has since changed dramatically that corporate social responsibility is now no longer just lip service. Compliance with the law and regulations is of course a given, and even if not legally punishable, companies with poor awareness of compliance, environment and safety can be seen by public opinion as "below investment grade" which may seriously damage the business' reputation and ability to operate. In fact, this has actually happened in the past. And since the measures established by risk assessment are costly, they are operated based on the concept of "visualisation: a numerical understanding" of cost-effectiveness through an index of frequency of occurrence.

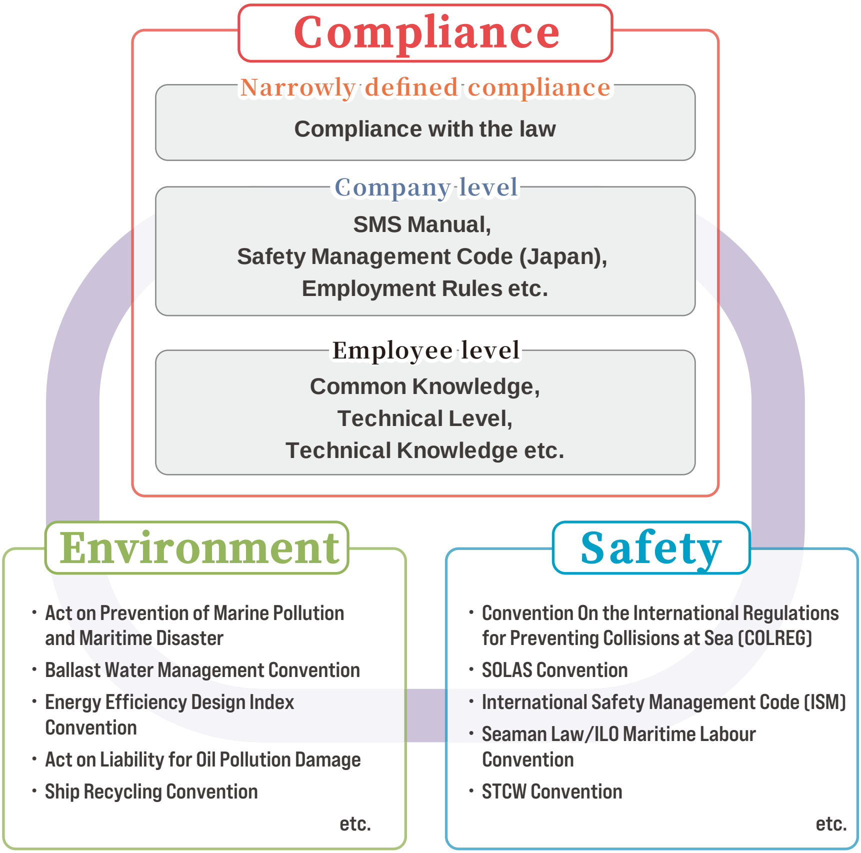


Fig. 23　Compliance in a broad sense

On the other hand, a ship is required to "operate with 100% safety". This means that safety measures must be implemented regardless of the frequency or severity of incident occurrence. In other words, neglecting a risk that is close to zero in frequency on the vessel would be unthinkable. There was no idea that the crew, as technicians, would be expected to accept the aforementioned "risk prioritisation" and "ALARP region" requirement.

Based on this awareness and concept, the results of the risk assessment practised on the vessel are reported to the ship management company. However, if the managing departments (managers) are instructed to "take no positive action despite the high severity of the index due to the cost involved" and feed this back to the ship, those on board may find this difficult to accept, which may result in a loss of trust between ship and shore.

In particular, when people in higher positions (such as the management layer of a management company or the Master of a ship) are two-faced, it only causes confusion among their subordinates. As a result, on board the vessel as a workplace, they will only follow instructions from the company and will not "question" a decision.

This may be one of the reasons why risk assessments are not so familiar on board a ship, owing to the difficultyofincorporatingriskassessments.

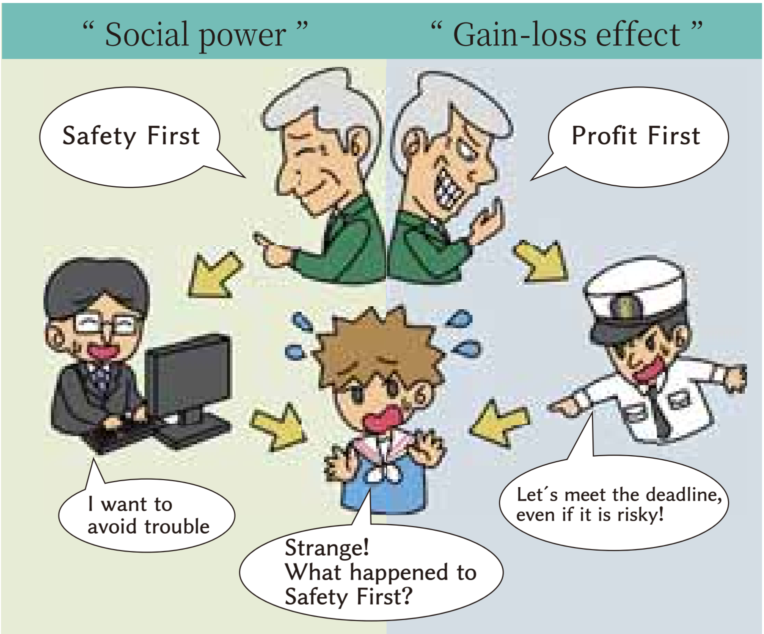


Fig. 24　Gain-loss effect and Social power

3-5-2　Inability to utilize psychological factors effectively

There are psychological factors that prevent risk assessment from being utilized effectively. This can make risk communication difficult, which in turn makes risk assessment difficult to practice. There are two main psychological factors here.

Fig. 25　Factors that make Risk communication difficult

Perception gap for risks

There is a gap between “actual risk” and “perceived risk”.

■ Hazard perceived to be greater than the actual risk

This is amplified when faced with unknown risks, little information, or hazards that we do not understand well or have no control over.

■ Hazards perceived to be smaller than the actual risk

We have a tendency to believe that it is smaller because of the clear convenient or beneficial factors, when we attempt to play the hazard down by ourselves. This is where “ Normalcy Bias ” (“ I'm special, nothing can hurt me!) or Confirmation Bias ” (“ Stop exaggerating! ”) come to the fore.

Assumptions about safety

If, in the 12 Human characteristics that we all have, “ ⑨ Human beings sometimes make assumptions” comes to the fore, and Normalcy Bias (this is when people believe, “I'm special, nothing can hurt me”) is triggered making us assume that this is correct, it will be more difficult for us to change this way of thinking.

For example, when on board, are not the following assumed?

- ☐ To begin with ships are built to be safe.
- ☐ In the periodic maintenance of the equipment in the engine room, it is not yet time for open maintenance, because it is within the manufacturer's recommended operating time.
- ☐ We pass this sea area all the time and there are not many fishing vessels today, so it will be safe to leave the bridge watch shift to the duty officer only.
- ☐ This is what we have been doing all along, and we've never had any problems before, so there's no risk involved. We really do not need to practice a risk assessment of anything.

And so on...

Crew members also feel a sense of reprisal when they are instructed to do these duties by management at the shore office such as shipowners and ship management companies, because they feel that they are intruding on the pride of the technicians (feelings like: “Do you know how long I have been on board?”). And then, psychological factors such as Psychological Reactance (self-efficacy: “This is when people do not wish to do something that is not of their own volition.”) triggers, which can bring the opposite effect.

