8-28-2016

Brief discussion on emergency towing in salvage operation

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BRIEF DISCUSSION ON EMERGENCY TOWING IN SALVAGE OPERATION

By

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

MASTER OF SCIENCE

In

(Maritime Safety and Environmental Management)

2016

Declaration

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

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

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Date: August 5, 2016

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ACKNOWLEDGEMENTS

First and foremost, I would like to thank Nanhai Rescue Bureau of the Ministry of Transport. It is my leaders and colleagues that provide me this precious opportunity to join the MSEM program in Dalian.

I would like to thank Professor Zhu Yuzhu, my dissertation supervisor for his perfect guidance.

I will always cherish the days we spent together with my classmates.

Last but not least, I am everlastingly grateful to my beloved parents and parents-in-law who are always encouraging me by offering their full support and tolerating my long absence during the studies in Dalian, especially my dear wife Zhang Manping, who is always taking my duties of caring for the whole family during my studies and helping me out of frustrations and sharing happiness at all times.

ABSTRACT

Title of Dissertation: **Brief Discussion on Emergency Towing in Salvage Operation**

Degree: **MSc**

For the past few years, the globalization of economy has been deepened gradually, the international shipping business is blooming rapidly, large and automatic ships are growing in number, which has stimulated the development of the national trade and ship industry. But behind these phenomena, the marine accidents have also increased, and have caused severe consequences, resulting in not only casualties and economic losses, but also pollution of the sea environment, therefore the society should pay more and more attention to the problems during emergency towing in rescue operation at sea. This paper mainly focuses on the emergency towing in rescue operation at sea, and makes a thorough research on relevant problems in emergency towing from the perspective of emergency towing devices, emergency towing modes, emergency asylum selection, salvage safety insurance etc. Moreover, the attentions and safeguard measurements during emergency towing are analyzed at the end of this paper via actual examples.

KEY WORDS: emergency towing; safety insurance; salvage operation; asylum

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Chapter 1 Introduction

Emergency towing is a main way of rescue operations at sea, when the ship encounters danger, it can be used to tow the ship out of the dangerous water to a safe place, and guarantee the safety of the ship and people on board, which occupies an important position in salvage at sea. Through fast and effective emergency towing, casualties and losses can be greatly reduced, the danger level can be eased, and the safety of the ship and people can be secured. Normally it is the premium choice of salvage at sea, which is also safe and practicable. But in real rescue operations at sea, emergency towing is normally needed in the rough sea, and risks are complicated and changeable, often resulting in fire, explosion, leakage, power loss, casualties and so on. Besides, the operation time permitted is usually very short. All these things bring countless disadvantages to emergency towing. During salvage, in order to finish the job successfully, when the ship is towed to a safe asylum, factors like the selection of the towing course, safety of towing and so on should all be taken into consideration when deploying the rescue plan, and the relevant problems should also be handled well for the sake of fulfilling the job.

Chapter 2 Emergency Towing Devices

2.1. Definition

It refers to the devices that can tow the ship out from the danger when it suffers from disorders like main power failure, main propulsion failure, leakage of the oil and gas, main steering devices failure and so on.

2.2. Constitution

Normally the emergency towing devices mainly include towing line, line roller, towing point, recycling device, hull bracket structure, recycling box, etc. The recycling device includes reclaim line, lifting line, buoy with light and so on. These devices are shown in Figure 1.

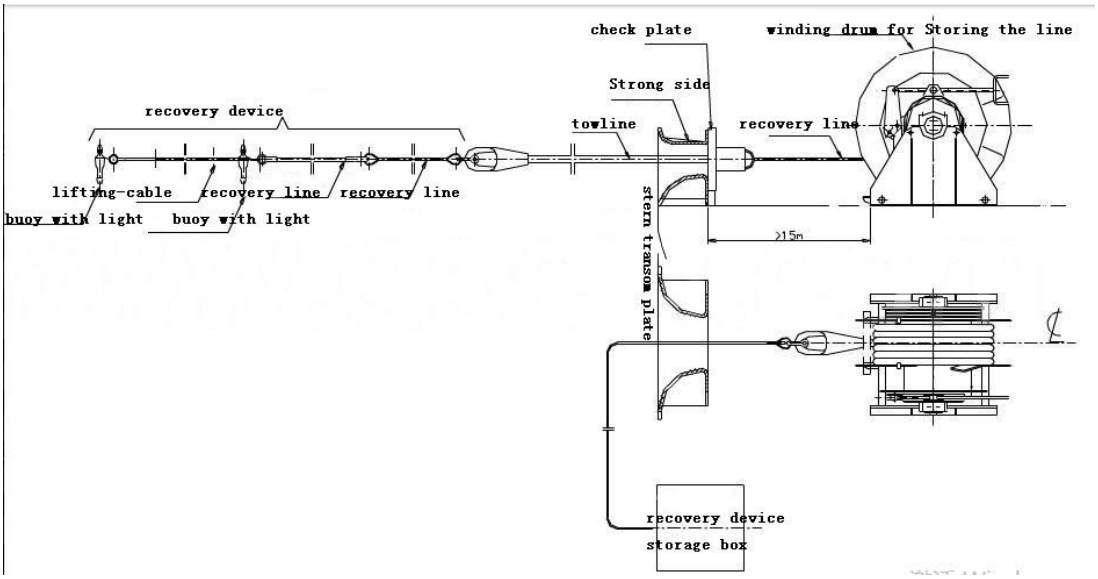

Figure 1: Emergency towing device structure diagram

Source: From "Emergency Towing Specification"

http://www.docin.com/p-278700538.html

2.3. Configuration

As per Figure 1, the following items should be noticed when configuring the emergency towing devices: (1) the layout of the rope leading holes and stress points should be helpful to reduce the stress of the towing device system, meanwhile be helpful to carry out the towing operation from either side of the ship stern and bow. Usually the rope leading hole is arranged on the center line of the ship, if unable to make this arrangement due to the limitation of the objective factors, it is allowed to be off the center but within the permitted deviation range; (2) the storage box of the recycle devices is usually arranged at the ship stern, near the tail sealing plate; (3)where the ship's DWT is greater than 150,000t, if the single point mooring devices, the relevant rope leading holes and the chain stoppers are equipped at the ship's bow, stress points and the rope leading holes should be arranged 1 meter from the ship's center line, and within the distance of 1.5m.

