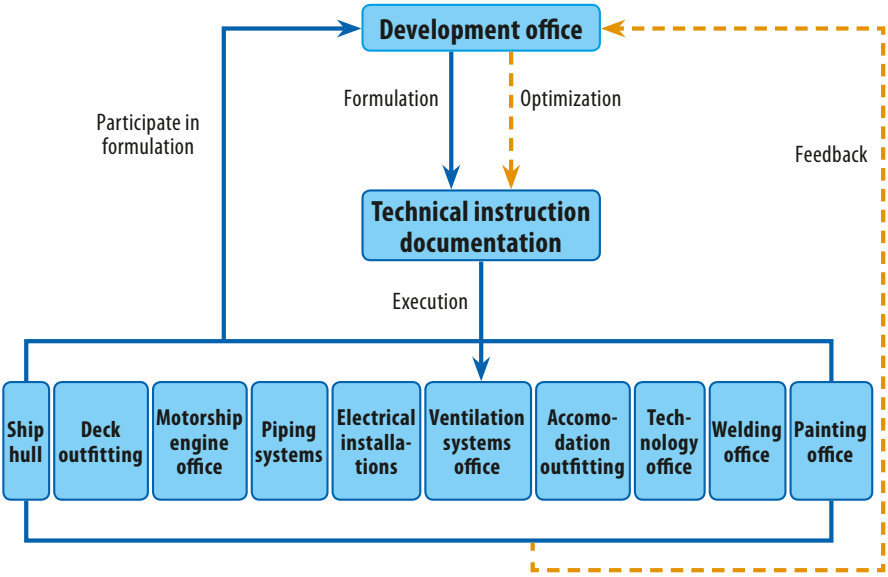

Figure 2 – Organizational structure of the Design Institute

7.6 Standards used within the scope of the assessment

To determine the economic benefits of external standards (which include international, national, industry and company standards) in the R&D business function, we start from the use of standards in the 11 work areas or organizational units of the Design Institute. The core functions performed within the 11 areas are explained in **Table 8.**

Organizational units	Core activities	Number of standards applied	Relationship between standards and core activities
Development office	Development and research of shipbuilding products, fixed price design, contract design, product stability experiments, empty ship weighing, float calculations, cruise speed tests, manoeuverability tests, etc.	32	With support of standards, it becomes easier to compile technical instructions for contracts with a higher degree of accuracy in determining technical parameters and shorter times to reach agreement with ship-owners. Compilation of test files tends towards format clauses with consequent improvement of work efficiency and design quality.
Ship hull office	Detailed design of the hull structure according to contracts ; production design of the hull structure for shipbuilding and maritime products.	11	Depending on the specifics of a field of application, hull standards focus on a common language for basics, symbols, nodes, etc., they standardize the basic elements of drawings and help improve design efficiency.
Deck outfitting office	Detailed design and production design according to contracts as well as technical services for large outfitting except engine room ; contract design, detailed design and production design of maritime work deck outfitting.	179	Outfitting is highly varied and relates to various aspects of the deck with many relevant standards. Standards facilitate the selection of designs, the manufacture and installation, and help improve work efficiency and design quality.

Organizational units	Core activities	Number of standards applied	Relationship between standards and core activities
Office for accommodation outfitting	Detailed design and production design according to contract as well as technical services of whole ship accommodation outfitting ; contract design, detailed design and production design of maritime accommodation outfitting work.	43	Standards facilitate the selection of designs, manufacture and installation, and help improve work efficiency and design quality.
Motorship engine office	Detailed design and production design according to contract as well as technical services for motorship engines ; contract design, detailed design and production design of maritime motorship engine work.	11	Most motorship engine products are approved product types. The standards applied in design contain technical requirements, specify concrete indicators and designs, and facilitate inspection and acceptance.
Piping system office	Detailed design and production design in accordance to contract as well as technical piping services ; contract design, detailed design and production design of maritime piping system work.	216	There are many types of piping systems and many standards that facilitate the selection of designs, manufacture and installation, and help improve work efficiency and design quality.
Electrical installations office	Detailed design and production design as well as support services for electrical systems ; contract design, detailed design and production design of maritime electric installation work.	64	Standards facilitate the selection of designs, manufacture and installation, and help improve work efficiency and design quality.
Ventilation systems office	Detailed design and production design as well as support services for the ship air cooling ventilation systems ; participation in contract design, detailed design and production design of maritime air cooling ventilation system work.	35	Standards facilitate the selection of designs, manufacture and installation, and help improve work efficiency and design quality.