3-5-3 The blurring line between safety and danger

As explained in 3-5-1, unlike the manufacturing industry on land, the environment on board a vessel does not have the concept of risk prioritisation or ALARP regions. In addition, the concept of risk did not exist in the Japanese language, but when the method of risk assessment was introduced here, it could be said that the crew felt uneasy about the middle ground between danger and safety (Fig. 26).

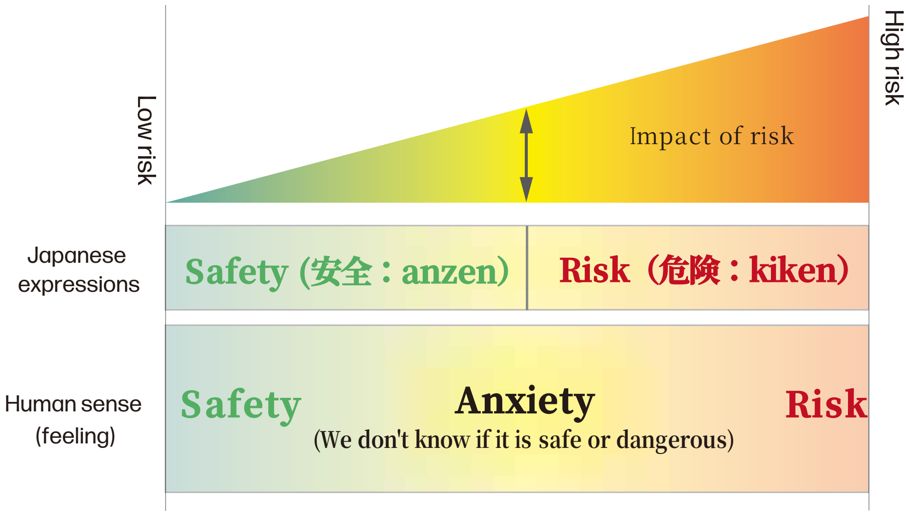


Fig. 26 The blurring line between safety and danger

It is easy for crew or a technician to distinguish the difference between risks that are, by anyone's reckoning, "major and unacceptable", and risks that are "minor and generally acceptable". However, if we do not properly use risk communication for the risks that lie in between, and fail to connect safety which is supported by the science, physics, technology and engineers that we have developed, with the sense of security which is supported by trust that is built on top of it, the result will be the very opposite of security. This may be one of the reasons why risk assessment has not been successfully implemented on board.

This is especially true in the case of vessel operations, where the severity of the risk may be minor, but if it leads to absence from work, it can have a direct impact on other vessel operations as replacements cannot be arranged immediately. In addition, when shipowners, ship management companies and other shore based management departments suggest an "interim response: ALARP", the common nature of technicians (see Loss Prevention Bulletin Vol.50 for more details) means that they have no choice but to follow the instructions, despite their opposition, which may make them even more anxious.

3-5-4 An absence of human resource development to identify risks

It has only been around a decade since risk assessment was introduced to the maritime industry, this is partly due to a lack of familiarity with the concept of risk assessment on board ships and in the land management department, and partly due to a lack of trained personnel to lead risk assessments. It is quite common in the manufacturing industry on land, and various training courses are offered, so it is a good idea to participate in them for our human resource development.

§ 4 How to Handle Risk Assessment

4-1 Fundamental countermeasures

4-1-1 On the vessel

The purpose of risk assessment is to prevent any accidents occurring by communicating and sharing information about risks such as blind spots, secrets and unknown areas among crew members, or between the vessel and management at the shore office such as the shipowner and ship management company, in the event of carrying out various risky operations.

It is therefore important that the briefing includes all of those involved in the operation and that the results be announced to the crew and shore management, rather than it being carried out by the Master/Chief Engineer or Chief Officer/First Engineer only at a desk.

In order for risk assessments to be effective, the following must be taken into account:

- ▷ The vessel must also be cost conscious. Please note that our top priorities are " safe operations " and " safety first ".
- ▷ What is important in risk assessment is to clarify 5W1H plus 2F1H (For what, For whom and How much (cost conscious) before starting any work, and to study countermeasures by identifying " what risks " are involved on board from an " objective and bird's eye view " and to consider countermeasures. In particular, it is strictly forbidden to deliberately underestimate the " assessment of severity " .
- ▷ The Master/Chief Engineer or Chief Officer/First Engineer should also carefully consider and quantify the " Frequency " to determine the risk level.

In particular, measures to further reduce the risk level must be considered for those judged to have a medium, high or very high risk level.

- ▷ Report to the person in charge of the company once the pre-operational risk assessment of the vessel has been completed. In this case, for those with a medium, high or very high level of risk, further explanation will need to be provided as to "why the level of risk could not be reduced to low or very low and the kind of work necessary" when planning countermeasures.

4-1-2 Management at the shore office : shipowner and ship management company

Once the results of the pre-operational risk assessment of the vessel have been received, the ship's superintendent should not carry out the assessment by him or herself as a management representative, but should ensure that the contents of the report from the vessel are reviewed by several parties, including the risk manager. Management at the shore office such as the shipowner and ship management company should note the following points when assessing the report from the vessel.

- ▷ For those with a medium risk level (region of uncertainty) or low risk level (region of safety), the content should be examined and additional advice given as necessary.
- ▷ For "high/very high" risk levels reported as hazardous areas, measures should be considered with a view to on shore support.
- ▷ The results of the evaluation and feasibility of the work determined by the land management department must be fed back to the vessel prior to the planned start of operation. This must always include the following information. Without such an explanation, trust between ship and shore will erode.
    - Company is to decide on whether or not work can be carried out based on the results
    - Additional countermeasures to be taken by the company to reduce the level of risk
    - Clear instructions on the timing and location (port) of implementation
    - If not implemented, a reasonable reason for not doing so, is to be provided, etc.

Fig. 27 The importance of mutual trust

More importantly, if top management does not implement the countermeasures taken both on board and on land, their existence will quickly become meaningless. It is no exaggeration to say that "awareness raising" at management level is key to the continuation of risk assessment.

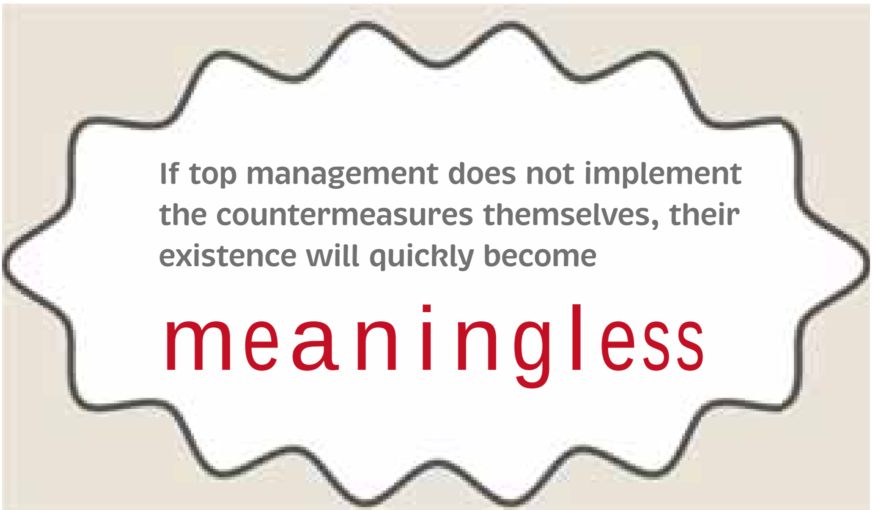


Fig. 28 Top management practice

4-2 Risk assessment in practice

4-2-1 Practice

As explained in 3-3-5 Why is risk assessment not effectively utilized on a vessel and/ or by ship management companies? "=Problem areas=", we understand that risk assessment is an effective accident prevention measure, but know also that it is not yet at a practical level to be easily carried out. However, there is no need to dwell on this too much, because it will be incorporated more easily if we think of it as simply making something that has been done implicitly on board the ship "visible" by using a risk assessment table.