Chapter 3 Emergency Towing Modes

3.1. Single Point Towing

In accordance with the regulations in the amendments to SOLAS 96, ships with the DWT less than 20000t must be equipped with emergency towing devices at both ends of the ship, and meet the requirements for the towing line's strength when being towed at 90 degrees from the port or starboard side and 30 degrees downward. Besides, the amendments put forward basic operational requirements for emergency towing: for a ship used for towing operation, her designed load should be 1.5 times greater than the maximum towing load. The so called single point towing is using a single towing line to link to the towing point and conduct towing. This towing mode is convenient for operation, which requires less deck space, and is easier to be arranged. But during the towing, the single stress point will bear all stress, which has a very strict requirement for the towing devices. If the ship's structures can't meet the requirement for strength, then the single point towing is not adaptable. Therefore before installing the towing devices, the towing devices' layout should be authorized, and the ship structure's strength needs to be checked and strengthened. Although this can bring more convenience to towing operation, it costs more to the ship's owner too, and has less economic benefits.

3.2. Multi-Point Towing

Multi-point towing is a kind of towing modes dispatching the towing stress to multiple mooring devices in accordance with the characteristics of the layout of the ship's mooring devices. In this mode, the strength check only needs to be done as per the actual towing stress bore individually by the single points, and it's much easier to meet the requirement for the towing devices' strength. When distributing the towing points, the layout of the bollards that bear the stress should be taken into

consideration. There are many kinds of layouts for the bollards, which normally include: evenly place a pair on both sides, evenly place pairs on both sides, evenly place pairs on both sides and the center, place a pair on port side, starboard side and the middle and so on. The number of the towing points can be determined in accordance with the ratio between the breaking strength of the towing line and the mooring line, and the towing line's breaking strength should be less than the sum of all SWL of the towing points, to make sure the towing is safe and reliable. There are mainly the following types of multi-point towing in actual working practice.

3.2.1. Y-Type Towing

It's a kind of multi-point emergency towing using two towing lines and the towing points are evenly placed on both sides. The configuration type is shown in Figure 2, specifically: evenly place the bollard holes on both sides, the towing lines go through the bollard holes individually, and link to the tug abeam the ship, then make the towing devices. The main advantage of the Y-type towing is that when the towing line is long, it can be regarded that the towing angle has no influence on the stress; meanwhile the towing stress is only half of the tug's towing stress, which greatly reduces the working requirement for the towing point of the emergency towing. When this type of towing is used, normally the ship needs to be equipped with two long-enough towing lines, to make sure that the towing operation can be carried out under emergent situation.

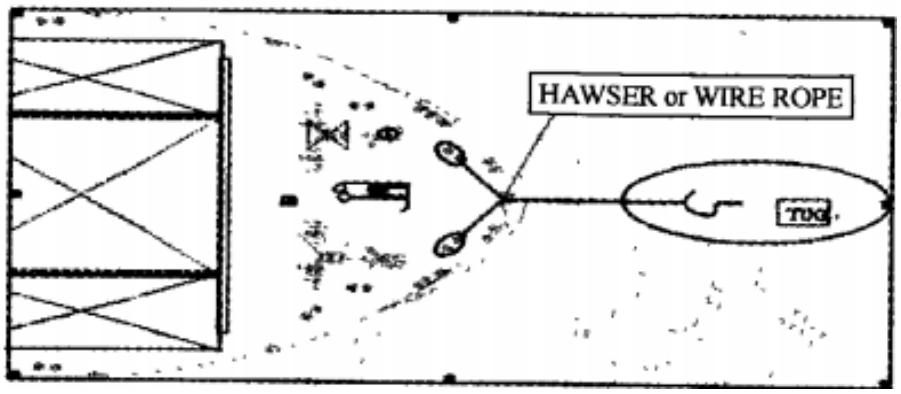

Figure 2: Y-type towing schematic diagram

Source: From "Emergency Towing Specification"

http://www.docin.com/p-278700538.html

3.2.2. V-Type Towing

V-type towing is a kind of multi-point emergency towing using a single towing line and the towing points are placed fore and aft. The configuration type is shown in Figure 3, specifically: place the bollard holes fore and aft at the ship's bow, with the single line going through two bollard holes, linking the towing line at the mid-ship. The two fore and aft towing points are linked to the leading devices, like the rope leading devices, the towing stress is only half of the tug's towing stress. As can be seen from Figure 3, if the ship's fore and aft towing points are not on the line of the ship's center towing line, or have trouble to link the two towing points to the ship's center line, the stress angle of the leading devices can be changed by adjusting the leading tackle, and make sure the towing points are linked to the leading line.

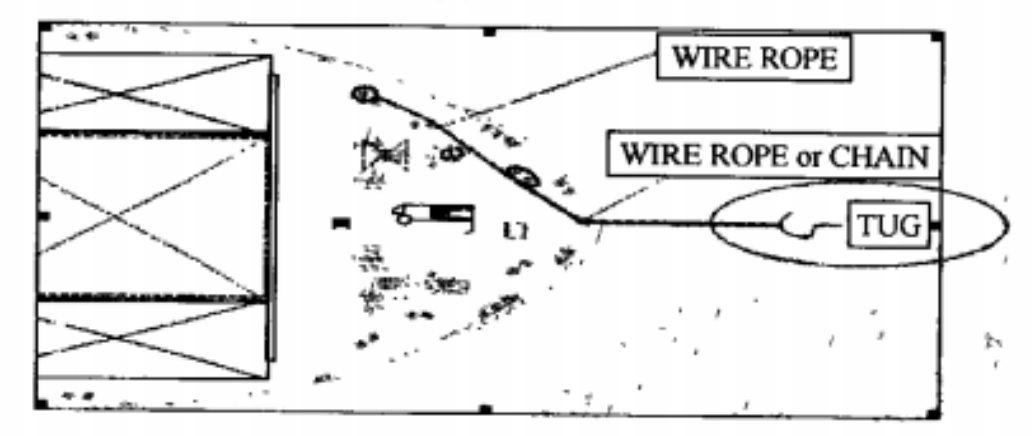

Figure 3: V-type towing schematic diagram

Source: From "Emergency Towing Specification"

http://www.docin.com/p-278700538.html

3.2.3. △-type towing

This is a kind of multi-point emergency towing using a single towing line and the towing points are evenly placed on both sides. The configuration type is shown in Figure 4, specifically: evenly place the bollard holes on both sides, with the towing line going through the bollard hole and linking the towing line at midship, then fix the towing line by using chain locker, and form into one towing line. In this case, the towing stress is only half of the tug's towing stress.

