



# Safety Measures and Practice of Ship Navigation in Restricted Visibility Base on Collision Case Study

Zhongming Hu<sup>1</sup>, Yijun Liu<sup>2,\*</sup>, Hao Sun<sup>3</sup>

<sup>1</sup>Shanghai Pilot Station, Shanghai, China

<sup>2</sup>Merchant Marine College, Shanghai Maritime University, Shanghai, China

<sup>3</sup>Ningbo Pilot Station, Ningbo City, China

## Email address:

13764062866@139.com (Zhongming Hu), lyj454023810@outlook.com (Yijun Liu), thmos5852@163.com (Hao Sun)

\*Corresponding author

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**Abstract:** Maritime transportation is one of the most important modes of freight transportation. The navigation industry has been developing rapidly and the number of ships is increasing day by day. However, the navigable waters are limited, and the increase in the number of ships will inevitably increase the ship traffic density in navigable waters, leading to an increase in the risk of maritime accidents. According to the analysis of the causes of marine accidents in recent years, it is found that many marine accidents occurred in restricted visibility. Ship sailing in poor visibility will easily lead to difficulties in ship lookout, positioning by land marks and identification of targets, thus causing stranding, collision and other marine traffic accidents. Dense fog also affects the propagation of radio waves and acoustic signals, and then affects the normal use of the corresponding navigational equipment, which seriously threatens the safe navigation of ships. The article, by analyzing typical ship collision accidents occurred when the visibility is poor, analyses the cause, feature and regular pattern, and discusses the precautions and safety measures for navigation in poor visibility waters, provides good experience and practice for ship navigators to ensure the safety of ship navigation in poor visibility conditions. It can also play a certain role in prompting young navigators to navigate and manage the ships correctly in poor visibility.

**Keywords:** Ship Navigation, Marine Accident, Collision Avoidance, Navigation Safety Measures

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## 1. Introduction

Economic globalization has promoted the development of trade, and the transportation of goods by sea has completed more than 80% of the world's freight, which has significantly increased the number of ships in navigable waters, not only in port waters, but also in coastal and customary routes. With the increase of navigation density, the frequency of ship accidents increases, especially in the waters with poor visibility. Sea fog is a disastrous marine phenomenon that affects the navigation of ships [1]. Foggy weather will greatly reduce the visibility at sea [2], and ships sailing in fog will often slow down and proceed cautiously. However, collisions with other ships and rocks, as well as ship grounding, often occur every year in the foggy season [3]. Relevant research results show that there is a close relationship between maritime collision accidents and

insufficient visibility [4]. Through the analysis of various problems leading to maritime collision accidents, it can be seen that the International Maritime Organization has made relevant regulations, especially in the cases of poor visibility. In order to reduce the influence of rain and fog weather on the navigation safety of ships and meet the navigation safety of ships with poor visibility, it is necessary for ship operators to be familiar with the relevant regulations on fog navigation, conscientiously abide by these regulations, and make full use of good boating skills to steer ships. In rainy and foggy weather, it is easy for ship operators to judge the situation inaccurately because of limited lookout vision, which in turn leads to improper collision avoidance control measures, imminent danger and collision accidents. There are many reasons for ship collision accidents besides the obstruction of sight. This paper focuses on the influence of poor visibility

caused by fog on the safety of ship navigation, and combines cases, predecessors' experience and my professional knowledge to carry out relevant research and put forward matters needing attention for safe navigation of ships in fog.

## 2. Typical Case Analysis of Ship Collision Accident When Sailing in Restricted Visibility

At around 0200lt (local time) on March 19, 2013, the motor ship "Zhesheng XX" (hereinafter referred to as ship "Z") was on the way back from the destination port, and the motor ship "Tai Lianhai XX" (hereinafter referred to as ship "T") was sailing off the coast of Qidong, Jiangsu, China, a few nautical miles away from ship "Z". There was heavy fog in the vicinity of collision area, and the visibility was less than 100m. At around 0203lt the said two ships collided with other at GPS position: 32°5'21.97"N, 121°44'55.92"E due to improper look out and miss navigation operation, leading to six people died and two were missing in the accident.