Unlike land-based industries, including manufacturing, where crews change every few months and are far removed from management, a risk assessment can increase the level of safety.

- In particular, before carrying out any unusual (unfamiliar) work (e.g. tank inspections, open maintenance or repair of critical equipment, work on board while in dock)
- For routine tasks such as weighing the anchor, entering or leaving port, etc. when the crew changes

4-2-2 Functional sustainability

In order for risk assessment to be functional, it is necessary to have a predetermined system of organisation and review procedures. It is therefore essential to regularly review and improve the organisational systems that enable risk assessment to take place.

The key elements of a risk assessment are:

- Creating a risk assessment system
- By enabling the organisation to be capable of utilizing risk assessment effectively

- Specific rules are needed such as " At what stage, who by, and when is it to be conducted? " and " How will the results be utilized? "
- Regular risk assessment reviews are also important (To be aware of the need to respond in a timely manner to changes in society's tolerance levels)
- Practise as early in the process as possible (phases of design and planning)
- Risk assessments should be repeated for " designs with changing tasks or objectives " and for " new or revised critical processes that have been planned "
- Practise from a variety of perspectives, including with multiple personnel members
- Consider all processes in the operation procedure
- Information should be collected at the earliest opportunity in order to evaluate, review and take action
- The results of the review should be stored in a database and used when planning subsequent new work or work that needs to be redone
- Human resource development to identify risks
- Continue to gather, review, evaluate data and consider public information in the search for the best solution after the work has been carried out

4-3 Risk assessment procedures

4-3-1 From the perspective of frequency, likelihood (probability) and severity

As we have seen in detail in Chapter 3, if we now summarise the processes leading to personal injury and trouble in terms of "frequency, likelihood and severity", we can see the relevance, as shown in Figure 29.

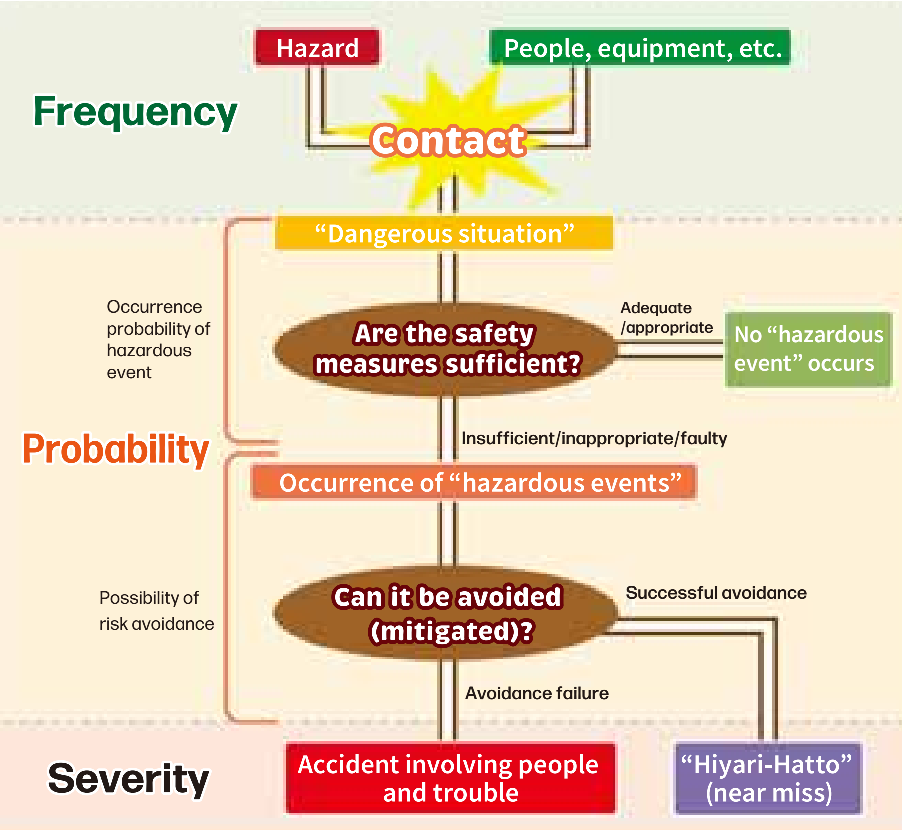


Fig. 29 Process leading to personal injury or trouble and its relationship with frequency / probability / severity

Identify the frequency of dangerous situations, examine the occurrence probability of hazardous event avoidance, and assess the severity of personal injury and trouble if risk avoidance fails.

4-3-2 Procedure (Example) (Fig. 30 and 31 Attachments 4 and 5)

Pre-work assessment table (Fig. 30) and Risk assessment table (Fig. 31) are to be used here.

On the Vessel

A risk assessment meeting is to be held with the related crew members regarding the work to be carried out.

- Identify possible risks and hazards where possible and determine the level of risk using the Pre-work assessment table.
- For each of the risks identified, measures are considered and changes in the risk level are assessed.
- This is then compiled and reported to the management department responsible such as the shipowner or ship management company on shore.

Management at the shore office : shipowner and ship management company

A risk assessment meeting is to be held with the relevant parties.

- For each risk listed in the Pre-work assessment table submitted by the vessel, it is to be assessed by the managing shore office.
- In addition, the results are transferred to a risk assessment table and a decision is taken on whether to carry out medium or high level risk work, which is then fed back to the vessel.

