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# Study on the Mistakes and Countermeasures in Ship Firefighting - A Case Study of M. V. Zhonghua fuqiang

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**Abstract:** This article firstly introduces the characteristics of fire on board ships, which includes “more of ignition sources, flammable and explosive materials, fire spread quickly on board, hard to be extinguished, lack of external assistance, large losses and hazards”; and secondly takes the fire accident of M. V. Zhonghua fuqiang as an example, elaborating the whole fire extinguishing process of the ship including the discovery of the fire, the initial emergency extinguishing of the fire, closing the fire compartment and releasing CO<sub>2</sub> to extinguish the fire, returning to the port of departure for berthing, transferring the command authority from the master to the shore-based fire department, the explosion caused by the opening of the fire compartment by the shore department, and the severe damage of the ship. Third, this article points out that its firefighting mistakes include the loss of the master’s command authority, wrong firefighting procedures and improper use of fire extinguishing agent; then analyzes that the reasons are unclear responsibility and authority between ship and shore, unfamiliarity of the shore-based support department with firefighting procedures and the existence of inapparent dangerous cargo. Finally, this article proposes countermeasures against such mistakes, including clarifying and guaranteeing the command authority of the master, improving the familiarity of the shore-based firefighting support department with firefighting procedures on board, and strengthening the management of inapparent dangerous cargo, etc.

**Keywords:** Ship Firefighting, Mistakes, Countermeasures, Master’s Overriding Authority

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## 1. Introduction

According to the statistics from Allianz, there was an approximate average of one fire every two weeks onboard ships, while fire/explosion remained the third most common cause of ship total losses (11%) over the past decade [1]. Any outbreak of fire on board a ship poses a significant risk to the safety of the vessel and to everyone on board.

Fast and effective ship firefighting can slow down, control and even eliminate fires, which is an important means to reduce accident losses and ensure the safety of human life and property at sea. However, due to the complex structure of ships and limited fire-fighting equipment on board, as well as difficulty in obtaining outside help [2], it is easy to make mistakes during firefighting, which becomes one of the key

factors for failing to control fires on board ships.

In order to control and reduce ship firefighting mistakes, the International Maritime Organization (IMO) requires shipping companies to formulate firefighting management systems, ships to regularly maintain and repair firefighting equipment and devices, and crew members to periodically conduct firefighting training and drills through compulsory regulations and recommended methods. These methods seem to be well, but there are still many shortcomings in the implementation process, such as imperfect systems, unclear responsibilities, indeterminate command authority and poor implementation, which lead to a further expansion of fire endangered the safety of ships and personnel, polluted the marine environment, and caused irreparable damage.

Among all kinds of mistakes in the process of firefighting on board ships, the loss of the master’s command authority

caused by the unclear command power between the ship and shore is one of the most serious harmful hazards, which excludes the ship master who is most familiar with the ship fired and its emergency handling measures from the decision makers, and leave the decision making authority to the shore firefighters who are not familiar with fire on board ships, which will not only make it is impossible to extinguish the fire quickly and efficiently, but also may further deteriorate the fire situation.

In order to solve the problem of the loss of the master's command authority during the firefighting process of the ship, and to solve a series of consequences that may result from this mistake, this paper takes a typical fire rescue accident as an example, points out the main mistakes in its firefighting process, analyzes the reasons for the mistakes, and proposes critical countermeasures against such mistakes.

## 2. Characteristics of Ship Fire

Compared with fire ashore, ship fires have some unique characteristics which mainly include:

### 2.1. More of Ignition Sources, Flammable and Explosive Materials

Ships are the main carriers of international trading cargos, undertaking more than 80% of the global international trading goods transportation volume [3]. There are many electrical and mechanical equipment with a long working period on board ships, which is easy to become the source of ignition; besides, There are various types of goods, as well as many combustibles and explosives cargos on board, which can cause fires of different types and intensities, such as oil fire, gas fire, electrical fire, and even explosion, etc. [4].