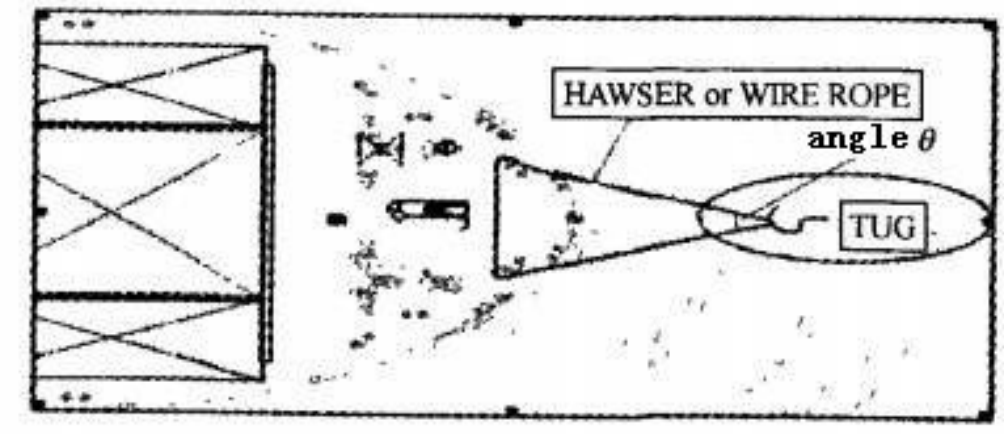

Figure 4: △-type towing schematic diagram

Source: From “Emergency Towing Specification”

http://www.docin.com/p-278700538.html

The above-mentioned three modes of emergency towing are commonly used in rescue operations at sea, which should be selected in accordance with the layout of the ship’s mooring devices and made sure it is reasonable and flexible. When a towing mode cannot meet the needs of emergency towing, integrated application of a variety of multi-point towing can be adapted, and the towing force must be able to ensure meeting the requirements of the work intensity. When multi-point towing is used, its basic criterion is to set up multiple bollard holes as the towing point, and make sure the stress is shared uniformly, so as to avoid a breakage in the line. In a word, compared with single point towing, the multi-point towing is more complex in layout and operation. When in emergency, it is difficult to carry out multi-point towing, so normally the single point towing is used first as the temporary emergency salvage; when the ship is out from danger, the multi-point towing is used, and the ship is then towed to the temporary asylum.

Chapter 4 Analysis for the Sheltering Problems of the Ship

It is unavoidable to skip the selection of sheltering place when analyzing the emergency towing in salvage operation. As mentioning this topic, in order to have a further analysis, the definitions to **shipwreck** and **asylum** should be made clear. As to the definition of **shipwreck**, there are different international regulations. For example, shipwreck is defined as the ship encountering perils at sea in the *Maritime Law Dictionary*, such as the ship suffering from stranding, collision, firing, striking a reef, capsizing, explosion, etc. and resulting in great loss to life and properties; as mentioned in the IMO Indications to Ship Asylum Memo, shipwreck refers to the ship that is about to sink or may cause great damage to the environment or sailing. As to the definition of **asylum**, there are different kinds of international definitions. For instance, in the *Maritime Law Dictionary*, asylum refers to the port which can be sailed to safely when accidents happen at sea; in the IMO Indications to Ship Asylum Memo, asylum is the spot where the salvage procedures are being provided to the ship in need and safety can be assured. Some individuals reckon that asylum is just a port for the shipwreck, and call it as asylum port. In fact, it is too limited to call it as asylum port, since not only ports can be used as asylum, sometimes covert waters can also be used as temporary asylum, and this has been acknowledged internationally. Based on the clarification above, the selection of asylum for salvage at sea can be analyzed.

4.1. The Discussion of Legal Basis for Vessels in Distress to Enter Shelters from the Legal Dimension

The core of the research into the problem of shelters for vessels in distress lies at the study whether vessels in distress have rights to enter shelters in coastal countries. As for this problem, it is involved in UN Convention on the Law of the Sea in 1982 and

UN Convention on the Law of the Sea in 1989. However, none of these conventions provides accurate legal basis. According to the regulations in UN Convention on the Law of the Sea in 1982, it is obligation for contracting parties to protect and secure the maritime environment. Though it is written in the convention that costal countries are obliged to provide shelters for vessels in distress, the regulations are not much clear. According to the regulations in UN Convention on the Law of the Sea in 1989, it is mandatory obligation for coastal countries to save life and property at sea but it does not mean that costal countries are obliged to provide shelters for vessels in distress. Because costal countries could save vessels and people in distress by means of life boats or other lifesaving equipment, and need not take vessels in distress that have pollution hazard to their own shelters. Therefore, it can be concluded from the conventions above that it is basic obligation for coastal countries to provide shelters for vessels in distress. However, the legal basis is not clear whether vessels in distress have rights to enter coastal countries for shelters, which leads to certain difficulty for the emergency rescue operations.

According to relevant investigations, the accidents of crude oil leakage of large vessels due to ship faults and other reasons have been increasing year by year, which results in seriously negative consequences. Moreover, the situation gets much worse because coastal countries have taken some improper measures on large vessels. As for this situation, IMO pays high attention to this problem. The 23rd session assembly of the IMO passed resolutions on the rescue of vessels for shelters guidelines (hereafter referred to as Guideline), which provided guides for the establishment of shelters in coastal countries and the relevant actions. This Guideline applies to the rescue of vessels in distress not involving life safety. If vessels in distress involve life safety, rescue operations should be conducted according to the relevant search and rescue conventions. This Guideline acknowledges that when

vessels are in distress, in order to prevent the situation from deteriorating to bring damage or pollution, the best method is transferring cargoes and fuel on vessel and repairing the hull, which is better to conduct in a shelter. However, considering that taking polluted vessels to shelters might jeopardize the basic interests of coastal countries, coastal countries are permitted to decide whether it will provide shelters for vessel in distress after taking overall consideration of the interests of both vessels in distress and environment protection factors. It can be clearly seen from the above that coastal countries are not strictly required to provide shelters for vessels in distress according to the Guideline. The Guideline does not have a strong force on coastal countries so the decision on whether or not they provide shelters for vessels in distress depends on their own intention. However, in order to resolve the problem that vessels in distress enter coastal countries for shelter, this Guideline suggests the establishment of mechanism for maritime rescue service which builds information exchange channels between vessels in distress and coastal countries in order to make timely information exchange, which contributes to coastal countries to allow vessels in distress to enter shelters in their jurisdiction. In addition, this Guideline involves rescue action guideline for coastal countries and staff working in shelter, and other content, which provides guidance on whether or not it considers accepting the request for shelter.

IMO and other institutions pay high attention to the problem of shelters for vessels in distress, and try to make many efforts. However, these institutions only serve to provide some guidance for problem of shelters for vessels in distress due to lack of mandatory force, but cannot resolve this problem fundamentally. Suggestions for the solution of problem of shelters for vessels in distress are provided as follows: Firstly, conventions should strictly regulate the obligations for coastal countries to provide shelters for vessels in distress, but coastal countries would not like to sign such

conventions. Therefore, conventions should be further modified to restrain the behaviors of coastal countries in order to ensure the fulfillment of their obligation; secondly, competent authorities should be established and should be assigned. It is emergent for vessels in distress to apply for the entrance to shelters so many authorities would lead to a mess, and decrease the efficiency of rescue action. In order to provide both timely and efficient rescue service, coastal countries should establish a department to specialize in this affair, assign the person chiefly in charge of this department and form groups of senior experts to serve rescue service; thirdly, risk assessment should be strengthened. The rational decision whether or not coastal countries would provide shelters for vessels in distress should be made after the full consideration of all parties. In order to improve the accuracy and rationality of the decision, coastal countries could make a qualitative evaluation on the risk of vessels in distress entering shelters and clearly consider the impact and severity of the risk, and make a scientific decision based on the assessment result.