Attachment 4

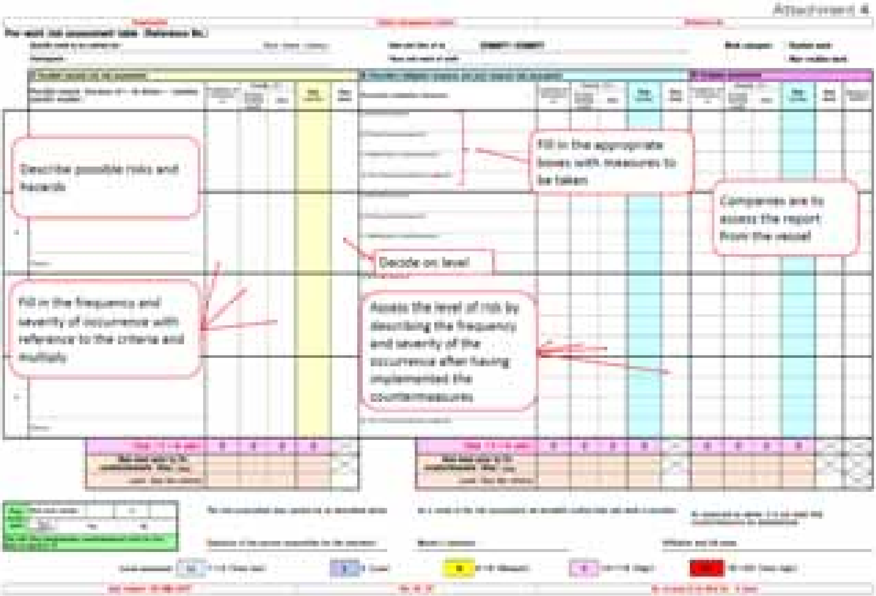


Fig. 30 How to fill in the Pre-work risk assessment table

Attachment 5

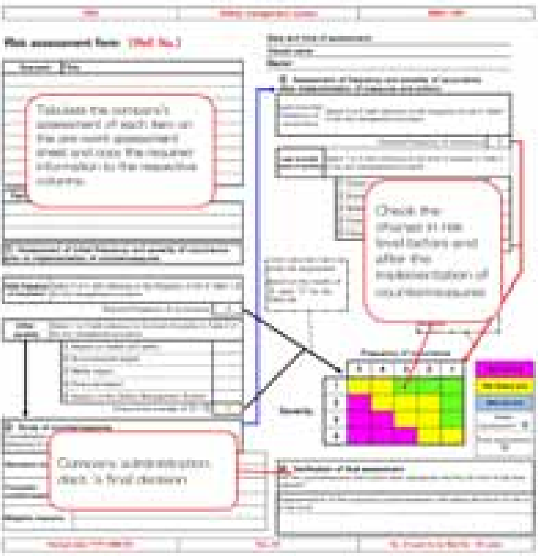


Fig. 31 Risk assessment table by management department on land

4-3-3 Risk assessment example = rough weather preparation =

As an example, the risk assessment will cover the Deck department, the Engine department and the Office assuming rough weather preparation for a typhoon forecast from dawn the next day. Please refer to Attachments 6 to 14 for the Pre-work assessment tables of each department.

① Deck (Figs. 32, 33, 34, and 35 Attachments 6, 7 and 8)

A total of eight risks were identified on the vessel and the results are summarised as below.

・Mean value in Frequency of occurrence	: 3
・Mean value in Severity (Personal injury)	: 4
・Mean value in Severity (Non-personal injury)	: 4
・Risk level (Applied both Personal injury and Non-personal injury)	: 12 **(H)**

For the risks identified above, the following countermeasures were established. The risk level is the product of frequency of occurrence and severity.

・Mean value in Frequency of occurrence	: 3
・Mean value in Severity (Personal injury)	: 2
・Mean value in Severity (Non-personal injury)	: 1
・Risk level (Personal injury)	: 6 **(M)**
・Risk level (Personal injury)	: 3 **(L)**

By preparing for rough weather on the deck, Accidents involving people has dropped from (H) to (M) and Non-personal injury from (H) to (L). Accordingly, in this example, the higher overall risk level of 6 (M) for personal injury has been adopted.

Fig. 32　Pre-work risk assessment table : Deck　Attachment 7

In the example, eight risks have been identified, and we will now compare two of them with a significantly lower risk level.

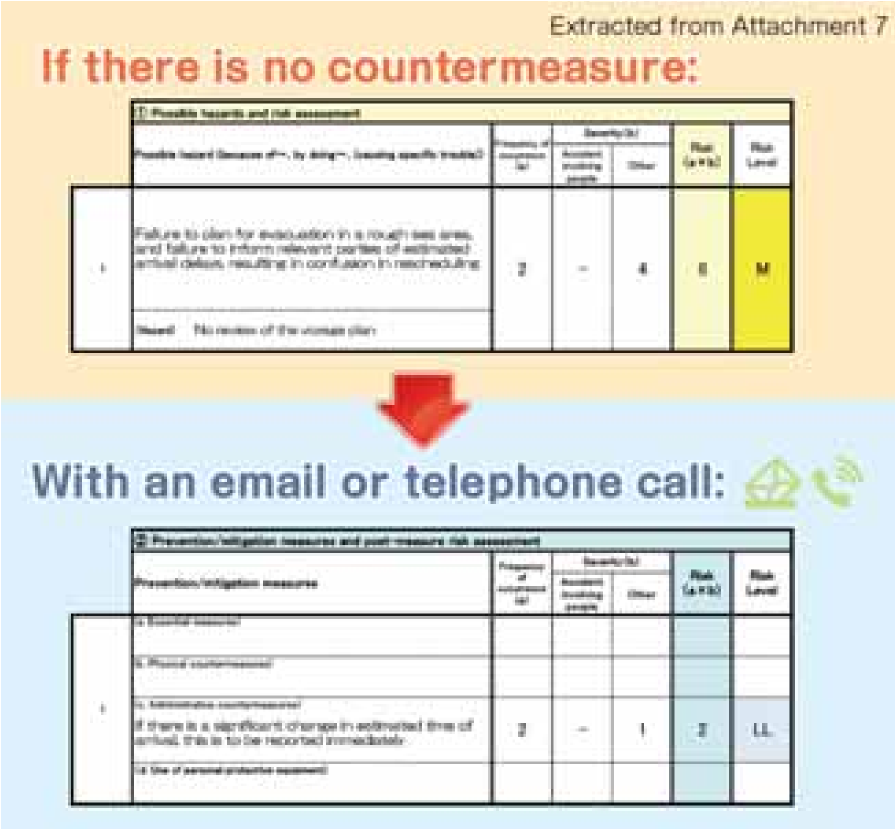


Fig. 33 Risk assessment regarding countermeasures for rough weather on Deck (Example 1)

Failure to plan for evacuation in a rough sea area, when the vessel actually enters a rough sea area, causing a significant delay to the estimated time of arrival (ETA), or where the vessel has made an evacuation plan but has not informed the related parties such as charterers etc. of the revised ETA, its failure to share information can cause confusion on shore, because it is assumed that the vessel will arrive as originally scheduled, and arrangements are made for entering port and cargo handling.

This may result in Off Hire Cases. If this were left as it is, the ship would need to be contacted, so this is rated under Frequency as “2: infrequent”, and Severity as “4” as it would interfere with the ship's operations. Multiplied by this, the risk level becomes 8:M. If this is communicated by email or phone call, the shore side will know what is going on and will be able to plan countermeasures in advance. This has been assessed as a reduction in severity to "2" with a risk level of 2 : LL. It shows the importance of communication between ship and shore.

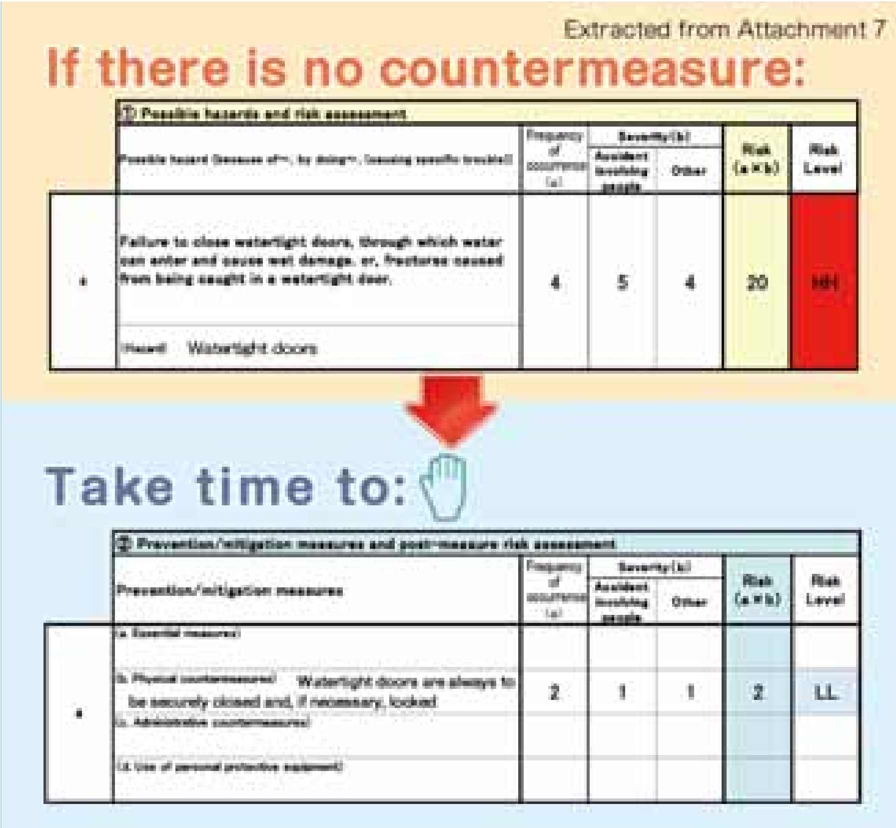


Fig. 34 Risk assessment regarding countermeasures for rough weather on Deck (Example 2)

Also, if the watertight doors at the entrance to the accommodation area are not closed (or they have not been checked), there is a possibility that water will enter through them. It is also possible that a person could get caught in a door and break a bone in the rush to close it in rough weather.