Organizational units	Core activities	Number of standards applied	Relationship between standards and core activities
Technology office	Compiling information about construction technology, installation, debugging and delivery and acceptance of technological documents on hulls, motorship engines, electrical and piping systems etc. for shipbuilding and maritime products, designing and developing large technological equipment as well as application and dissemination of new technologies and processes.	51	Standards specify requirements for indicators, make it easier to prepare documentation, and help to improve work efficiency and design quality.
Welding office	Product bids and related preparation of welding techniques, qualification of welding technology and welding technology design, developing new materials, technology and processes, as well as application and dissemination of highly efficient welding techniques.	19	Standards specify the requirements for indicators, make it easier to prepare documentation, and help to improve work efficiency and design quality.
Painting office	Paints and related technological development design, contract design, detailed design, production design, process routes, material quotas and chemical process work for each ship berth before launch.	35	Standards specify the requirements for indicators, make it easier to prepare documentation and help improving work efficiency and design quality.

Table 8 – Core activities of the organizational units

7.7 Determination of core areas and key operational indicators to measure the impact of standards

R&D is key to the competitiveness of companies. The use of standards in R&D can provide both parties in an agreement – the manufacturer and customer – with a common language in negotiations and in formulating requirements that can reduce the time taken to reach agreement. A main objective for R&D is the improvement of designs and reduction of design costs through more efficient product research and by limiting part variety. An explanation of the impacts of standards used by the organizational units and areas of R&D is given in **Table 9.**

Organizational units	Impact of standards
Development office	The Development office is the very core of Dalian's R&D function. The competitiveness of the products it develops directly influences the future of the company. Whether technical indicators are advanced, prices are competitive and responses to customer requests are fast determines if orders are placed or not. With the support of standards, relevant technical parameters and performance indicators in technical documentation can be established. Negotiations with ship-owners can be based on common rules, development efficiency increases and development costs can be reduced. R&D teams of 60+ persons each develop and prepare price quotations for more than 30 ships annually and complete acceptance tests for approximately 40 ships. All these activities would be inconceivable without the support of standards.
Hull office	The Hull office is mainly engaged in the detailed design and production design of the hull structure as well as the design and reinforcement of large production equipment. In accordance with the requirements of standards, technical drawings are unified, node and component designs are specified, and up-to-date information is entered into a database. This ensures that unnecessary deviations from standardized parts are avoided, resulting in improvements in design efficiency, and a reduction in design errors and costs. The Hull office with 100+ employees completes the design of about 10 ships and the related tasks of approximately 40 ships annually.