### 2.1. Progress of the Accident

At about 2000lt on March 17th, 2013, the ship "Z" loaded about 690 tons of stones from the "Shulang Lake" in Zhoushan city, Zhejiang province, China, and sailed to the destination for unloading. At 1941lt on the 18th, after cargo unloading in the anchorage, she heaved up anchor and sailed for next destination; At 0025lt on the 19th, the ship "Z" sailed in the coastal waters near Qidong city, Jiangsu province, with a visibility of about 100-200m. She kept her navigation equipment on normally, displaying masthead lights, side and stern lights, but no fog signal was shown. At about 0142lt, her speed was 7.4 knots, her heading was 112°, and the visibility dropped to about 30 meters; At about 0157 her speed was 7.4 knots, heading was 146°, and the duty officer found on her radar that the echo of ship "T" was located about 1.5 nautical miles away and bearing 30° on her port bow, but no AIS signal was received from ship "T". The duty officer of ship "Z" thought that the target on radar was a fishing boat, and no avoidance action was taken. At about 0201lt, ship "Z" speed was 7.5 knots, and the heading was adjusted to 143°. At this time, it was found that the echo of ship "T" was still located about bearing 30° on her port bow, the distance dropped to 0.5 nautical miles, and still no actions were taken by both ships. At about 0203 o'clock, ship "Z" duty officer observed by visual the outline of ship "T" and immediately slowed down, stopped and backed up with full astern engine. However, it was too late, and the bow of ship "Z" collided with the starboard middle hull of the of ship "T". After collision, ship "Z" stopped on scene and called ship "T" via VHF radio channel 08, but there was no response. The ship "T" was badly damaged and holed on the starboard hull, sea water flooded into the cargo hold immediately and soon capsized and sunk, causing six people died and two were missing in the accident.

### 2.2. Cause Analysis of the Accident

According to the second-instance civil judgment of Shanghai Higher People's Court, the reasons for this accident are as follows:

- (1). The navigation equipment and related information provided are not fully utilized. In this case, both ships are in foggy waters, and the visibility is less than 100m, so it can be easily judged that the visibility at that time was difficult to find the bow of the ship and it is sailing in dense fog, but neither ship has sounded the fog signal. Therefore, the driver of the other side can't judge whether there is a coming ship and the direction, distance change and direction change of the coming ship by using the sound signal, so that it can't effectively carry out regular lookout and take collision avoidance measures. When the ship was sailing near the collision waters, the AIS signal was not turned on by the T ship, which led to the failure of the Z ship to identify the incoming information. At the same time, although Z ship turned on radar, AIS, GPS and other navigation AIDS, it didn't make full use of the collected information, didn't use radar observation for systematic plotting or observation, and didn't use VHF to communicate with each other and didn't make coordinated avoidance before the collision, which were the main reasons for this collision accident.
- (2). The regulations related to navigation in restricted visibility were not strictly observed. When the visibility in vicinity was less than 100 meters, neither of the two ship involve in the accident arranged additional watch-keeper, and no look-out were sent at the fore and aft station, especially at the ship's bow. The presence of the other ship at the bow could only be detected by the radar on the bridge (the duty officers of both ships did not take effective measures, and did not carried out proper plotting and considerable systematic observation). The accident investigation report showed that the two ships failed to maintain a safe speed when sailing in poor visibility, and failed to comply with the relevant regulations on safe navigation of ships, which eventually led to the accident.
- (3). Improper collision avoidance. Because the collision caused the "T" ship to sink, and the AIS signal was not turned on during the voyage, the actions to avoid collision by ship "T" could not be effectively understood. As for ship "T", when sailing in the waters with poor visibility, she failed to maintain safe speed, and didn't take any active measures to avoid collision during the period from the detection of the ship's radar signal to the occurrence of collision. No actions were taken, such as slowing down, stopping and reversing her engine until the ship "T" was visually observed, but it was too late.
- (4). The proficiency of ship navigators was insufficient. According to the accident investigation report, it was discovered that the personnel on duty of both ships

were not holding any recognized certificate of competence. The personnel on duty on ship “Z” could make some simple operations of navigational equipment, such as switching on and off the radar, electronic chart. During the voyage, the radar range had been set at 1.5 nautical miles, which makes it impossible for the duty personnel to perform the duties of safe navigation.