4.2. The Discussion of Procedure for Vessels in Distress Entering Shelters from the Institutional Dimension

According to the regulations of the relevant conventions, coastal countries are obligated to provide shelters for vessels in distress, but it does not mean that vessels in distress have the absolute right to enter shelters in coastal countries. If a vessel in distress intends to enter shelters in a coastal country, she needs to perform the following steps:

a) Application for the shelter. After the vessel is in distress, she should apply for the shelter to the port of local costal country. Ship documents, cargoes on the vessel and the intention for the shelter should be included in the application materials.

b) The port should take immediate actions and work together with all parties

involved to make a discussion on the shelters in detail after receiving the application from the vessel in distress. The discussion should be based on adequate materials of vessel in distress, risk assessment, search and rescue equipment, and should include suggestions of all parties involved.

c) The port should make a decision on whether or not the vessel in distress could berth in the place, proceed or enter the shelter according to the suggestions of all parties involved.

d) Due to the decision on the supply of a shelter for the vessel in distress, the port should work with the specialized group to choose several shelters based on actual operations.

e) After the choice of several shelters, the port should consult with the vessel in distress to determine the most suitable shelter. At the same time, the port should be aware whether or not the vessel in distress could safely arrive at the shelter and whether or not she needs towing operations. If the vessel in distress is disabled or seriously damaged, generally she needs towing provided by the port. Under such circumstance, the port should immediately form command workgroups responsible for the formulation of towing plans, insurance of the safety of route and any other work.

f) The port should make a preparation for the relevant documents after the determination of shelters.

g) The above procedures are made based on the previous research results, analysis and summary of the international practice. It is for reference only, and it is not the basic procedures for vessels in distress to enter shelters in coastal countries. Certainly, because of the concrete circumstances of coastal countries, analysis on how to provide shelters for vessels in distress should depend on the situation without the damage of the fundamental interests of the country and the people.

4.3. The Discussion of Choice of Shelters for Vessels in Distress from the Technical Dimension

4.3.1. Problem of the Designated Shelters in Advance

In consideration of safety factors, in order to cope with risks caused by the maritime accidents, coastal countries generally formulate risk early warnings and contingency plans to handle the unexpected situations in order to reduce risk and loss, and ensure the interests of the country and the people. According to the regulations in OPRC, there are a lot of factors and standards for the port and the location to consider whether or not it would accept the application from an uncontaminated vessel in distress. In particular every maritime accident has its own characteristics such as the location of the vessel, draft, sea condition and weather where the maritime accident occurs. Therefore, it is better to take action based on the actual condition to cope with the unexpected situation. However, European Traffic Monitoring Directive explicitly stipulates that the contracting parties should take the content of the Guideline into consideration, consult with the vessel in distress and formulate plans to provide shelters for the vessel in distress in their own jurisdiction. At the same time, European Traffic Monitoring Directive also regulates that the plans should involve specific shelter operations to ensure the vessel in distress would enter the shelter in time. In this regard, the author would like to share his observations as follows:

Firstly, every maritime accident has its different specific situation and different requests for shelter, so the designated shelter might not meet the requirement of the vessel in distress. Moreover, the vessel in distress can only enter the nearest shelter that is close to the maritime accident. If the designated shelter is not suitable for the vessel in distress, it will not only fail to provide the shelter service in time, but also

make a bad influence on the interests of the coastal country that provides the shelter.

Secondly, it is not necessary to designate shelters for vessels in distress in advance. That is because there are careful sailing plans and specialized crew for a vessel sailing at sea. Furthermore, with advanced modern marine technology, crew members on the vessel would be clearly aware of the route and shelters in coastal countries, and choose the most suitable location as the shelter based on its actual requirements without a designated shelter in advance.

Thirdly, it is difficult to get support from all coastal counties if designated shelters in advance are needed. At present, only a few countries such as the United Kingdom and Germany designate shelters in their jurisdiction. Thus it could be seen that this action does not get strong support from coastal countries. The reason is that whether or not vessels in distress could have right to enter shelters in coastal countries is still unclear itself. Therefore, it is not suitable to designate shelters for vessels in distress in advance. Moreover, if shelters for vessels in distress are designated in advance, economic burden would increase.

Fourthly, in regard to the operations of contingency plans, the plans that coastal countries formulate should involve specific places for shelters and their situations such as draft, tide, berth, safety equipment and tugs, in order to make timely reactions to the unexpected maritime accidents.

With full consideration of the factors above, we can safely draw the conclusion that it is not suitable for coastal countries to designate shelters in advance. However, tugs, specialized crew and contingency response mechanism for unexpected maritime accidents are suggested to take maritime rescue operation in time. For vessels in

distress, they do not have right to directly enter shelters in coastal countries. Vessels in distress should apply for shelters to the coastal country and then enter shelters after receiving its permission. However, the vessel in distress has the initiative to choose a shelter which is suitable to its actual situation, which could reduce loss and risk to ensure the safety of the vessel in distress to the greatest extent.

4.3.2. Problem of the Choice Standard of Designated Shelters

This problem focuses on the places that can be chosen as shelters for vessels in distress. The choice of shelters is vitally important to vessels in distress. A good shelter enables vessels in distress being rescued in time while a bad one leads to heavy injuries and causalities as well as economic loss. In regard to the choice of shelters, there are no clear standards yet. No convention regulates what places can be chosen as shelters and what cannot. If a place could provide rescue service for vessels in distress and ensure the safety of vessels in distress, the people and cargoes on board, and reduce the harm to environment, it can be chosen as shelter as a whole. As a result, after a vessel is in distress, she should look for such a place for shelter in time in order to leave the hazardous sea, for which there is no standard for choice.

4.4. Discussion of Supply of Shelters for Vessels in Distress from the Risk Dimension

Obviously, the supply of towing and shelters for vessels in distress carries certain risks, including not only safety aspects, but also environmental pollution, economy and other aspects. In particular, leaking of crude oil from some vessels is likely to pollute water environment. For instance, the accident of oil tanker Prestige in 2002 led to a heavy damage to the marine ecological environment, a hard hit to fish industry and a big loss to economy in coastal countries. Therefore, the application of

shelters for vessels in distress should require a comprehensive risk assessment, which serves as a strong support to the final decision.