### 2.2. Fire Spread Quickly on Board

The ship has compact structure, small space, few passages between each compartment, and good thermal conductivity of hull metal components, which makes the heat in the fire compartment not easy to be distributed and the temperature rises quickly, once the fire starts, it will spread faster. Once the fire occurs on board, the structure of compartments, ventilation holes and stairways will easily produce heat convection and chimney effect, which will further increase the spread area of fire [5].

### 2.3. Hard to Be Extinguished

Ship firefighting is mainly conducted by crew members on board and using their own equipment, however, the number of seafarers arranged according to the Principles of Minimum Safe Manning issued by International Maritime Organization (IMO) [6] is limited, as well as the firefighting appliances equipped on the basis of the International Code for Fire Safety Systems (FSS Code) [7]. In addition, spaces in the ship is narrow and the scope of activities is limited, which makes the ship's firefighting more difficult.

### 2.4. Lack of External Assistance

As a mobile and independent entity, ships spend most of their time sailing at sea. Once a fire breaks out, there is no other body around for help and no external assistance can be obtained; even if the ship can return to port to put out the fire when sailing along the coast, the time to obtain onshore fire rescue will be delayed. [8].

### 2.5. Large Losses and Hazards

Although ship fires account for only 11% of the total number of ship accidents, they cause the most damage and hazards in marine accidents [9]. Improper handling of ship fires can easily cause serious accidents such as ship damage or total loss, crew injury or death, and marine environment pollution. The Sanchi & the CF Crystal collision incident occurred on 6 January 2018 in the East China Sea breached the cargo tanks of the Sanchi resulting in fire, explosion and the subsequent sinking of the vessel. There were 32 casualties onboard the Sanchi, 3 of which were confirmed dead and 29 declared missing. The incident was declared a "very serious marine casualty" [10].

## 3. Analysis of Fire Accident on Board M. V. Zhonghuafuqiang

### 3.1. Summary of the Accident

At about 2206 hours on April 19, 2021, M. V. Zhonghuafuqiang caught fire in a truck in the third deck vehicle compartment on the way from Weihai port to Dalian. The master turned his ship back at 2249 hours after the fire was controlled initially by crew members on board, then he activated the fixed CO<sub>2</sub> extinguish system, released CO<sub>2</sub> into the fired cabin on the way back. The ship berthed at Weihai port at 0003 hours and 762 passengers and crew members were evacuated safely at 0025 hours on April 20. The danger was preliminarily controlled.

At 1142 hours on April 20, the ship was deflagrated in the process of firefighting carried out by shore-based firefighters, causing the ship's hull above the fired compartment to be covered by fire, and vehicles and cargos were damage, with a direct economic loss of about 92.3325 million Chinese Yuan.

### 3.2. The Process of the Accident [11]

At 2206 hours on April 19, the smoke alarm system alarmed, and the master asked the AB on duty to check the alarm information and location of the fire through the fire alarm panel.

At 2212 hours, the compartment patroller Wang Jian reported that smoke coming from a truck in the third deck vehicle compartment, the master immediately instructed the third officer to check fire situation, then broadcast the information to all crewmembers at 2215 hours, gathering them to extinguish the fire as per the muster list.

As the goods on fire were unknown, the master ordered to

use fire extinguishers to put out the fire. At 2220, the chief officer reported that the fire had been extinguished, and the master left the bridge to check the fire situation on scene at 2236 hours.

At 2239 hours, the second officer reported that the goods on the fired vehicle were silicon mud.

At 2246 hours, the fire broke out again when the on-site fire fighters tried to find out the exact fire point by looking through the cargo, the master instructed the second officer to prepare turning back and he came back to the bridge at 2249 hours, steering the ship back towards the port.

At 2251 hours, the master instructed the third officer to prepare for the release of fixed CO<sub>2</sub> and the chief engineer to open the water spray system in the fire area.

At 2304 hours, the master instructed the chief engineer to stop the water spray system because it was ineffective, and the chief officer was required to evacuate the on-site fire fighters and prepare to release the CO<sub>2</sub> to extinguish the fire.

At 2310 hours, the master instructed the third officer to release the fixed CO<sub>2</sub> into the fired compartment after it was confirmed for many times that all the personnel in the fire compartment had been evacuated and the fire compartment had been closed, the chief officer was required to cooling around the fired cargo hold.