By identifying these risks, it is possible to avoid inadvertent memory lapse (errors in the memory process) by appointing (specifying) who is responsible for closing watertight doors (e.g. Boatswain (Bsn)) and having them report back explicitly when the work is completed.

Therefore, the risk level is assessed as 20：HH because of the potential for serious injury if left unattended. However, the risk level can be reduced to 2：LL by ensuring that the watertight doors are closed and reported, and that a supervisor, such as a Master or Chief Officer (C/O), visually inspects the site.

The closing work of watertight doors is one of the countermeasures for rough weather that we take for granted, but by practising a risk assessment and sharing the information with the crew, we can ensure that we don't carelessly forget to do it.

The vessel's pre-work risk assessment table is reported to the ship management company's responsible department, which reviews the ship's report and re-evaluates it each item. The results are then posted on the risk assessment table (Fig. 35) and fed back to the vessel with a decision on whether or not to proceed. In this example, the risk level has been reduced from HH to M, and although it is in the ALARP region, it has been determined a tolerable area.

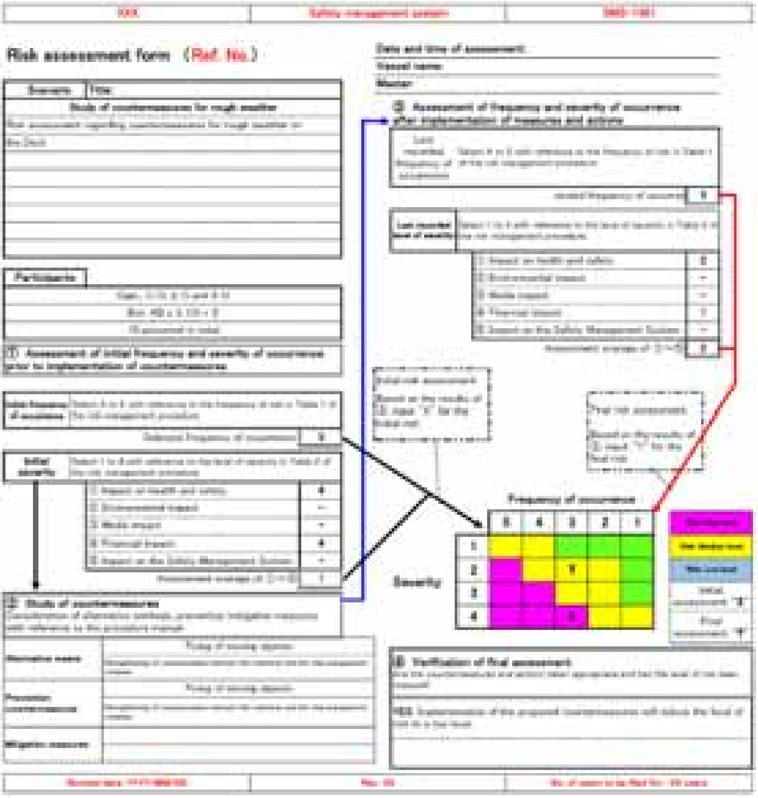


Fig. 35　Risk assessment regarding countermeasures for rough weather on Deck

② Engine department (Figs. 36, 37, 38 and 39　Attachments 9, 10 and 11)

As with the Deck, a total of 8 risks were identified and the change in risk level between before and after measures are implemented is shown below. The severity of Personal injury has reduced from 12(H) to zero and Non-personal injury severity has reduced from 12(H) to 6(M).

		Before measures are implemented		After measures are implemented
・Mean value in Frequency of occurrence	:	3	➡	3
・Mean value in Severity (Personal injury)	:	4		-
・Mean value in Severity (Non-personal injury)	:	4		2
・Risk level (Personal injury)	:	12 (H)		-
・Risk level (Personal injury)	:	12 (H)		6 (M)

Attachment 10

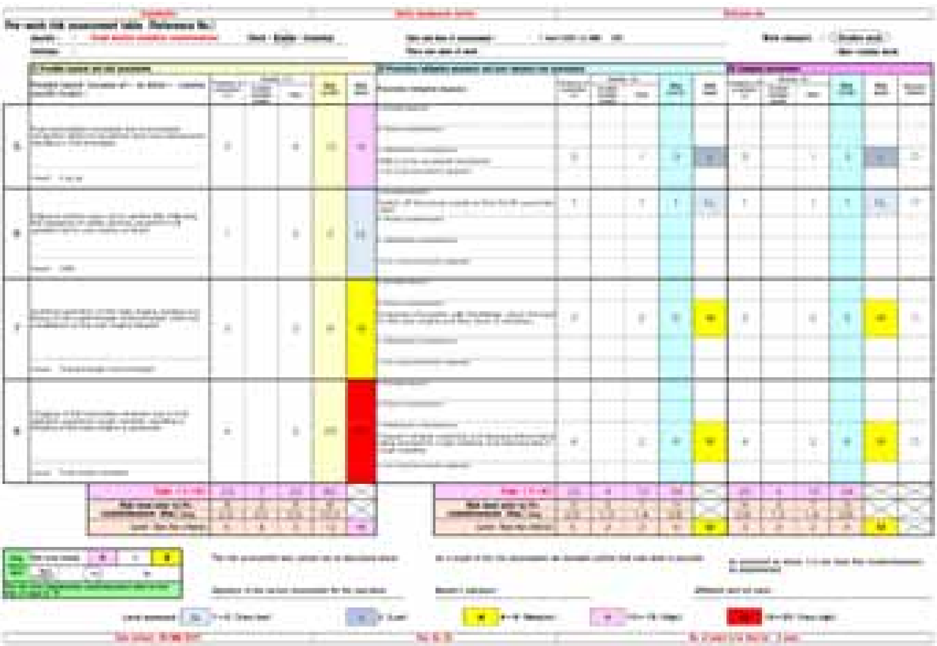


Fig. 36　Risk assessment regarding countermeasures for rough weather effect on Engine Attachment 10

As with the Deck, two items are extracted from the eight risks and compared.