### **3. Analysis of Influencing Factors of Fog Navigation Safety**

#### **3.1. The Influence of Human Factors on the Safety of Fog Navigation**

Man-made factors are always an important factor that cannot be ignored in the three aspects of ship management: human, machine and environment. Among them, there is a close relationship between the crew's quality and the ship accident in restricted visibility. Crew members are lack of sailing qualifications, lack of experience, not familiar with the relevant rules of navigation, and fail to fulfill their due responsibilities in maritime navigation duty [5]. In particular, crew members are not always aware of safety risks. Under such bad weather conditions, they cannot accurately estimate navigation risks, have poor judgment ability, and fail to accurately grasp the ship's course. In this case, if there is an emergency, it is likely to lead to maritime accidents.

In addition to the crew's own quality factors, the crew's lack of equipment and the crew's failure to strictly abide by the regulations are also very likely to lead to accidents. What's more, sailing in fog often some time takes a long time, and this long-term state of high tension is likely to lead to the fatigue of the on-duty and lookout personnel, irritability or inattention, which will easily reduce the ability of the on-duty personnel to analyze and determine the surrounding situation [6], and in the event of an emergency, the possibility of misjudgment will increase greatly.

#### **3.2. Influence of Equipment Factors on Fog Navigation Safety**

Relevant research shows that there is also a certain correlation between ship collision accidents and ship conditions. If the ship is not well maintained as planned, there may be failures of navigation equipment during the voyage. In case that the ship's communication equipment fails, the communication between ships will be blocked. Without sufficient communication and fog signals as required by the rules, ships sailing in restricted visibility may easily enter into urgent situation and danger, and then lead to the occurrence of ship collision [7]. In case that the navigation equipment such as the main engine and rudder fails, it is difficult for the personnel on duty to control the ship's movement, which will also bring high risks of ship collisions [8].

In foggy weather, the poor visibility will inevitably affect the sight distance of the personnel on duty, and then reduce the

accuracy of the navigators' judgment and analysis of the current situation. In addition, due to the special physical properties of sea fog, the performance of ship radar to capture targets is also reduced. This will easily lead to unclear radar echo, and even fail to detect small targets, which will bring certain risks as well to the navigation of ships. [8].

#### **3.3. Influence of Environmental Factors on Safe Navigation in Restricted Visibility**

Sea fog will have many adverse effects on the safety of ship navigation, and the decline of visibility at sea is the most direct manifestation, and will also affect the performance of navigation aid such as radar target detection performance, making possibility of collision accidents increase obviously. In the urgent and dangerous situation, actions taken by a ship, such as alteration of course with large angle, can't be observed visually by other ship in short time, so it is quite difficult to expect other ship involved to make coordinated actions, which also increases the risk of collision between ships.

In addition, ship traffic condition will also bring safety hazards to ships sailing in foggy area. In many coastal waters, such as China East Coast, Malacca Strait and English Channel, ship traffic are very heavy, different type of ships are coming and going from/to different directions, and collision accidents are prone to occur, especially those sailing in fog area. Ship navigators sailing in these sea areas should strengthen their sense of responsibility, and exercise good seamanship and practice with extreme caution [9].

### **4. Safety Measures for Ships Sailing in Restricted Visibility**

#### **4.1. Safety Precautions for Navigation in Fog**

It is inevitable for ships to encounter rainy and foggy weather during sailing at sea. Statistical data show that the frequency of accidents due to foggy days is much higher than that in waters with good visibility. Because of the objective factor of poor visibility, it is easy to cause the judgment error of the ship's duty officer responsible for navigation, which has a far-reaching impact on the safe navigation of the ship. Poor visibility has seriously affected the visual observation effect of the ship's personnel in charge of navigation. The Collision Avoidance Rules require that all effective means such as radar should be fully used to strengthen the observation. Professor Cockcroft's viewpoint in the book “Guide to Ship Collision Avoidance Rules” is that when the visibility is less than 5 nautical miles, it should be considered as a sea condition with low visibility. It is also often cited in the judicial practice of many ship collisions [10]. As we all know, fog is an important factor to reduce the visibility of the sea. This kind of weather problem is sometimes light fog and sometimes heavy fog. Generally, the scale of fog is judged according to the visibility. Sometimes the speed of fog formation is very fast. If the visibility is poor, it is more necessary to make full use of radar to judge the state around the ship. At the same time, it is