Organizational units	Impact of standards
Deck outfitting office	Deck outfitting is mainly engaged in the detailed design and production design of mooring, anchoring and loading/unloading functions. Many products are involved and standards are used extensively. Time needed for negotiations is reduced through references to standards in agreements. The use of many standards reduces the need for special ship design, improves design efficiency, reduces design errors and costs. Deck Outfitting employs about 50 people, and completes the design of some 10 ships and the related tasks for approximately 40 ships annually. The contribution of standards for these tasks is evident.
Accommodation outfitting office	Accommodation outfitting is mainly engaged in the detailed design and production design of decorative and insulating materials, deck coverings, firefighting and lifesaving equipment, furniture, doors and windows. The use of standards reduces the time to reach agreement, improves the design efficiency and reduces design errors and costs. The office employs about 30 people and completes the design of about 10 ships and the related tasks for approximately 40 ships annually. Standards are an important element.
Motorship engine office	The motorship engine office is mainly engaged in the detailed design and production design of marine power plants, including the main engine, dynamo, boiler, air compressor, engine room pump, drive shaft equipment, and monitoring instruments. Many products are used, and most are type-approved. The relevant standards contain technical requirements, specify indicators and parameters, etc. The use of standards facilitates the design, reduces the time needed to reach agreements, improves the design efficiency, reduces design errors and costs. The motorship engine office employs some 50 people and completes the design of about 10 ships and the related tasks for approximately 40 ships annually. Standards play a very important role in this work.
Piping systems office	The piping systems office is mainly engaged in detailed design and production design to ensure reliable operation of oil, water and gas piping systems for the whole ship. The standards used mainly relate to materials for pipes, accessories and valves. There are numerous supplier companies, and over 90 % of products used are covered by standards. Standards contribute to reduction in variety and expansion of quantities of the parts used, to reduction of cost and time to reach agreements, improvement in design efficiency, and reduction in design errors and costs. The office for piping systems employs about 150 people, and designs around 10 ships and the related tasks of approximately 40 ships annually, and uses standards extensively.
Electric systems office	The electric systems office is engaged in the detailed design and production design of electrical systems for the whole ship, including all controls, lighting, communication, and navigation. Many products are used and most are type-approved. The use of standards has facilitated design, reduced the time to reach agreements, improved design efficiency, reduced design errors and costs. The electric systems office employs about 90 persons and designs about 10 ships and is involved in tasks related to approximately 40 ships annually.

Organizational units	Impact of standards
Ventilation office	The ventilation office is mainly engaged in the detailed design and production design of air cooling and ventilation of the whole ship including connection through air conduits, pipelines and fittings, to guarantee reliable and comfortable operation. Many different types of product are used. By adopting standards, the time to reach agreement is reduced, design efficiency is improved, design errors and costs are reduced. The ventilation office employs some 20 people and designs for about 10 ships and is involved in tasks related to approximately 40 ships annually.
Technology office	The technology office takes charge of compiling construction technology, installation, debugging, delivery and acceptance of technical documentation on hulls, motorship engines, electrical and piping systems, etc., for shipbuilding and maritime products, designs and develops large technical equipment and applies and disseminates new technology and new processes. Standards used by this office are mostly focused on test methods and quality requirements. The use of standards facilitates the compilation of files, improves design efficiency and reduces design errors and costs. The technology office employs about 40 people and completes designs for about 10 ships and is involved in tasks relating to approximately 40 ships annually.
Welding office	The welding office mainly takes charge of bids related to preparing welding techniques, qualification of welding technology and welding technology design, development of new materials, technology and processes as well as the application and dissemination of efficient welding techniques. The standards most used by this office contain welding specifications. The use of standards facilitates the compilation of documentation, improves design efficiency, reduces design errors and costs. The welding office employs about 20 people and completes designs for about 10 ships, and is involved in tasks related to approximately 40 ships annually.
Painting office	The painting office is responsible for the technological development of paint, contract design, detailed design, production design, processes, the establishment of quotas for materials and the chemical processes for each ship before launch. The standards used mostly focus on test methods and technical requirements. The use of standards facilitates the compilation of documentation, improves design efficiency and reduces design errors and costs. The painting office employs 13 people and completes designs for about 10 ships and is involved in tasks related to approximately 40 ships annually.

Table 9 – Organizational units in R&D and the impact of standards

7.8 Calculation of the economic benefits of standards

The calculation of the economic benefits of standards is based on the use of standards in the eleven areas and organizational units in the Design Institute. The data collected for the operational indicators are given for each of these units. The calculation of impacts given in **Table 10** is based on estimations by employees on the basis of their long-term practical experience, expressed as reductions in the costs for the respective unit.