The ship berthed at Weihai port at 0003 hours and 762 passengers and crew members were evacuated safely at 0025 hours on April 20, and the fired compartment was closed.

At 0140 hours, the shore-based fire fighters asked all crew members to evacuate from the ship, but the master insisted that the second officer be on watch at the bridge to monitor the safety of the ship and the chief engineer be in the engine room to ensure a normal working condition of the auxiliary engines.

At 0820 hours, the command authority was transferred from the master to the shore-based fire department. Personnel of the shipping company and some experts suggested that the fire compartment should be opened. The commanding officer formulated a three-step handling principle of "cooling, fire detection and cabin opening".

At 1000 hours, the on-scene commander asked the master to make preparations for opening the forward and after doors of the fire compartment, the master informed that full ventilation would be formed and the fire would be enhanced if the forward and after doors were opened simultaneously, the commander then changed his order to open the after doors and the master reminded that a uncontrollable risk may exists because the after doors could not be closed after open.

At 1142 hours, 4 crem members opened the after doors of the third deck compartment as per the order of the on-scene commander, and the compartment was re-ignited and exploded during the process of opening.

At 1148 hours, the on-scene commander ordered to continue to open the doors after confirming all crew members were safe, and the compartment exploded again when opening, the fire was out of control, personnel on board evacuated ashore quickly without any casualties.

It was until 7 days continuously burning and extinguishing, the fire was finally put out at 1700 hours on April 27, the ship

was totally damaged as well as all vehicles and other cargos on board. Fortunately, there were no casualties.

### 3.3. Analysis of the Mistakes in Firefighting

From the point of the effect of emergency handling, the whole extinguishing process can be divided into three states: 1) using fire extinguishers and water spray system at initial state; 2) using the fixed CO<sub>2</sub> system for the closed compartment when the fire was out of control; 3) opening and extinguishing the fired compartment by the shore-based firefighting department.

#### 3.3.1. Improper Use of Fire Extinguishing Agent

According to the fire tetrahedron as shown in Figure 1, the key point of extinguishing fire is to block at least one of the elements [12].

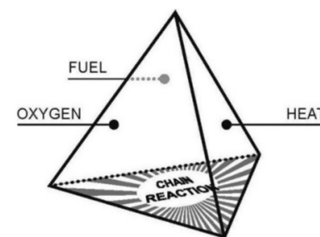
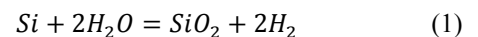


Figure 1. Fire tetrahedron [13].

At the early stage of the fire, the master ordered to use fire extinguisher without knowing the type and characteristics of the fired cargo, and then use the water spray system after the second officer reported that the goods were silicon mud. Although the temperature could be reduced by the water mist to block one of the elements of the fire tetrahedron, the silicon mud could react with water and produce hydrogen which was flammable according to its characteristic [14]. as expressed in Equation (1). It was one of the most important reasons for the explosion caused by opening the doors to extinguish the fire later after.



#### 3.3.2. Loss of the Master's Command Authority

The master's command authority was transferred from the master to the shore-based fire department after berthing, and the shore-based firefighters who were unfamiliar with the ship's structure and characteristics of fire on board made and implemented the extinguishing fire plan, making it impossible for the master who known the firefighting procedures mostly to make decisions and command, it not only obviously violated the provisions about the master's authority in Ch.5 Reg.34-1 of SOLAS Convention [15], but also inconsistent with the requirements of master's absolute authority in Part A 5.2 of ISM Code [16].

#### 3.3.3. Wrong Firefighting Procedures

The on-scene commander did not take the master's warning seriously when implementing the firefighting plan of "cooling, fire detection and cabin opening", and ordered to open the compartment which was closed less than 12 hours without a

fully detection of the fire situation, making a sudden influx of fresh air and explosion subsequently, with a secondary explosion when continuing to open. It was absolutely a violation of the firefighting procedures on board ships.