necessary to realize the judgment of the specific position in the state of radar and vision recognition, and it is impossible to make the judgment of the encounter situation by using insufficient radar data. Only through visual observation and full and systematic radar observation can we make a correct judgment on the encounter situation. When sailing on the ocean, it is easy to have safety problems in navigation, and it is necessary to drive carefully to achieve safe navigation of ships.

Usually, when sailing in a foggy sea area, two ships will meet. Once they are close, there may be a collision danger, an urgent situation or even an urgent danger. When the situation requires avoidance actions between ships, it is difficult to take appropriate avoidance actions without regular lookout, and the effect of avoidance can be imagined. According to the Collision Avoidance Rules, in the case of poor visibility, there is usually no distinction between the responsibilities of "giving way ships and direct ships". Therefore, when the situation encountered in fog navigation requires collision avoidance actions between ships, both parties usually have the same responsibility to avoid collisions. If during the foggy voyage, when a ship encounters an incoming ship and it is judged that there is a collision danger, it should take active avoidance maneuver to prevent an urgent situation or even an urgent and dangerous encounter state as much as possible.

#### **4.2. Measures to Eliminate the Influence of Human Factors on Fog Navigation Safety**

- (1). Consciously and earnestly abide by the relevant regulations on fog navigation. These rules include technical requirements from collision avoidance rules, legal requirements, duty rules, national and local rules, and relevant regulations from shipping companies. The captain shall, according to the ship's own conditions and personnel allocation, draw up the assignment of personnel on duty during fog navigation and issue practical requirements for fog navigation.
- (2). Continue to strengthen the vocational education of seafarers and improve their ideological quality. Thought is the guide of action, and a high-quality driving team is conducive to improving the safety of ship navigation. The driving team on duty in fog navigation should be clear about their responsibilities, keep a regular lookout, be able to inform the captain without hesitation when it is necessary to get on the bridge, and sound corresponding sound signals according to regulations when it is necessary to sound them, without worrying about whether it will affect the crew's night rest in the first place. Be familiar with the ship's action rules under different visibility conditions, and make prompt and correct choices of avoidance measures. [11] For example, when two ships meet in foggy weather, there is no distinction between a direct ship and a giving way ship, and the incoming ship does not turn in the direction of the incoming ship. At any time, the ship needs to sail at a safe speed, and the dynamics of the incoming ship can be better grasped

through effective communication. It is not necessary to use insufficient radar data to judge the encounter situation, and the effective avoidance action needs to be checked.

- (3). Strengthen safety training and improve the cultural skills of the crew. All crew training institutions, crew departments of companies and maritime authorities should attach importance to the improvement of crew cultural skills. According to the requirements of STCW revised by the International Maritime Organization, the training program are formulated, and the training institutions draw up teaching plans and teaching programs of various courses according to the training program, and effectively ensure the quality of training, strengthen the crew evaluation link, make the evaluation process true and effective, and ensure that the cultural skills of each certified crew member correspond to the certificates of competency held by them. Every voyage, the captain should be called for a pre departure meeting. When the foggy voyage is expected to come, the captain can remind the crew to abide by the foggy navigation regulations again, improve the crew's safety awareness and consciously abide by the operating rules and beliefs, and use good boating skills to ensure the navigation safety of the ship [12]. Use education and training to further improve the knowledge and operation level of the whole crew, and at the same time, maintain a good state at work.
- (4). Strict management system. According to the safety management rules, shipping companies and ships should formulate safety management systems and maintain effective operation. Usually, before sailing, shipping companies should make arrangements in advance for the navigation mode and work in foggy areas, and have clear guidance for special weather conditions. Quality administrators also need to conduct follow-up inspection to strengthen the importance and necessity of each crew member's system for ship navigation safety. [13].