Organizational units	Operational indicators	Basis for the calculations	Financial (EBIT) impacts
Development office	Technical documentation, which is part of the contract between the dockyard and the ship-owner, is the most important technological document in a shipbuilding contract. It requires that a project must comply with respective specifications, rules, general conventions, international, foreign, Chinese national, industry and company standards as a condition of obtaining the order. Standards can be used in preparing the technical documentation. Negotiations with ship-owners can be based on common rules. This results in an increase of development efficiency and a reduction in development costs of at least 5 %.	The design cost of the development office is about CNY 12 million.	CNY 12 million / (1 – 5 %) – CNY 12 million = CNY 631 600
Hull office	The use of standards and specifications improves design efficiency and reduces design errors. Design costs are reduced by at least 3 %.	The design cost of the hull office is about CNY 28 million.	CNY 28 million / (1 – 3 %) – CNY 28 million = CNY 866 000
Deck outfitting office	The use of standards and specifications reduces the time needed to reach agreement, design efficiency is improved and design errors are reduced. Design costs are reduced by at least 15 %.	The design cost of the deck outfitting office is about CNY 8 million.	CNY 8 million / (1 – 15 %) – CNY 8 million = CNY 1 411 800

Organizational units	Operational indicators	Basis for the calculations	Financial (EBIT) impacts
Accom-modation outfitting office	Standards and specifications reduce the time to reach agreement, design efficiency is improved and design errors are reduced. Design costs are reduced by at least 10 %.	The design cost of the accommodation outfitting office is about CNY 8 million.	CNY 8 million / (1 – 10 %) – CNY 8 million = CNY 888 900
Motorship engine office	Standards and specifications reduce the time to reach agreement, design efficiency is improved and design errors are reduced. Design costs are reduced by at least 5 %.	The design cost of the motorship engine office is about CNY 7 million.	CNY 7 million / (1 – 5 %) – CNY 7 million = CNY 368 400
Piping systems office	Standards and specifications reduce the time to reach agreement, design efficiency is improved and design errors are reduced. Design costs are reduced by at least 15 %.	The design cost of the piping systems office is about CNY 30 million.	CNY 30 million / (1 – 15 %) – CNY 30 million = CNY 5 294 100
Electrical installations office	Standards and specifications reduce the time to reach agreement, design efficiency is improved and design errors are reduced. Design costs are reduced by at least 10 %.	The design cost of the electrical installation office is about CNY 16 million.	CNY 16 million / (1 – 10 %) – CNY 16 million = CNY 1 777 800
Ventilation systems office	Standards and specifications reduce the time to reach agreement, design efficiency is improved and design errors are reduced. Design costs are reduced by at least 10 %.	The design cost of the ventilation systems office is about CNY 2.5 million.	CNY 2.5 million / (1 – 10 %) – CNY 2.5 million = CNY 277 800
Technology office	Standards and specifications improve design efficiency and reduce design errors. Design costs are reduced by at least 10 %.	The design cost of the technology office is about CNY 7 million.	CNY 7 million / (1 – 10 %) – CNY 7 million = CNY 777 800
Welding office	Standards and specifications improve design efficiency and reduce design errors. Design costs are reduced by at least 15 %.	The design cost of the welding office is about CNY 4 million.	CNY 4 million / (1 – 15 %) – CNY 4 million = CNY 705 900

Organizational units	Operational indicators	Basis for the calculations	Financial (EBIT) impacts
Painting office	Standards and specifications reduce the time to reach agreement, design efficiency is improved and design errors are reduced. Design costs are reduced by at least 10 %.	The design cost of the painting office is about CNY 2.5 million.	CNY 2.5 million / (1 – 10 %) – CNY 2.5 million = CNY 277 800
Total (CNY) :		**CNY 125 000 000**	**CNY 13 277 900**
Total (USD) : (basis : average exchange rate of 1 USD = CNY 6.5)		**USD 19 230 769**	**USD 2 042 753**

Table 10 – Assessment of the impact of standards on the R&D business function

As shown in **Table 10** the average annual financial impact of standards on the company EBIT in R&D amounts to CNY 13 277 900 (or about USD 2 million). Since the lifetime of standards in R&D in the shipbuilding industry is quite long, their impact has blended into routine R&D activities. If we analyze the contribution to company revenues of the standards used in R&D on the basis of the average revenues over the last five years, we arrive at the results given in **Table 11**.