The risk assessment mainly involves three aspects: The first aspect is the reason why vessels in distress apply for application of shelters, such as grounding and collision; the second aspect is the potential threats brought by the application of shelters, such as the threats to public safety, environment, rare species, fishing grounds in the vicinity and fish breeding and poultry raising, and industrial facilities; the third aspect is analysis to draft, tide, current, meteorology and other information of shelter within certain limits. By means of risk assessment of the above aspects, the risk report of the supply of shelters would be made. The final decision on whether or not the coastal country would provide shelters for vessels in distress and ensure its own interest is based on the risk report.

Chapter 5 Safety Recommendations and Tips for Emergency Towing Operation

Maritime rescue emergency towing is a high-risk, professional and strong, large amount of labor operations and the ease or complexity of operations depends on sea condition, the situation of the vessel in distress, operational performance of rescue vessel and other factors. After a vessel in distress applies for shelter, the coastal country makes a risk assessment of shelter and decides whether or not the vessel in distress is permitted to enter the shelter in its jurisdiction. After the permission, the relevant port in coastal country assigns towing fleet to go to waters where the maritime accident happens and makes towing rescue operations to the vessel in distress. Under time pressure, security must be guaranteed if the rescue towing operation is successfully completed. Therefore, tips and safety recommendations in every ring of the emergency towing operation are proposed as follows.

5.1. The Choice of Escort Vessels

Generally emergency towing operation is needed in severe sea condition and has high risks and complexity in operation. Therefore, in order to increase safety factor, there must be at least one tug as escort vessel to enable the safety of route in towing operation. The main tasks of escort vessels are listed as follows:

a) Transfer working personnel on rescue vessels to the vessel in distress, inspect the situation of the vessel in distress and make preparations beforehand for towing operation;

b) In the process of towing operation, observe vessels, obstructions and other substances on water, drive away vessels that might influence the safety of towing operation, and clear obstructions to enable the safety of fairway;

c) Inspect towing lines, towing ringing and the situation of the vessel in distress in the process, find in an unexpected situation and prepare for emergency management;

d) In case the main tug of rescue occurs to an accident, provide rescue operations in time and assist with the main tug to control and complete the towing work.

5.2. Formulation of the Command Group of Towing Operation

The process of rescue towing operation is complex and needs cooperation among towing party, towed party and port. It also needs the help of special working groups to organize the towing operation, command work, enhance the exchange among working personnel and cooperate the relevant affairs to make a feasible towing plan. The towing command groups include command group on land and at sea. The towing command group on land consists of representative of the ship owner as the director, representative of the ship tenant as vice director responsible for the collection of meteorological information and other work; command group at sea consists of the master of the main tug of rescue as the director and the master of escort vessel as vice director.

5.3. Preparation of Navigation

Before navigation, the information of draft, obstructions, widths of channel that the vessel has to cross should be collected, and the towing plan and pilot plan should be formulated according to the actual situation. Before departure, the command groups on land and at sea should work together to have a meeting to discuss the detail of towing operation. At the same time, weather forecast of the area where the vessel is in distress should be known and meteorological information should be closely paid attention to ensure whether or not there is meteorological condition for rescue towing operation. Before towing operation, the main tug and the towed vessel should all be prepared in order to ensure the safety of towing operation.

5.3.1. Preparation of the Main Tug

a) Master, chief officer and relevant crew should be full of experience of rescue towing;

b) Inspect towing ringing, mechanical equipment and relevant emergency equipment to ensure these equipment and tools available;

c) Take emergency towing lines in case of need;

d) The main tug, escort vessel and the towed vessel should build special VHF communication channel to ensure effective communication;

e) Lay out the towing route according to meteorological condition and the situation of towed vessel. There is a certain amount of leeway and shelters from wind alongside the route. It is better to keep clear of waters with dense traffic and fishing areas;

f) Ask for information of the situation of the towed vessel including faults, cargoes, crew and whether or not the vessel is disabled, and keep good communication with the towed vessel.

g) After receiving the task for towing operation, ask for the situation of the towed vessel in time, and formulate towing plans, including planned route, destination of towing operation, plans for mooring and Unmooring, and tips for towing operation. Furthermore, inform the towed vessel to do some preparation and inform her the operation points and tips in the process of towing operation before the arrival of the main tug through communication channel. Track the situation of the towed vessel in real time in the preparation, including marine risk and the preparation and hold the rescue information in time to ensure to have emergency reaction in case of unexpected situations;

h) Calculate the towing force. In the process of towing operation, the towing force and resistance would act upon the towed vessel, preventing the main tug from a successful towing operation. In order to guarantee the towing operation to run smoothly, the main tug should estimate the towing force and determine the speed of

towing according to its own type of tug, power of the main engine and resistance in the process of towing operation. Resistance in the process of towing operation mainly comes from waves caused by the propelling of the towed vessel so the propelling factor cannot be ignored in the estimated calculation of towing force;

i) Choose the appropriate towing equipment. In rescue operation, the choice of towing equipment is of vital importance. If the choice is proper, towing lines would be successfully connected to the towed vessel so that the towed one would be clear from hazardous waters safely; however, if the choice is improper, towing equipment is likely to break, thus making the rescue towing operation a failure. When choosing the towing equipment, safety load, method of connecting towing lines, power of the towed vessel, sea condition, layout of point of towing force, voyage of towing and weather should be in full consideration. There is professional and complete towing equipment in specialized rescue towing vessels, which could meet the requirements of emergency towing in rescue operation. Despite all this, strength and measurement of towing equipment should be checked to make sure it meets the work requirement of safety load.

5.3.2. Preparatory Work of Towed Vessels

a) Watch safely and control vessel's condition. After the vessel loses power, it is still necessary to keep standard watch and supervise the safety condition of vessels. The captain needs to decide whether they should keep drifting, anchor the boat or wait for better timing to anchor and wait for aid according to the drifting course of the vessel and the state of sea. In this process, the captain can adjust course with rudder and anchor for the fine tuning of the vessel's drifting direction and speed;

b) Check the point of towing force and confirm the location of fair lead. Whatever ship type it is, there are fair leads and bollards on the bow and at the stern to deal

with emergencies. When an accident happens, vessel in distress makes distress calls immediately and checks the point of towing force and the location of fair lead, strengthens fair leads and bollards to enhance the towing force load and gets preparation for emergency towing;

c) Adjust the drifting condition of the vessel. Before towing, the towed vessel should adjust its drifting condition by itself and records the draft condition of six sides in order to judge the changes of draft condition during towing;

d) Keep in touch with the main tug. After the vessel loses power and there is no power supply, it should save the electricity to ensure effective communication. Keeps the night indicating lights on.

5.4. Connection of the Towrope

5.4.1. Delivery of Towrope and Rigging

At present, towrope and rigging used in salvage by towing mainly includes wire rope, strong rope and nylon rope. Experiments show that under the condition of breaking the same tension, the weight of strong rope is the lightest, followed by wire rope and nylon rope. It is shown from previous work experience, when the vessel loses power, it takes at least 5 people to pull towrope which is not made of steel aboard the vessel. Under the condition of heavy sea, it may take more people. When connecting the towrope, it is best to control the distance between two vessels under 25 meters. The rope should be thrown manually and the running line should be used to pull the towrope aboard the towed vessel.