#### **4.3. Full and Correct Use of Radar**

As a navigation aid for ships, radar is one of the necessary equipment for all seagoing ships. According to the requirements of STCW Convention, crew members, especially the navigation officers on duty, need to be trained in radar plotting or its equivalent system. Radar has become one of the important means for ships to carry out regular lookout, especially when sailing in fog with poor visibility. Therefore, the Regulations for Collision Avoidance clearly stipulates the use of radar, and every duty officer should be aware of these regulations and implement them effectively. [14] If the appropriate display mode should be selected, the display mode of the bow line that is relatively running can usually be selected during navigation; We should change the range and find the incoming ship early, leaving more time for continuous observation and judgment; Properly adjusting the radar can not only make the echo of the radar clear and debatable, but

also not cause the small target to be lost; You can use the capture function of radar to make a correct risk judgment on the target; According to at least three consecutive observation data with a certain time interval, radar plotting or equivalent systematic observation should be carried out to judge whether there is a collision danger in the encounter situation. Therefore, the correct use of radar is an essential skill for captains and drivers. When sailing in foggy weather with poor visibility, the correct use of radar is helpful to accurately judge the collision danger and prevent the misjudgment of the situation because the observation line is blocked. Only by correctly judging the encounter situation can we take reasonable avoidance measures in time.

#### **4.4. Maintain Effective Communication and Take Coordinated Avoidance Actions**

According to the requirements of ship communication in GMDSS, ships are equipped with communication equipment for long-range, medium-range and short-range and should be properly used. Many VHF (Very High Frequency Radiotelephones) equipped on ships are effective communication equipment at sea in close range. Marine VHF radio communication refers to the radio communication between ships, inside ships, between ships and shore, or between ships and shore users through shore-based communication. It is widely used in ship avoidance, maritime management, port production scheduling, ship internal management, distress search and rescue and safety information broadcasting, etc. It is the main means to complete water traffic field communication. VHF communication plays an important role in ensuring the navigation safety of ships, which cannot be replaced by other means of communication. Because of the wide range of activities of ships, the harsh use environment, and the great changes in temperature and humidity at sea, the marine walkie-talkie is particularly professional, and its working frequency is uniform in the world to meet the needs of safe navigation at sea around the world.

During maritime navigation, attention should be paid to VHF communication with the following matters [15]:

- 1) Before a ship enters a specific port, navigators must carefully study and understand the VHF communication rules of the port water area. The channels and modes must be confirmed before communication between the two parties; When the channel is correct and the communication is not smooth, you should change the channel or walkie-talkie; In case of interference or interference with others, the channel should be changed in time;
- 2) Speak concisely and try to shorten the time of each launch. Don't speak loudly, otherwise it will cause voice distortion; Pay attention to adjust the volume and quiet, otherwise you may not hear or produce disturbing noise;
- 3) The effective communication distance is within 20-30 nautical miles;
- 4) At ordinary times, it is necessary to maintain the duty of 16 channels and 75 frequencies and 2181kHz, and after

establishing communication channels, it is necessary to switch to other frequencies for communication;

- 5) Try to communicate in plain language, such as standard maritime language;
- 6) Observe the general procedures of maritime communication of ships, such as important information should be repeated, errors should be corrected, letters and numbers should be sent separately, etc.

Ship navigators must be soberly aware that there is no relevant provision about VHF walkie-talkie in the international regulations for collision avoidance, and only think that VHF walkie-talkie is one of the means for seafarers to conduct regular lookout. It should also be fully realized that the use of VHF communication is only an auxiliary means to help avoid collisions, and it cannot be used in violation of the Rules. Therefore, relevant personnel should correctly use VHF walkie-talkies to better serve navigation safety, maritime management, shipwreck rescue and port production.

