Comparative Study on Design Specifications of Bow Loading System for Shuttle Tanker

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Abstract. A Shuttle Tanker is a special type of ship in the tanker category, designed specifically for the transport of bulk liquid cargoes such as oil and liquefied natural gas. Compared with traditional oil tankers, shuttle oil tankers have unique characteristics in ship type design and equipment, which can meet the complex needs of maritime transportation. In shuttle tankers, the bow loading system is a key factor in ensuring the efficient and safe handling of cargo, and its design and operation must follow a strict set of codes and standards to safeguard the safety of cargo and the environment. In order to meet the requirements, Brazil, Norway, as well as China and other relevant organizations have developed a series of design specifications to guide and regulate the design, construction and operation of bow loading systems. This paper will compare and study the design requirements of various design specifications for the bow loading system of shuttle tanker, including technical standards, safety requirements, etc., in order to enable professionals in the design, operation and supervision of shuttle tanker, as well as relevant researchers and policy makers to have a deeper and comprehensive understanding of the bow loading system design specifications.

Keywords: Shuttle tanker; Bow loading; Standard specification; Safety requirements

1. Introduction

Maritime transport has always been an important pillar of global trade, especially involving the transport of bulk liquid cargoes such as oil, liquefied natural gas, chemicals, etc. With the development of energy resources and the increasing market demand, shuttle tankers are playing an increasingly important role in the field of ocean transportation. A Shuttle Tanker is a special type of ship in the tanker category, designed specifically for the transport of bulk liquid cargoes such as oil and liquefied natural gas. Compared with traditional oil tankers, shuttle tankers have unique characteristics in ship type design and equipment, designed to meet the complex needs of maritime transportation. In this field, bow loading systems are a key factor in ensuring the efficient and safe handling of cargo, and their design and operation must follow a strict set of specifications and standards to safeguard the safety of cargo and the environment. In order to meet the requirements, Brazil, Norway, as well as China and other relevant organizations have developed a series of design specifications to guide and regulate the design, construction and operation of bow loading systems.

This paper will first introduce the bow loading system, and discuss the design specification of each shuttle tanker bow loading system. As a key component of the shuttle tanker, the bow loading system is mainly responsible for the loading and unloading of liquid cargo. It includes

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a variety of mooring, hydraulic, control, safety and other equipment, directly related to the safe loading and unloading of goods. Its design specification is an important document to guide and test the design of this system, ensuring its reliability and performance under various complex conditions. Compare and analyze the existing design specifications of shuttle tanker bow loading system, in order to view the design methods of bow loading system comprehensively. This paper will compare and discuss the design requirements of each design code for shuttle tanker bow loading system, including technical standards and safety requirements. The purpose of this paper is to enable professionals in the design, operation and supervision of shuttle tankers, as well as relevant researchers and policy makers to have a deeper and comprehensive understanding of the bow loading system design specifications, so that professionals can design and transform the bow loading system of shuttle tankers more comprehensively, so that shuttle tankers can transport cargo more safely and efficiently.

1.1. Basic Equipment

The bow loading system is a loaded system designed to receive crude oil or other liquid oil products. It is commonly used in the transportation of crude oil from offshore fields to land or other storage facilities, so its loading system must be able to transfer liquid goods safely to the ship[1]. The following is the basic composition and function of the shuttle tanker bow loading system:

(1) mooring system

The mooring system is used for fixed oil tankers or loading facilities in designated locations to ensure safe loading. It includes the guide cable hole, the chain, the roller wheel, the traction winch and the relevant equipment. The mooring system provides stable position control through 76mm chain + mooring hawse + 76mm chain connect to FPSO. The ship is allowed to carry the operation under different sea conditions. The mooring system can be released quickly to respond to emergencies or hazards[2-3].

(2) loading the manifold system

The loading manifold system is a pipeline system used for loading and unloading liquid cargo on oil tankers or liquefied gas carriers. It includes the loading manifold unit, the control table, the pressure sensor, the tanker side valve, the hose hoisting winch and other related equipment. It is used to load liquid cargo from the dock or other ships into the ship's oil tank or to unload liquid cargo from the ship's oil tank onto the dock or other ships.

(3) hydraulic system

The hydraulic system provides power for the bow loading system, and controls the operation of winch, valve and other hydraulic components. He includes hydraulic pump station, hydraulic storage unit, on-line flow detection and other equipment. The hydraulic system will provide the hydraulic power required to operate the winch, valve and hydraulic device. Ensure the stability and reliability of the system in case of leakage and failure. It also works with the control system to ensure that the loading operation is performed smoothly.