5.4.2. Connecting the Point of Towing Force

Under the negotiation between the captains of tug and towed vessel, determine the plan of transferring and towing should be determined and the force bearing point of

towrope and fair lead be strengthened. If single-point towing mode is chosen, the included angle formed vertically by the chosen force bearing point of towrope, fair lead and vessel should be as small as possible in order to lower the resistance suffered by the towed vessel, which can help avoid yawing. In addition, delivering towrope, abrasion proof and connecting the point of towing force should be determined according to the actual situation (drifting or anchoring), the state of sea and meteorological condition. Scratch-resistant texture such as rubber tube can be used to wrap the parts that are prone to wear and tear for abrasion proof. Paint beef tallow on the towrope can enhance the effect of abrasion proof. Other ropes should be used to continue twining around the bollard 5 to 6 times in Figure 8 to fix the towrope, in case the towrope pops from the bollard.

5.5. Towage

Towage is the most crucial process in salvage by towing. In order to ensure the towage safety, it is necessary to do the following work in towage:

a) Collect meteorological data timely and completely and deal with severe weather in time. If suffering severe weather during towage, adjust the ballast, protect the towrope and change the course if necessary;

b) Ensure the effective communication among the main tug, towed vessel and convoy. Communicate with each other to inform their condition at short intervals;

c) Operate the commencement of towing safely. The commencement of towing is a process of the main tug slowly accelerating and adjusting the course of towrope after finishing connecting the towrope. During the commencement of towing, the speed of the main tug should be as slow as possible. When dead slow is used, it is necessary to keep certain quantity of suspension to avoid the towrope being suddenly tightened up due to the influence of the towed vessel's inertia. Until the towed vessel keeps up

with the main tug and the tension of towrope is not strong, the main tug can accelerate gradually and reach the expected speed;

d) When sheering off, the angle should be less than 20 °. Keep the speed steady and sheer off slowly to keep the moving path of the towed vessel consistent with the main tug and ensure the safety of the towed vessel. Try to avoid taking a sudden turn with a large rudder angle. If a large angle turn is inevitable, operate in several times. When suffering the influence of tide and surge, the turn angle is best to be less than 5 °. Each time the main tug sheers off, it should check whether the moving path of the towed vessel is in consistent with its own path. Only when the path is in consistent can it sheer off;

e) Pay attention to the adjustment of the towrope length. The main purposes of adjusting the towrope length are reducing the yawing of the towed vessel and keeping the appropriate towrope length to keep the swinging of the main tug and the towed vessel in the waves coordinating, which reduces the impact suffered by the towrope and enhances the stability of the towed vessel. When reducing the speed of towage or towing in shallow water, the length of the towrope can be shortened appropriately to avoid the towrope dragging. When towing on narrow waterway, the length of the towrope can be shortened appropriately to improve the operating performance;

f) Pay attention to the examination and protection of towrope during towage. The captain of the main tug should arrange specially-assigned people to take charge of watching to do this work well. Meanwhile, add lubricating oil to the towrope protection appliance frequently and protect the main towrope bulwark to avoid the fracture of towrope;

g) Try to avoid dense area of vessels. If it is unavoidable, the captain of the main tug should go to the bridge to steer in person. The chief engineer should go to the engine room. All good sailors should fully play their roles to ensure the towage

safety of the vessel. Meanwhile, keep warning the nearby vessels to avoid in time. Do the same under severe weather or state of sea;

h) During towage, in order to ensure the course safety, the marine navigator can give a timely towage warning every other 4 hours to warn the passing vessels to avoid and make it convenient for this vessel to pass;

i) Overcome yawing. Under the influence of storm, towing speed and towrope, it is easy for the towed vessel to yaw, which has a strong impact on the stability of towage. The impact of yawing is severe. It can strengthen the tension of towrope, aggravate the abrasion of towrope, make the towing course deviate and even cause the fracture of towrope. Therefore, it is necessary to take effective measures to control the yawing during the towage. Specific measures include: first, adjust the draft condition of the towed vessel before and after yawing. Make the vessel trim by stern to enhance the stability of towage. Second, reduce the speed appropriately, which can also enhance the stability of towage and reduce the yawing force. Third, shorten the length of towrope appropriately according to actual situation. Fourth, add some floaters to the stern of the towed vessel or connect the convoy to the stern of the towed vessel to enhance the stability of towage. Fifth, the towed vessel should adjust the course by rudder. If the rudder of the towed vessel is broken or missing, emergency rudder can be installed. Fix the rudder on certain angle and make the towed vessel navigate steadily on the track side to strengthen the resistance of the towed vessel and the stress level of towrope so that the course can be adjusted. Sixth, fix the tail shaft of the towed vessel to prevent it from free rotation and strengthen the resistance of the stern and enhance the stability of towage. The above measures can effectively prevent the towed vessel from yawing but they all strengthen the resistance of towing and cause other negative effect. Therefore, the maritime command group needs to weigh the advantages and disadvantages and choose appropriate measures to overcome yawing.

Towage is a job that requires high specialty and technicality and corresponding risk is also high. During the operation of salvage by towing, in addition to the above work, it is also necessary to do the following work in order to ensure the safety of towage.

a) All staff who participate in towing operation should strictly follow the command group's orders and carry out the work orderly. If anyone has different opinions about the order, they can report timely but cannot stop the work at hand;

b) The main tug must prepare towropes for the following convoy and towage;

c) After the commencement of towing, the main tug should accelerate slowly. After entering the expected course, release the towrope to the set length and then accelerate to start regular navigation;

d) During the towage, the main tug is in charge of correcting course and warning the passing fishing vessels to avoid. Convoy is in charge of cleaning the obstacle in course and ensures the smooth execution of towing plan;

e) Establish safety consciousness. It is common that people believe it is important to speak while it is less important to act. It is obvious that many people take chances. It is bad for the operation of towing. For such bad customs, it is necessary to strengthen institutional restriction, enhance safety education, establish the cultural atmosphere of safety first. Crew members should consciously obey rules and regulations of the vessel and operate as requested;

f) Get mentally prepared. The amount of information has a great influence on people's mindset. After the vessel is in danger, collect the needed information as much as possible, such as risk information, operation information and environment information. Make responses quickly according to the information and determine the disposal plan.