## **5. Conclusion**

When a ship sails in a foggy area, it must consciously abide by the relevant provisions of the International Regulations for Preventing Collisions at Sea, and consciously abide by the requirements of the flag state, the sovereign state of the waters where it is located, the local government, the shipping company and the STCW convention on duty. Every person on duty should have a high consciousness, and the responsibility for safe navigation of the ship lies in his own duties. At ordinary times, he should strengthen the ideological education of the crew, improve their professional quality, strengthen the teaching and training of their cultural skills, improve their professional level, improve the overall quality of the crew, implement the safety management regulations and establish a safety management system. During the foggy voyage, the members of the bridge who are in charge of navigation duty should make full use of all effective means, keep regular lookout, correctly and effectively use radar to observe, use sufficient radar data to make radar plotting or its equivalent systematic observation, make a correct judgment on the encountered situation, take effective avoidance measures as early as possible, and correctly use VHF to communicate and exchange information, which is also helpful to make a correct judgment on the encountered situation and take coordinated avoidance measures. In the process of work, the members of the bridge who are in charge of navigation duty should be able to keep the basic vigilance at all times, make a decisive decision, avoid fear or retreat, and steer the ship carefully, so as to make the navigation of the ship safer.

## **References**

- [1] Du, P., Zeng, Z., Zhang, J., Liu, L., Yang, J., Qu, C.,... Liu, S. (2021). Fog season risk assessment for maritime transportation systems exploiting himawari-8 data: A case study in bohai sea, china. *Remote Sensing*, 13 (17), 3530. doi: <https://doi.org/10.3390/rs13173530>.

- [2] Xian, J.; Han, Y.; Huang, S.; Sun, D.; Zheng, J.; Han, F.; Zhou, A.; Yang, S.; Xu, W.; Song, Q.; et al. Novel Lidar algorithm for horizontal visibility measurement and sea fog monitoring. *Opt. Express* 2018, 26, 34853–34863.
- [3] Gao, Y.; Jiang, G. Research on Influencing Factors and Countermeasures of Fog Navigation in Weihai Harbour. In *Proceedings of the 5th International Conference on Education, Management, Arts, Economics and Social Science*, Sanya, China, 10–11 November 2018.
- [4] Deng Xiaoyun. The necessity and countermeasures of fog navigation in China's coastal ports [J]. *China Water Transport (the second half of the month)*, 2015, 15 (11): 60–62+165.
- [5] Sun Haoran, Yang Xinghui. Exploration on the application of AIS technology in maritime management of fog navigation safety [J]. *China Water Transport (the second half of the month)*, 2016, 16 (10): 69–70+72.
- [6] Zhang Honggang, Ai Wanzheng. Safety countermeasures for ship navigation in fog [J]. *Shipping management*, 2016, 38 (07): 24–27.
- [7] Emel'yantsev, G. I., Blazhnov, B. A., Dranitsyna, E. V., & Stepanov, A. P. (2016). Calibration of a precision SINS IMU and construction of IMU-bound orthogonal frame. *Gyroscopy and Navigation*, 7 (3), 205–213. <https://doi.org/10.1134/S2075108716030044>
- [8] Rafal Szlapczynski, Joanna Szlapczynska, A method of determining and visualizing safe motion parameters of a ship navigating in restricted waters, *Ocean Engineering*, Volume 129, 2017, Pages 363–373.
- [9] Cao Huazhong. Typical case analysis of foggy ship accidents and preventive measures [J]. *Journal of Wuhan Institute of Shipbuilding Technology*, 2011, 10 (02): 30–34.
- [10] Wang Dan, Jing Yan, He? Brief analysis of the ship's navigation in the waters of Qinzhou Port [J]. *China Water Transport (the second half of the month)*, 2014, 14 (12): 31–32.
- [11] Zhang Jiahui. Pilotage safety model in poor visibility weather [J]. *China Water Transport*, 2022, 22 (05): 9-10+57.
- [12] Feng Ye. Basic countermeasures to prevent fog navigation accidents [J]. *Marine Technology*, 2012 (01): 26–27.
- [13] Szlapczynski, R (Szlapczynski, Rafal), Evolutionary Planning of Safe Ship Tracks in Restricted Visibility, *JOURNAL OF NAVIGATION*, Volume 68, 2015, Pages 39-51.
- [14] Chen Delai. Analysis of ship navigation during poor visibility [J]. *Pearl River Water Transport*, 2018 (05): 56-57. DOI: 10.14125/j.cnki.zjsy.2018.05.031.
- [15] Li Leixi. Several problems that should be paid attention to in foggy navigation along the coast of China [J]. *Marine Technology*, 2012 (02): 20–21.