(4) control system

The control system is used to monitor, manage and control the running of the entire bow loading system. It includes the loop control system, remote sensing system, and uninterrupted power

supply. Its function is to provide the operator interface, allowing them to monitor the system's status and control. Adjust loading speed, flow and pressure to accommodate different operating conditions. Integrated security functions to cope with emergencies or failures[4].

(5) security system

The security system is designed to ensure the safety of loading operations, including monitoring system status, detection failures, and responding to emergencies. It includes fire and gas body detectors, fire fighting equipment, lighting and CCTV monitoring systems, safety channels and other equipment. The specific function of the security system is to monitor the system parameters to ensure that the system is run within the scope of security. Detect potential faults or anomalies, such as leaks or overload. Provide emergency downtime and release mooring system to respond to dangerous situations[5-6].

1.2. Basic layout

The bow loading system is shown in figure 1. The number 1~ 7 is corresponding: the load manifold, the leading cable hole, the stop chain, the traction winch and the leading roller, the hose hoisting winch, the rope area, the hydraulic equipment and the accumulator.

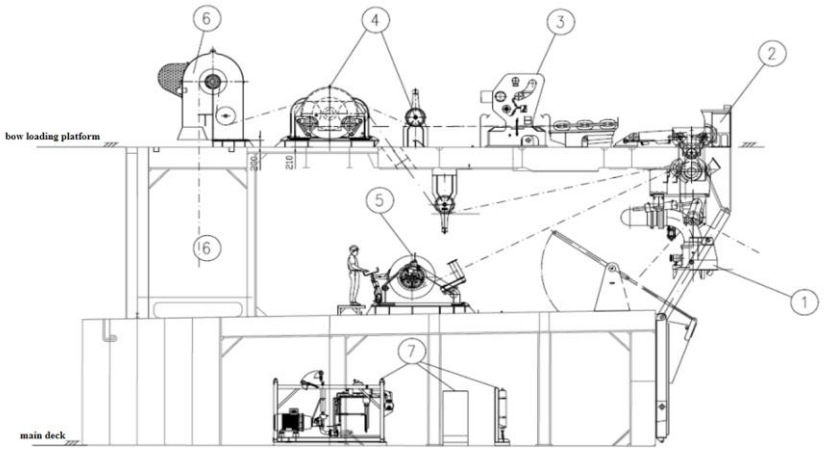

Figure 1. Figure with The main equipment of the bow loading system

2. Design specification for bow loading system

2.1. Foreign system design specification

(1) Norwegian - travel tanker guidance for 140-norwegian oil and gas treatment guidelines for offshore loading shuttle tankers.

The guide was jointly launched by operators of Norway's oil and gas companies and the NCS(Norwegian continental shelff-based). The purpose of the guide is to capture and record the selected results of the industry, and to recommend a minimum technical requirement for the shuttle tanker to ensure the safe loading operation on the NCS, which presents the requirements for the design of some stem loading system equipment[7].

(2) Brazil - shuttle tanker loading guide (campos basin offshore loading guidline for dp shuttle)

This guide is compiled by the Brazilian national oil company (petrobrybrin e&p-based), which is used as an auxiliary tool for the production, storage and unloading of the oil boat(fpso)operation volume as the production asset management department. This guide aims to ensure the offshore loading of the campos basin in line with the standards of Brazil's national oil company and in a safe and efficient way. In this guide, the specific parameters and performance requirements of the partial equipment of the bow loading system are made.

2.2. Domestic system design specification

(1) China shipbuilding engineering association -" design, arrangement and installation requirements of the shuttle tanker"

The specification is proposed by the China shipbuilding engineering conference, which stipulates that the design requirements and installation requirements of the shuttle tanker's first loading system, which can meet the requirements of the north sea and the local regulations of the country, apply to the shuttle oil tanker that is loaded with 100,000 t to 150,000 t. This specification is systematically classified, and it is described in detail the parameters and requirements of the equipment in each system, which is the most comprehensive reference specification for the loading system in China[8].

(2) Chinese classification social organization -" steel quality Marine classification specification 2023"

The "steel quality Marine classification specification 2023", developed by the China classification association, also puts forward the specification requirements for the forward loading system. In contrast to the domestic specification of the design, arrangement and installation requirements of the shuttle tanker, this specification mainly expounds the requirements of the normal work of the bow loading system.