Revenues / Year	Revenue of the whole corporation	Revenue from shipbuilding	Revenue of the R&D business function
2006	10 460 000	9 410 000	52 450
2007	14 190 000	12 771 000	85 170
2008	18 000 000	16 200 000	113 120
2009	20 590 000	18 531 000	143 250
2010	22 750 000	20 475 000	150820
Average annual revenue over the last five years	17 198 000	15 478 200	108 962
% contribution of standards as a percentage of annual revenues from R&D	0.08 %	0.09 %	12.19 %

Table 11 – Overall contribution of standards (unit : thousand CNY)

7.9 Evaluation of results

Table 2 shows that DSIC experienced strong development during the period of China's 11th Five-year Plan (2006-2010), which can be related to the reliance on technical progress and a boost in using standardized designs. Other factors such as the number of employees and working hours did not change, and did therefore not influence this development. Currently the slogan " Follow standards and apply procedures " is very popular. By improving development and design efficiency in R&D and reducing design errors, the contribution ratio of standards to R&D has reached a level of 12.19 %. The main reason is that standards help to raise the technology level in R&D and expedite the development of new products. At the same time, standards help to improve the technical level and the work efficiency of employees and reduce manufacturing time. The study therefore confirms the important contribution of standards for R&D.

7.10 Conclusions

7.10.1 The assessment of economic benefits of standards stimulates the development of standardization

Applying the ISO methodology to assess the economic benefits of standards, to undertake case studies in China, to compare the results with studies in other countries under different socio-economic conditions, and to study approaches and methods of improving the economic benefits of standardization can provide useful inputs for the formulation of policies. The successful application of the methodology in China facilities a better understanding among interested parties of economic benefits of standards, and improves the recognition of the importance of standards by company managers and technical staff.

Studying the economic benefits of using standards in companies, and the collection and scientific analysis of objective data can motivate company managers to achieve further progress in standardization.

7.10.2 Proposals for improving the assessment methodology

In this pilot project, it was possible to calculate the economic contribution of standards to R&D of the selected shipbuilding industry company. Such an understanding will help companies to allocate their resources effectively. However, the assessment method itself still needs to be improved and three proposals are made for this purpose :.

- The value chain concept is the key framework used in the ISO methodology to assess the economic benefits of standards. However, the biggest challenge in applying the methodology is to distinguish between the impact of standards and those of other factors. Familiarity with the subject field and the business in the scope of the study is therefore very important. In order to obtain raw data for the assessment from various perspectives, one should relate the data obtained from interviews of company staff with information obtained for the whole industry and/or from similar companies, in order to compare findings.
- China's standardization system combines mandatory and voluntary standards. For this reason, we decided, in assessing the impact of standards, to disregard whether the status of a standard was mandatory or voluntary.
- Although the methodology does not take company standards into account, company standards with technical parameters that exceed those of external standards (international, national, industry and other standards), should be included in the scope of the assessment.

7.10.3 Assessment of the economic and social benefits of standards

The positive impact of standards on economic and social development is not only expressed in measurable economic indicators, but is also visible in areas such as environmental protection, human health and in other aspects that cannot be quantified easily. Both the economic and social benefits of standards should therefore be studied comprehensively, in order to assess the impact of standards on the national economy and on social development in a scientific and objective manner. The objective of such an assessment is to provide a basis for decision-making by various government agencies, to guide detailed industry standardization strategies, and to further encourage companies to participate in standardization.