## 4. Reasons and Countermeasures of Mistakes in Firefighting

### 4.1. Reasons of Mistakes in Firefighting

There were three main mistakes in the firefighting process of M. V. Zhonghuafuqiang as per the above analysis. The first mistake was the loss of the master's command authority, followed by the wrong firefighting procedures of shore-based commander, and finally the improper use of fire extinguishing agent. The following analysis is for the reasons of these mistakes.

#### 4.1.1. Reasons of the Loss of the Master's Command Authority

The master who has independent rights of decision-making and command is the top commander and leader of the ship. Any decision about daily and emergency matters made by the master will not be unduly affected by any other crew members on board.

As per the IMCO Res.A.443 (XI), governments should take necessary steps to safeguard the shipmaster in the proper discharge of his responsibilities in regard to maritime safety and pollution prevention by ensuring that: the shipmaster is not constrained by the shipowner, charterer or any other person from taking in this respect any decision which, in the professional judgement of the shipmaster [17]. This provision excludes factors that may interfere with the master's authority, including the employer, superiors, institutions with administrative jurisdiction, etc., to ensure the master's overriding authority with respect to safety and pollution prevention on board [16].

The maritime authorities of each contracting party should formulate corresponding domestic rules to clarify the master's command authority in accordance with the requirements of international conventions, and the shipping company should also specify the master's command authority in the safety management system operating on board the ship.

However, during the process of firefighting on M. V. Zhonghuafuqiang, the shore-based support fire department believed that the subsequent firefighting should be carried out under its leadership based on the fact that the ship had berthed, and took over the command authority using administrative power. The master then gave up his command authority due to a higher administrative level and a stronger firefighting force of the shore-based support department.

The apparent cause of this mistake was the chaos of firefighting command, but the fundamental reason was an unclear understanding of responsibility and authority between shore-based firefighting department and the master. They did not know, or may not realize the master's command authority in regard to ship affairs, and the master also did not explicitly

demand the command authority that should have belonged to him, and only put forward suggestions as an expert. Finally, the decision and command were made by personnel who did not know the characteristics of the ship's fire and the firefighting procedures, resulting in the re-ignition of the initially controlled fire and explosion [18].

#### 4.1.2. Reasons of Wrong Firefighting Procedures

The shipping company will formulate a specific firefighting procedure in the safety management system according to the characteristics of the ship fire. The key to quickly extinguish the fire is to strictly follow this procedure for fire emergency response.

The firefighting plan formulated by shore-based commander was apparently comply with regarding procedures, but not to be strictly followed during the process of detection and opening the compartment.

According to the firefighting procedures on board ships, any fired compartment which was to be extinguished with fixed CO<sub>2</sub> system should be sealed for at least 24 hours after the CO<sub>2</sub> was released, and the gas composition inside should be measured by using gas detector when the temperature dropped to a normal level to ensure safety before opening. M. V. Zhonghuafuqiang neither conduct a gas detection, nor did it reach the minimum sealing time for the compartment before opening, which was obviously a big mistake.

The root cause of this mistake was that the shore-based firefighters did not understand the characteristics of ship fires and firefighting procedures, they took the wrong operation even after the captain repeatedly emphasized it.

#### 4.1.3. Reasons of Improper Use of Fire Extinguishing Agent

Ships carry a wide variety of cargoes, among which dangerous cargoes have a greater impact on the safety of ships, the master should know or be able to get the nature and the emergency handling ways of the dangerous goods carried on board.

During the process of firefighting on M. V. Zhonghuafuqiang, the master firstly ordered not to use water, and then instructed to use water spray system after knowing the fired cargo was silicon mud, which indicated that he did not understand or find that the silicon mud had the characteristics of reacting with water to produce hydrogen. The fundamental reason of improper use of extinguishing agent was that silicon mud was usually regarded as a non-dangerous ordinary cargo, which made both the shipper and the carrier ignore its dangerous characteristics.

### 4.2. Countermeasures for the Mistakes in Firefighting

#### 4.2.1. Guarantee the Master's Command Authority

To ensure the effective implementation of the master's command authority, the maritime authorities, shipping companies, ship masters, crew members, and other relevant parties should be familiar with the meaning of the master's command authority, perform their respective duties, and actively cooperate with the master in handling ship safety matters.