3. Design specifications

3.1. Mooring system design requirements

For the design of mooring system, the national oil company of Brazil introduces the introduction speed, traction ability and the adaptive size of the chain device in the system. The design, layout and installation requirements of shuttle tanker liner are the most detailed design requirements for the shuttle tanker for 100,000 t to 150,000 t. In this paper, the parameters such as the parameters of the system, such as the size of the main cable hole, the chain chain, the roller wheel and the load of the winch, are given the corresponding rules. In addition, the installation of the equipment on the deck also makes a certain requirement, such as: the guide chain wheel and other equipment should be arranged in the center line of the hull, the roller wheel installation should pay attention to the structure and the structure reverse strengthen the alignment, the weld should be full welding and so on. The parameters such as the diameter size of the chain and the speed of the tractor winch are also met by the national oil company's guidelines. The design requirements for the heading loading mooring system in 2023is mainly reference to the oil company's international maritime BBS (ocig) mooring equipment guide, which stresses the

safety design of the system equipment layout, and makes the requirements for the strength of the cable and the way of personnel operation. The Norwegian oil company's travel tanker guidance has not made specific requirements for the system design. The main requirements in the design specification of the mooring system are shown in table 1.

Table 1. Requirements for the design specification of key equipment for mooring system

Structural parts	Main design requirements	Main layout requirement
fairlead	The cable hole is designed to load 500T, and the space is at least 500mm.	The structural parts of the mooring system shall be arranged on the center line of the hull.When the roller wheel is installed, the structure and the structure of the structure should be carefully aligned, and the weld shall be fully welded.The structural parts of the mooring system shall be arranged on the center line of the hull.When the roller wheel is installed, the structure and the structure of the structure should be carefully aligned, and the weld shall be fully welded.
Chain stopper	The design load 500T, using the anchor chain (76~84) mm, should be able to release the chain through the hydraulic operation under full load.	
Fair-weather roller	Design load 900KN.Configure (0~ 100)T tension sensor	
Traction winch	Double drum, suitable for nylon cable(25-120)mm, configuration disc brake.	

3.2. Load manifold system design requirements

Because of the difference between different types of ships, the design of the load manifold system can be different, and the design can be used for less reference, which is provided by the design, arrangement and installation requirements of the shuttle tanker bow loading system. This requirement regulates the pressure design of the manifold unit, the arrangement of the pressure sensor, the closing time of the tanker side valve, the pull of the hose hoisting winch, the arrangement of the pipe room. The main requirements for the design specification of the key equipment in the load manifold system are shown in table 2.

Table 2. Load manifold system key equipment design specification requirements

Structural parts	Main design requirements	Main layout requirement
Loading unit	The valve that is combined with the hydraulic connector can be closed when the internal 4kg·f/cm^{2}pressure is under pressure.	Ensure that hose joints should be avoided in the center line of the hull, and the joints should be avoided.The interior should be installed with two kaleipers and two hydraulic cylinders.
Tanker side valve	In case of full flow of internal medium, the valve should be closed in the(15~35)s, which should prevent the safety measures of the rapid sudden closing of the tanker side valve.	
Hose hoisting winch	Tension: 500KN(the first cable), speed: 15m/min.	
Operation table	Close to load the manifold connector connector.	

3.3. Hydraulic system design requirements

The Norwegian oil company's shuttle tanker guide puts forward Suggestions for the arrangement of online traffic detection equipment in hydraulic systems: the downstream of the shuttle tanker inside valve, which has mechanical protection. The design, arrangement and installation requirements of the travel tanker is required by the pressure of the hydraulic pump station, the cooling pressure of the hydraulic pump, the heating power of the pump, the quantity of the equipment and the arrangement of the hydraulic storage unit, and the arrangement of the on-line traffic detection equipment is also given the supplementary requirements and Suggestions to make the arrangement more reasonable and safe. The main requirements in the design specification of the hydraulic system are shown in table 3.

Table 3.key equipment design specification requirements for hydraulic system

Structural parts	Main design requirements	Main layout requirement
Hydraulic pump station	Normal working pressure 250kg·f/cm^2, peak pressure 315kg·f/cm^2, standby pressure(20~30)kg·f/cm^2, low and low level switch, alarm and emergency stop function.	Ensure that hose joints should be avoided in the center line of the hull, and the joints should be avoided. The interior should be installed with two kaleipers and two hydraulic cylinders.
Hydraulic accumulator unit	Capacity should be considered to ensure system safety emergency release.	
On-line traffic monitoring	From the bridge, the traffic data should be accessed remotely by the monitoring system, and the location of the flow monitor sensor should be considered. The mechanical protection of sea fog should be provided.	