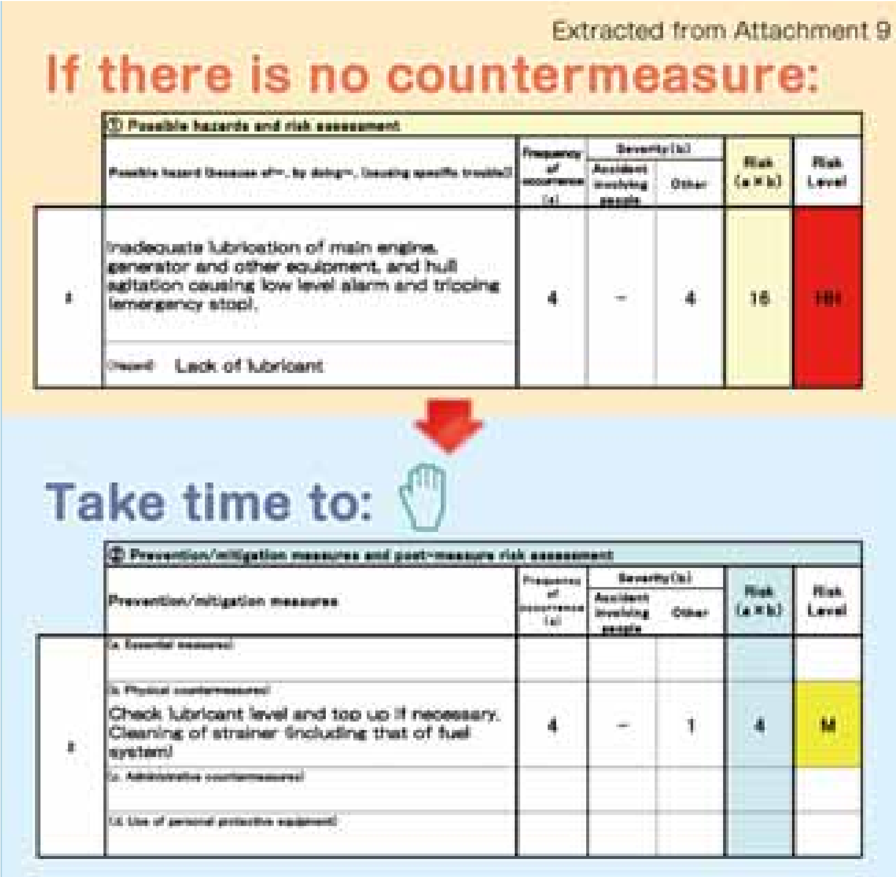


Fig. 37　Risk assessment regarding countermeasures for rough weather effect on Engine (Example 1)

Fig. 38　Risk assessment regarding countermeasures for rough weather effect on Engine (Example 2)

According to accident investigations by the Transport Safety Board, for example, cases of low lubricant levels being detected due to insufficient lubricant caused by hull movement in rough weather, or main engine tripping due to a clogged strainer, leading to accidents, have been reported. (See Loss Prevention Bulletin Vol.49 “Tips for Effective Engine Management and Maintenance”)

In engineering departments on most vessels, these countermeasures are a normal part of an engineer’s work when rough weather is expected. However, when a change in risk level is assessed numerically by risk assessment, the importance of the operation becomes all the more apparent.

The company also receives the risk assessment reports from the Engineering Department. After re-evaluating them, they approve the implementation of all countermeasures and feed them back to the vessel (Figure 39).

Also in this example, the risk level has been reduced from HH to M, and although it is in the ALARP region, it has been determined a tolerable area.

Attachment 11

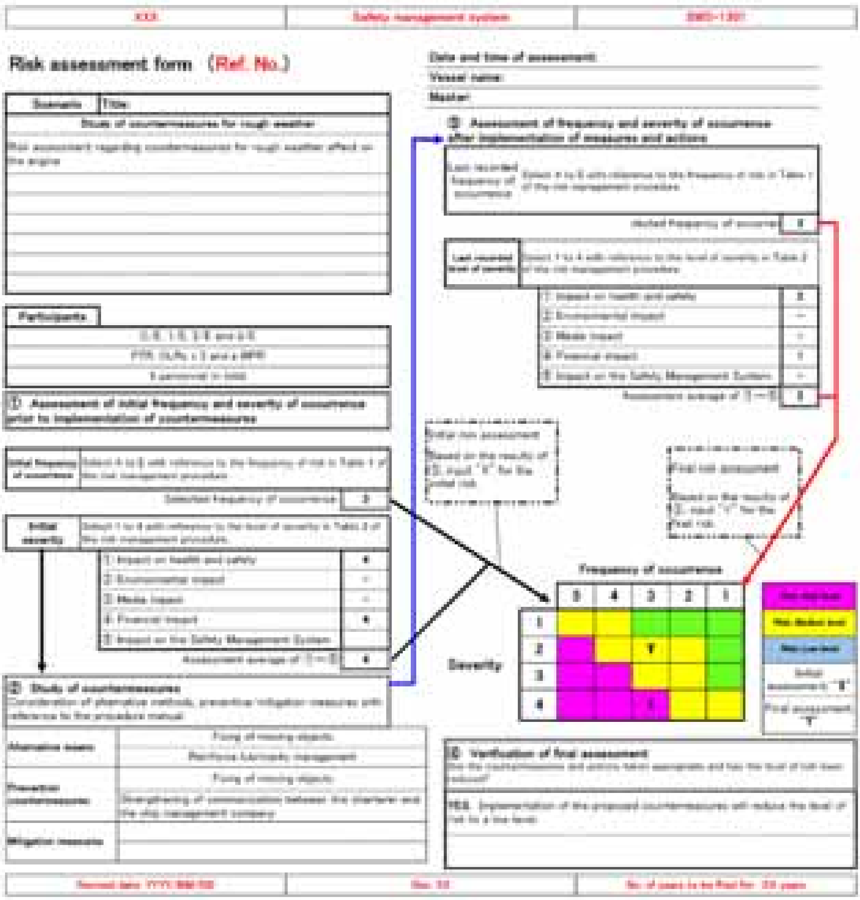


Fig. 39 Risk assessment regarding countermeasures for rough weather effect on Engine Risk assessment table (Attachment 11)

③ Office (Figs. 40, 41, 42 and 43 Attachments 12, 13 and 14)

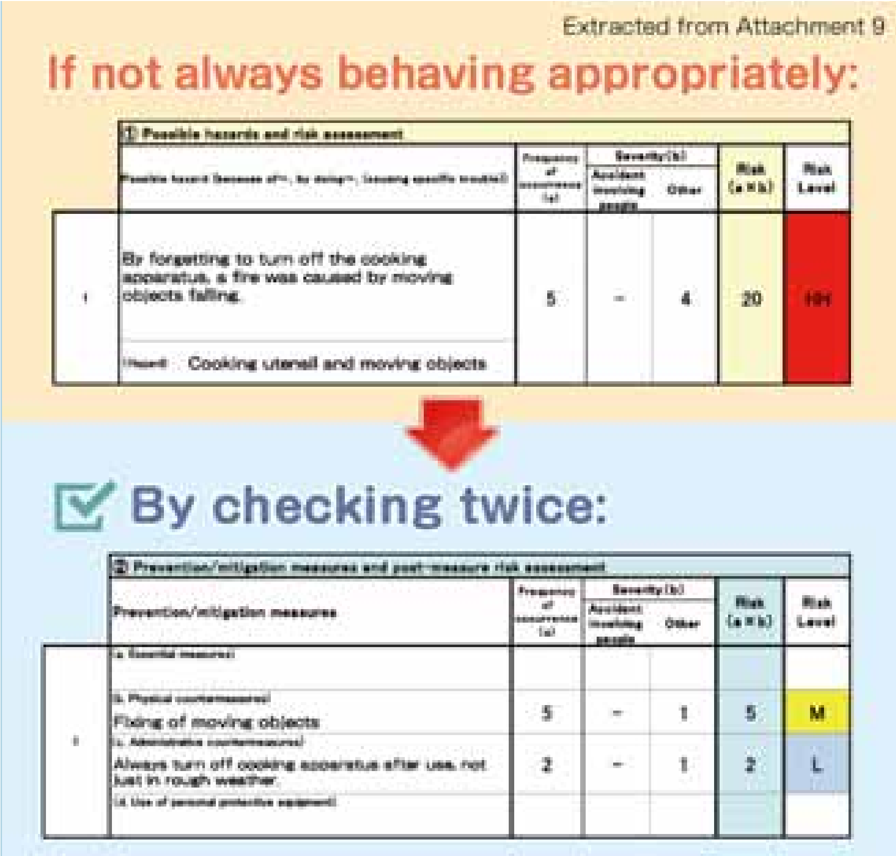
A total of seven risks were identified. The change in risk level between before and after measures are implemented is shown below. The severity of Personal injury has reduced from 15(H) to 4(M) and Non-personal injury severity has reduced from 15(H) to 4(M).