5.6. Arriving at the Port of Destination and Disengaging

Disengaging is the last stage of salvage by towing. It is necessary to ensure safe disengaging. After the towed vessel reaches the port of destination, communicate with the towed vessel timely before disengaging. Know the requirement of the towed vessel and tell the towed vessel about the intention of disengaging to prevent the towed vessel from taking actions without knowing relative conditions and causing itself and the main tug in danger. When reaching the port of destination, the main tug gradually reduces speed, retrieves the towrope to keep the towrope from dragging or surfacing and leads vessels to the location of disengaging. During retrieving the towrope, the main tug gradually reduces speed but keeps the towrope under stress to tow the vessel. After reaching the location of disengaging, observe the tide table and on-site wind direction. After making sure the condition of disengaging is satisfied, negotiate about the order of disengaging and the towed vessel anchoring. If disengaging first, it is necessary to fix the towrope and rigging in case they slip from the deck of the towed vessel and entangle with anchor; if anchoring the towed vessel first, it is necessary to avoid putting anchor on the towrope and rigging. Take disengaging first as an example. After retrieving the towrope, the main tug reduces the speed to the lowest and the towed vessel continues to move forward depending on inertia. At the moment, towrope and rigging are loose. Use joining shackle to entangle the deck and fix it. After that, dismantle the joining shackle; unhook the connection and disengaging the towrope and rigging. During the whole process of disengaging, avoid the rear-end collision between the main tug and the towed vessel. After disengaging, anchoring the towed vessel at expected location immediately.

Notes during disengaging are listed below:

a) After entering the port of destination, the main tug should go ahead at dead slow and control the leaving velocity. Retrieve the towrope gradually while keeping the towrope under stress. Draw the towed vessel to move forward. In this process, the

distance between the main tug and the towed vessel can be kept at 25 meters;

b) During the 24 hours before entering the port of destination, keep the staff of the port informed of ETA every other 2 hours so that the port can prepare for piloting and auxiliary tug;

c) Before entering the port of destination, the staffs of the port wait in advance at the location of disengaging. After the towed vessel reaches the expected location, the staff can get aboard the towed vessel and start disengaging.

Chapter 6 Case Analysis

In order to further understand the salvage operation of emergency towing and do related safety assurance work well, the salvage operation of emergency towing is discussed with a particular case as follows.

In March, 2015, some bulk carrier had an accident in some sea area. The main engine lost power and the vessel applied for shelter to nearby coastal state. After granting permission, the port of refuge of that coastal state sent a towboat as main tug for salvage. The main tug was 98 meters long and 15 meters wide. Its draft was 6 meters and the power of the main engine was 12400 horsepower. It carried two 1200-meter long towropes whose diameters were 64 mm.

6.1. Determination of the Time of Commencement of Towing

6.1.1. Meteorological Condition

In this sea area, March is a period when cold air from the north is frequent. Sea wind is strong, which influences towing operation. The towed vessel is a large light vessel whose wind age area is large. It has strict requirements of meteorological condition during towage. According to the stipulation in Guidelines for Towage at Sea, the decision is made to carry out the commencement of towing when the wind is under 6 degree.

6.1.2. Flow Condition

Water flows from east to west. The maximum flow velocity is 3 kn. Considering that the flow velocity is too high, the towrope should be connected in slack water where the flow velocity is lower than 0.5 kn. Before connecting the towrope, the main tug and the towed vessel need to take some time to get prepared for towage.

6.1.3. Navigable Condition of Water Area

It is a dense area of passing vessels. In order to ensure the course safety and avoid its impact on towage, the main tug applies to the local vessel traffic service center to delimit a traffic control area which passing vessels should avoid.

6.2. Preparation before Towage

6.2.1. Estimation of Safety Risks

After taking the task of towage, an expert team should be established to estimate the safety of this towage task, guide connecting towrope operation, towage operation and disengaging operation and make responses to emergency situation. This towage task, together with its difficulty and emphasis should be borne in mind by estimating the safety risk.

6.2.2. Calculation of Towing Force

The towing force needed in this towage task should be calculated according to Guidelines for Towage at Sea. It is obtained by the calculation that it is enough to satisfy the towage workload to provide 900 kn towing force.

6.2.3. Determination of Towage Plan

According to the specific situation of the towed vessel and local hydrologic regime, maritime command group makes detailed towage plan which covers content of course, shelter anchorage, connecting towrope and disengaging. Since towrope and rigging cannot be prepared in advance, how to smoothly finish connecting and disengaging becomes the difficulty and emphasis of this towage task.

When connecting the towrope, it is easy to yaw due to the strong sea wind. In order

to reduce the possibility of towrope fracture, 64mm diameter steel towing bridle should be used to connect the set square. Then the short rope should be connected and at last the main towrope. Two specific connecting plans are made. First, when the safety loads of bollards on both sides of the towed vessel are higher than 900kN, it is enough to tie the towrope to only one set of bollard. It is easy to operate and convenient for connecting and disengaging. Second, when the safety loads of bollards on both sides of the towed vessel are lower than 900kN, the towrope needs to be tied to two sets of bollards. On the one hand, it ensures that the towrope keeps the most appropriate angle with the set square. On the other hand, it leaves enough tow rope to twine around the bollard on the deck.

When disengaging, the quick and convenient method should be adopted since there are many vessels anchoring in the port of refuge and the water area is limited. In order to satisfy such an operation, the main tug also makes two plans of disengaging. First, the towrope should be disengaged from the snubbing post on the deck of the towed vessel. Second, if the towrope is too stiff to untie, the main tug can gradually retrieve the main towrope and untie the towrope from the junction of main towrope and short rope.

6.2.4. Thorough Examination

After the towing plan is made, captain of the main tug convenes a meeting of the whole crew, clearly informs the whole crew of towage procedure and notes, and clarifies their responsibilities. Meanwhile, the crew of engine room department and deck department should be notified to examine the related appliance, tools and equipment, for example whether the towrope and rigging are completely prepared, or whether life saving and firefighting equipment are completely prepared. After

confirmation, preparation can be made for commencement of towing at expected commencement time.

6.2.5. Establishment of Emergency Response Plan

Emergency response plan should be established according to stipulations and preparation should be made to respond to emergency. For example, it is cold in March and towrope is easy to break. Therefore, the captain decides to penetrate a 220-meter long high-strength nylon towrope into the Panama fair lead of the towed vessel to be the temporary emergency towrope, in case it is needed.

6.3. Towage

6.3.1. Submission of Notice of Readiness

According to international practices, after the main tug reaches the sea area of the incident, they should submit standard notice of readiness to the shareholder state representative of the towed vessel immediately and take the time when shareholder representative checks and approves the notice to arrange the towrope to gain preparation time for following towage operation.