3.4. Control system design requirements

The control system has a critical monitoring and security role in the bow loading system, and the travel tanker guidance of the national oil company of Norway has made the function of the control system design such as: any loop control system outage will automatically start the esd1and turn off the oil exports of the device. The steel quality Marine classification specification 2023is focused on the arrangement of control stations and equipment. The design, arrangement and installation requirements of the shuttle tanker liner are given by the control system, and the power time and equipment quantity of the uninterrupted power supply are also made. The main requirements of the control system's key equipment design specification are shown in table 4.

Table 4. control system key equipment design specification requirements

Structural parts	Main design requirements	Main layout requirement
Loop control system	Any node interrupts in the loop automatically trigger a first-level emergency cut on the tanker and close the oil oil or platform oil exports.	The remote sensing system consists of two transceivers and remote control panels. The two antennas

Remote sensing system	Fault safety design should be designed to ensure the safe start, control, and cessation of cargo transmission from olt to olst.	are spare and arranged as far as possible. The control board is in the cab, which can monitor the control of the loop status, the information of the floating oil tanker, and the state of the unloading process, which needs ups to power.
Uninterrupted power supply	The power supply time of the uninterrupted power supply is much less than 30min.	

3.5. Security system design requirements

The design requirements of fire protection system in the shuttle tanker bow loading area are more relevant, the system parts can be properly installed, the system debugging can be carried out smoothly, and the design of the security system is closely related. As a result, most of the requirements for the security system design have been proposed, and the oil company's shuttle tanker loading guide has given specific requirements for the distance and layout of the security system. In response to the fire control system, the steel quality Marine classification specification 2023 is the corresponding fire alarm arrangement criterion, which also requires the arrangement of the antiplug, the selection of the extinguishing system (the foam spray system and the standing high power foam system). The design, layout and installation requirements of shuttle tanker liner are not only provided for in the above content, but also the arrangement and functional requirements of the CCTV monitoring system and safety channel. The main requirements in the design specification of key equipment design in the security system are shown in table 5.

Table 5. Requirements for key equipment design specifications for security systems

Structural parts	Main design requirements	Main layout requirement
Fire protection equipment	Foam spray system, which should be able to work for at least 30 minutes at least 30 minutes of working at least 30 minutes per minute, and the jet intensity should be small at 5l/m^2 per minute.	The area of the center of the pipe room shall be installed with the flame and gas body probe, and the probe is mounted under the top deck. Fire foam cannon can cover the whole forecaster deck and top deck area. The camera should be able to cover the entire domain of the bow.
lighting	A 2kw rotating search lamp should be installed on the front mast.	
CCTV monitoring system	At least four monitors shall be installed in the cab, and the control room shall install at least two displays, and the cargo control room shall install at least two displays.	

3.6. Other design requirements

By dividing the design specification of system classification, the above guidelines and specifications also require the other bow loading related designs. The Brazilian oil company's shuttle tanker loading guide suggests that the tanker must be equipped with a suitable crane to transfer the personnel safely through the "crew lifting". "The steel quality Marine classification specification 2023" is required for the arrangement of the cargo tubing road and the welding of the pipe.

Acknowledgments: This paper mainly introduces the basic equipment and arrangement of the shuttle tanker's bow loading system, and through the current mainstream guide and specification, the design requirements of the current state of the shuttle carrier loading system are known.

(1) the design, arrangement and installation requirements of the shuttle tanker is the most detailed and comprehensive design specification of the current domestic transmission tanker, which is the most detailed and comprehensive design specification, which can meet other main guidelines and specifications and be able to make specific requirements for the specific layout and parameters of each system equipment, and should be the primary specification of the design of the bow loading system.

(2) the oil company's shuttle tanker loading guide focuses on the design of the forward loading system to focus on specific parameters of certain key devices.

(3) the travel tanker guidance of Norway's Norwegian oil company focuses on the arrangement and function of the control system.

At the request of the whole ship, the design of the forward loading is required.

The design requirements of the system design requirements of the shuttle ship loading area are more, and the instructions and specifications of these guidelines should be carefully studied, so that the whole system and the whole design of the shuttle tanker will be carried out smoothly.

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