		Before measures are implemented		After measures are implemented
・Mean value in Frequency of occurrence	:	5	➡	4
・Mean value in Severity (Personal injury)	:	3		1
・Mean value in Severity (Non-personal injury)	:	3		1
・Risk level (Personal injury)	:	15(H)		4(M)
・Risk level (Personal injury)	:	15(H)		4(M)

Attachment 13

Fig. 40 Risk assessment regarding countermeasures for rough weather: Office (Attachment 13)

Now we compare the top two with a significant reduction in risk level out of the seven risks, as well as with Deck and Engine.



① Possible hazards and risk assessment

	Possible hazard (because of~, by doing~, (causing specific trouble))	Frequency of occurrence (a)	Severity (b) Accident involving people	Severity (b) Other	Risk (a × b)	Risk Level
1	By forgetting to turn off the cooking apparatus, a fire was caused by moving objects falling. [Hazard] Cooking utensil and moving objects	5	–	4	20	HH

② Prevention/mitigation measures and post-measure risk assessment

	Prevention/mitigation measures	Frequency of occurrence (a)	Severity (b) Accident involving people	Severity (b) Other	Risk (a × b)	Risk Level
1	[a. Essential measures]					
	[b. Physical countermeasures] Fixing of moving objects	5	–	1	5	M
	[c. Administrative countermeasures] Always turn off cooking apparatus after use, not just in rough weather	2	–	1	2	L
	[d. Use of personal protective equipment]					

Fig. 41 Risk assessment regarding countermeasures for rough weather: Office (Example 1)

Extracted from Attachment 12

If not always behaving appropriately:

① Possible hazards and risk assessment						
	Possible hazard (because of~, by doing~, causing specific trouble)	Frequency of occurrence (a)	Severity (b)		Risk (a × b)	Risk Level
			Accident involving people	Other		
1	Doors of lockers installed in common areas (e.g. mess room) in the accommodation space are left ajar, causing the door to open by hull agitation, pinching fingers and causing injury. (Hazard) Doors	4	4	-	16	[illegible]

By checking twice:

② Prevention/mitigation measures and post-measure risk assessment						
	Prevention/mitigation measures	Frequency of occurrence (a)	Severity (b)		Risk (a × b)	Risk Level
			Accident involving people	Other		
1	(a. Essential measures)					
	(b. Physical countermeasures)					
	(c. Administrative countermeasures) Locker doors are to be closed, not just in rough weather. Doors that are left open, such as in the mess room, are to always have a door stop applied and are to be lashed.	4	1	-	4	M
	(d. Use of personal protective equipment)					

Fig. 42 Risk assessment regarding countermeasures for rough weather: Office (Example 2)

On several occasions during my night round on board, I discovered that someone was forgetting to turn off the stove in the galley, although the temperature was not set very high. In addition, the doors in the mess room are left open on many vessels, however, often the stoppers are removed and the automatic door closers are not adjusted properly. As a result, doors open and close with hull movement, which the author has experienced on many occasions. Injuries can happen when we least expect them, such as when we pinch our fingers.

In addition to rough weather, it is also important to make it a habit to switch off the stove in the galley at the end of each work session, and to check this with at least two other people in the Office without fail. Also, it is important to make sure that doors in mess rooms are always closed on a regular basis, as this can be a problem for fire safety if they are kept open. If there are a large number of crew passing through during the daytime, and there are always crew in the adjacent galley, and the door is left open because there is no risk of fire, it is recommended that a rope be used to lash it as well as a door stopper.

This is something that we usually do on board without thinking about it, but if we make it a point to carry out a risk assessment like this and recognise the seriousness of the risk, the safety level will be increased.

Upon receipt of the risk assessment report in the Office, the company will carry out its own assessment, as will the Deck and Engine departments, and provide feedback to the vessel, including a decision on whether or not work can be carried out.

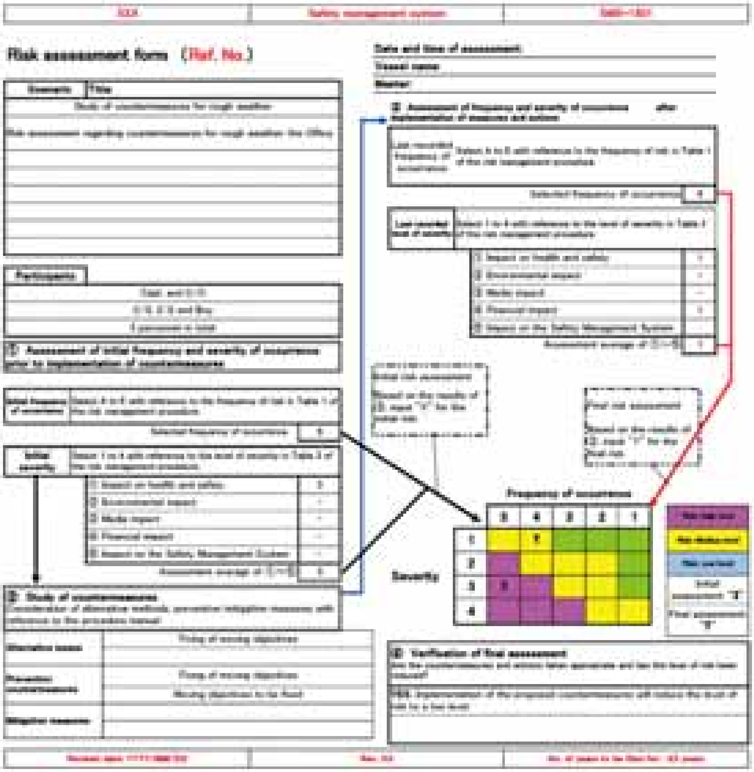


Fig. 43 Risk assessment regarding countermeasures for rough weather in the Office Risk assessment table (See Attachment 14)

4-4 How to handle risk assessment: summary

As we discussed countermeasures for rough weather as examples in the previous section, on the vessel, in particular, in the event of carrying out any unusual (unfamiliar) work, it is important that a risk assessment be carried out and that information is shared with all relevant crew members. Because even experienced crew may inadvertently forget or be unaware (error when inputting).

In addition, unlike the manufacturing industry on land, it is difficult for the management at the office or the safety department to visit the site to control the work, so most of the work itself must often be carried out under the supervision of a Master/Chief Engineer or Chief Officer/First Engineer.
This means that Essential measures and physical improvement measures are rarely taken. These countermeasures tend to be focused on administrative countermeasures which were established or developed on board and the use of protective wear which are designed to prevent trouble occurring.　For the crew, who are a group of highly skilled and professional technicians, it is important to remember that this is where the pitfalls lie.

In addition, the risk assessment should not just be filed away in a document, but should also be used in conjunction with BTM/ETM to increase the effectiveness of the work.