6.3.2. Arrangement of Towrope

After preparation, the towrope should be arranged when the wind in this sea area is lower than 6 degree. The main tug approaches its stern to the bow of the towed vessel. After approaching, the crew of the main tug enter the deck of the towed vessel to check fair lead and bollard and make field measurements. It is obtained by measurements; the safety load of the bollards on both sides of the towed vessel is 920kN. Towrope can be used when the wind is under 9 degree. Therefore, the towrope should be arranged according to the first plan. The towrope is tied to single

set of bollard and mooring line is used to tie up in case the towrope pops from the bollard. But it is found during running the line that the size of fair leads on both sides of the towed vessel is 250mm×400mm while the size of towrope casting which is planned to use is 250mm×250mm. Due to the limitation of sizes, it cannot penetrate when running the line. So socket bollard eye of same size is used instead. Besides, since the freeboard of the towed vessel is high, the distance between the fair lead and water is more than 20 meters, which causes the safety distance between the stern of the main tug and the bow of the towed vessel to become close during connecting short rope or connecting operation. For security reasons, it is determined to tie another 30-meter long short rope whose strength is the same as the strength of main towrope to the short rope. After dealing with these unforeseen circumstances, the towrope is arranged.

First, the operators get on the deck and connect the set square on the deck, towrope and short rope. Then the captain of the main tug sends the crew with rich experience of deck operation to get on the deck of the towed vessel to penetrate the towrope through the fair leads on both sides of the towed vessel and tie the towrope to the bollard as expected. After that, the main tug gradually retrieves the steel wire until the bollard eye entangles the towed vessel. At this moment, the crew are commanded to raise the short rope and set square out of water in case they are mixed up by storm or hung with fishing net. Finally, the main towrope is dragged through Panama fair lead, the towrope is coiled up and tightened. Meanwhile, floater and running line are tied to the towed vessel as emergency towrope.

6.3.3. Commencement of Towing

As the wind weakens gradually, both of the captains of the towboat and the towed

vessel decide to start commencement of towing after negotiation. The towed vessel discharges storm ballast to adjust the draft of the six sides to more than 3 meters and makes basic preparation for commencement of towing. After the towed vessel finishes the corresponding preparation for commencement of towing, the main tug immediately sets sail to make tow. When performing commencement of towing, the towed vessel first pulls up three sections of anchor chains. Then the main tug gradually approaches to the bow of the towed vessel when the flow is slow. After the main tug is close enough, the towed vessel takes the prepared short cable and succeeds in tying up with the main towline of the main tug. The whole process of cabling is finished within 10 minutes with high efficiency and smooth operation. When the main tug is responsible for towing, it is essential for the two vessels to keep a safe distance and the distance should be relatively stable, in order to avoid bringing threat to towing security for the reason that the short cable fractures because of sudden force. In addition, the crew of main tug must always watch chain direction in the process of towing, in order to avoid the direction migrating, bringing adverse effect on the main tug rudder, and to ensure the success of towing. After successful towing, the towed vessel sets sail, and the main tug moves forward slowly and gradually releases the main cable and tows until up to 260m. Considering that the inertia of towed vessel with large volume must be large, therefore the main tug must add cars at low speed in order to avoid that the main cable because of large force. After the towed vessel enters the planned routes, the main tug begins to tow as normal. The speed should remain around 6.5kn and the length of towrope remains around 550m.

6.3.4. The Process of Towing

Though the towing distance is not long, the main tug passes by three navigable

concentration areas where there are many passing fishing boats. To ensure the navigation safety, the ship-owner of the main tug should apply for traffic control and alarm the passing ships to go away. At the same time, the main tug appoints full-time crew responsible for monitoring the surrounding areas to comprehensively grasp the movement of surrounding vessels. In addition, the main tug should appoint the escort ship responsible for cleaning obstacles on routes to ensure that the routes have no obstacles to prevent towing. If the main tug needs to turn around in the process of towing, it should slow down and turn around with small angle to avoid affecting the stability of the direction of the towed vessel. In the process of towing, the distance between the main tug and the towed vessel should stay around 25m. The motion trail of the towed vessel should be consistent with that of the main tug. Keeping maximum coordination in movement can enhance the stability of towing. In the process of towing, the towed vessel has a problem of small yawing and makes the main towrope suffer serious wear problems. When the crew of main tug find the situation, they should immediately contact the crew of towed vessel to let the crew steer to control the yawing in order to reduce the wear of the main towrope. After the towed vessel is steered, it follows the movement of the main tug and there is no obvious yawing problem. In the proves of towing, the main tug checks the wear condition of the main towrope every hour and paints butter in the connection part in order to reduce friction. It passes the navigation concentration areas by three times in towing. With the assistance of escort vessel, it smoothly passes the navigation concentration areas and in the process there are no fishing boats passing through the towrope.

6.3.5. Casting off the Towline

Because the volume of the towed vessel is large, the main tug should slow down in

advance and navigate slowly before arriving at port of refuge to avoid being affected by the inertia. At the same time, the main tug takes back the main towline and reduces the speed to 3kn when the towline is 280m. Because the sea condition and the weather is good, a crew with rich experience of casting off the towline is appointed to guide the work in the towed tug when the ship-owner of main tug keeps in touch with the towed vessel. The equipment of port of refuge is considered, the first set of solution is decided to adopt, namely unlocking the towline on the towed vessel directly and the main tug is responsible for the recycling work of the towline.

After the main tug towing the towed vessel to anchorage, the port assists the main tug to stabilize the position. At this time, the main tug will take back the towline to 80m. The main towline stays relaxed in order for the crew to complete casting off the towline. After completing casting off the towline, the towline is put into the sea, but the direction of the water should be heeded to avoid affecting the rudder and propeller of the main tug. In the process of casting off the towline, the towline should be loosened before recycling steel wire to avoid the main towline falling into the sea to hurt the workers on deck.

Chapter 7 Summary and Conclusions

During the salvage operations, emergency towing is the most widely-used rescue technique with best effect at present. However, due to the complexity of salvage towing procedure, bad operation conditions, large amounts of accidents, the full cooperation of the main tug, the towed tug and the ports need to deal with the related issues and complete the towing task. Based on the research of the thesis, the following beneficial experience is concluded:

First, the main tug and the towed vessel should establish good communication mechanism, negotiate some problems and list the matters and attention in the process of towing in order to finish the towing work smoothly.

Second, a good security work should be guaranteed. Because there is a high degree of danger in salvage towing operation, the security work must be done and the safety arrangement must be established in order to fish the towing task successfully.

Third, efficient command system should be established and there should be a clear division of responsibilities for the main tug, escort vessel and the port to use efficient organizations to ensure the smooth implementation of salvage towing.

Forth, risk early warming and emergency response mechanism should be constructed for emergency. In the process of salvage towing operation, there are many factors influencing the towing work, most of which are controllable factors, such as waves, weather conditions, etc. Therefore, the command party should establish perfect and effective risk early warming and emergency response mechanism to deal with emergency and minimize the negative influence of emergency.

All in all, emergency towing is an effective technical measure for maritime salvage operation, whose concrete operation still has many issues worth of further deep discussion. In the future, research on the emergency towing operation in the salvage operation should be strengthened and the working ability and level of towing should be improved to meet the demand of towing shipwreck, to safeguard people's life and property safety, and reduce the economic loss and promote social and economic development.

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