Firstly, the maritime authorities should strictly perform their supervision duties, inspect the ship companies, ports, ships and other relevant parties to see whether they have clarified the master's overriding authority in the safety management system documents, and implement them in practice. Those who fail to clarify or implement, penalties should be imposed and a deadline for correction.

Secondly, the shipping companies should follow the requirements of ISM and NSM [19] to clarify the master's overriding authority in respect of maritime safety and pollution prevention in the safety management system documents, and make the management person, the master and the crew members to know and understand the meaning of the master's overriding authority through publicity training, examination and drill, etc.

Thirdly, the master's overriding authority should be included in the on-board familiarization, routine meeting and relevant safety training, so as to strengthen the understanding of its meaning through constant repetition and emphasis.

Finally, the port and shore-based support departments should develop a clear management and emergency response system with clear authority and responsibility, in which the master's overriding authority is clearly defined, and no one can interfere with any decision made by the master in respect of his duties related to maritime safety and pollution prevention, let alone deprive him of his command authority, so as to ensure that emergency response on board can be carried out professionally and efficiently.

#### **4.2.2. Be Familiar with and Master the Firefighting Procedures on Board**

The ship fire-fighting procedure is an emergency procedure made according to the characteristics of ship fire and the actual situation of fire-fighting forces and equipment. The key to quickly extinguish a fire is to be familiar with and master the ship's fire extinguishing procedures, and strictly implement them when a fire occurs.

The master should carry out firefighting drills periodically as per the requirements of the ship safety management system, to practice the firefighting methods for different types of fire in different parts of the ship, find out the problems that arise in the drills for a further learning, so that all crew members on board ships gradually familiar with and master the ship's fire fighting procedures.

The port and shore-based support department should obtain the text of the ship firefighting procedures, and organize relevant personnel to study and practice it, and to emphasize the particularity and differences of the fire between ship and shore. If conditions permit, joint fire-fighting drills can be held regularly with different types of ships in the port, or watch and learn on the ship when there are fire drills on board, in order to fully familiar with and grasp the firefighting procedures on board.

#### **4.2.3. Strengthen the Management of Inapparent Dangerous Goods**

The International Maritime Dangerous Goods Code (IMDG) is the main guiding document for the carriage and

management of dangerous goods on board ships, which is used by cargo owners, customs and ships for declaration, inspection and management of goods. However, some goods which do not belong to but can be changed into dangerous goods by external environmental changes are not included in it, which brings greater risk to ships.

All relevant parties should strengthen the collection, collation and research of such goods, forming a list of inapparent dangerous goods, listing the name, characteristics, carrying requirements, the conditions of transforming to dangerous goods, emergency handling measures and so on. And make checklists for the declaration, inspection, loading and discharging, carrying, emergency handling and other aspects, in order to reduce, and even eliminate the risk of carrying inapparent dangerous goods.

## **5. Conclusion**

Firefighting mistakes on board ships may lead to unbearable consequences like fire spreading, casualties, property losses, and environment pollution, etc. The fire accident of M. V. Zhonghuafuqiang indicated that: 1) the master, as the primary responsible person of safety affairs on board, played an irreplaceable role in fire emergency response, once his command authority been taken over by external support department which is not familiar with ship firefighting procedures, it will possibly endanger the safety of the ship. 2) the wrong firefighting procedures implemented by the shore-based firefighting support party may cause a secondary fire accident, which is a major mistake in firefighting. 3) inapparent dangerous goods are an important reason for improper use of fire extinguishing agents.

Countermeasures in response to the above mistakes include: 1) maritime authorities, shipping companies, ships, ports and other related parties should strictly follow the provisions of ISM Code on the master's overriding authority to ensure that it can be implemented effectively during fire emergency; 2) the shore-based firefighting support department should be familiar with and master the firefighting procedures of the ship through on board observing, learning, training and drilling, etc.; 3) strengthen the management of inapparent dangerous goods, and make a list of such goods for further reference by collecting, sorting and researching.

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