As mentioned above, risk assessments have been introduced mainly from a business management perspective in the manufacturing industry on land, which means that crew members who are used to working on board may find them too time-consuming or too obvious. This is why it has become less effective. However, as explained in the examples, if we visualise our everyday work in this way, we may find that we see things in a different light, so the author hopes readers will take this opportunity to feel free to use it. Figure 44 summarises this.

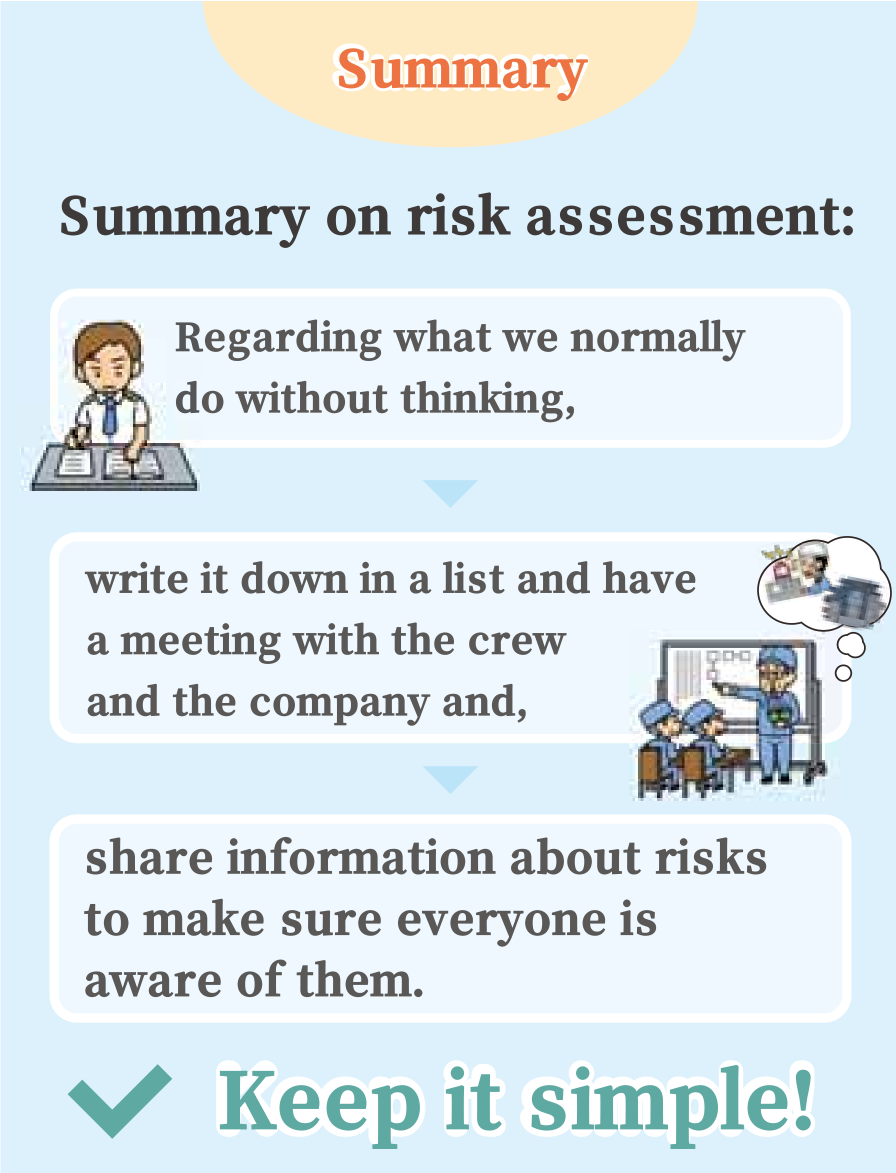


Fig. 44　Risk Assessment in practice: summary

§5 Case Study
Analysis of an Accident

Let us take the Japan Transport Safety Board Report (less sever (keibi) 2019-5) and the decision of the Marine Accident Tribunal (Local Marine Accidents Inquiry Agency in Kobe issued No.11 in 2019), together with a 4M4(5)E analysis and risk assessment to analyse the cause of the accident.

5-1 Date and time of occurrence and vessel particulars

Photograph 45 Vessel A

Date and time of occurrence
: On a certain day in November 2018, at approximately 12:09 (JST)

Vessel specifications
: Container Vessel A(748 GT) Single-engine, single-shaft stern hull bridge type coal ash and calcium carbonate carrier equipped with bow thrusters and a VecTwin system control unit (hereinafter referred to as "VecTwin system")

L × B × D : 79.26m x 14.00m x 8.15m

Draft : Bow 2.70m Stern 3.68m

Point accident occurs : Hanshin Port Kobe No. 2 port during entry work
Crew arrangement : Master, with third grade maritime officer (Navigation) and 7 other crew members in total
Manning system at time of accident

Bridge	: Master (Single-handed navigation)		
Chief Engineer	: Engine control	Bows	: C/O + 2 crew members
Astern	: 2/E + 1 crew member	Eng/Room	: First Engineer (1/E)

Weather and sea conditions when the accident occurred
: Fine, east-southeasterly wind Wind force of 2

Vessel movement

On a certain day in November, 2018, the vessel in question set sail at 14:10 from Kanda Port in Fukuoka Prefecture. At 10:40 the following day, she anchored in an offshore area South East of Kobe Airport in Hyogo Prefecture in order to await berthing time. Shortly after, the vessel then set sail for her scheduled 11:30 arrival at the KS1 berth in Kobe Port (now part of Hanshin Port) on her port side.

Rudder type: VecTwin Rudder (extracted from the homepage of Japan Hamworth & Co., Ltd.)

The VecTwin Rudder system consists of a pair of Schilling Rudders positioned aft to the starboard and port side of a single, fixed pitch propeller. With the propeller fixed in forward rotation, the ability to adjust these rudders to a variety of different angles provides for greater manoeuvrability (Figure 46).
The vessel is manoeuvred by means of a joystick which is used to adjust rudder angle, and control propeller wake whilst allowing the generation of thrust in all directions.
Since the VecTwin Rudders are positioned so that they surround any propeller wake, fluctuations in thrust due to the effect of waves are reduced and greater course stability is afforded. This means that there is less reduction of vessel speed or loss of horsepower due to changes in marine weather conditions. The system has gained a reputation for safety because of its ability to reduce yawing in following seas. It also brings about significant economic benefits since the processes of entering and leaving ports, and birthing and departure have been speeded up, leading to a consequent reduction in the mental and physical fatigue of the crew.

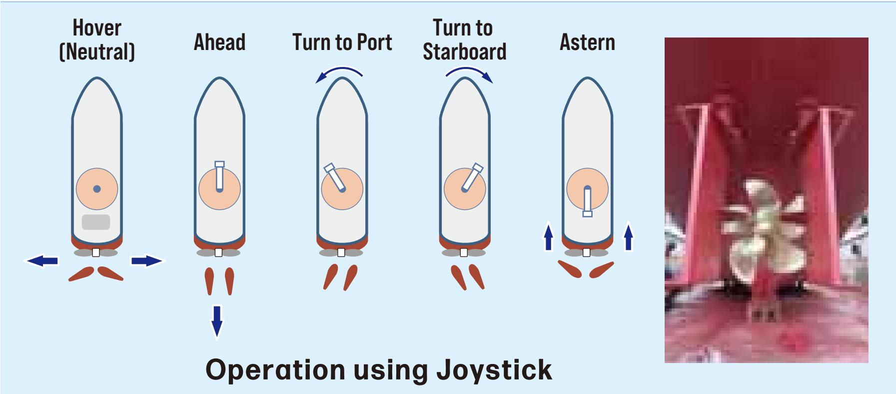
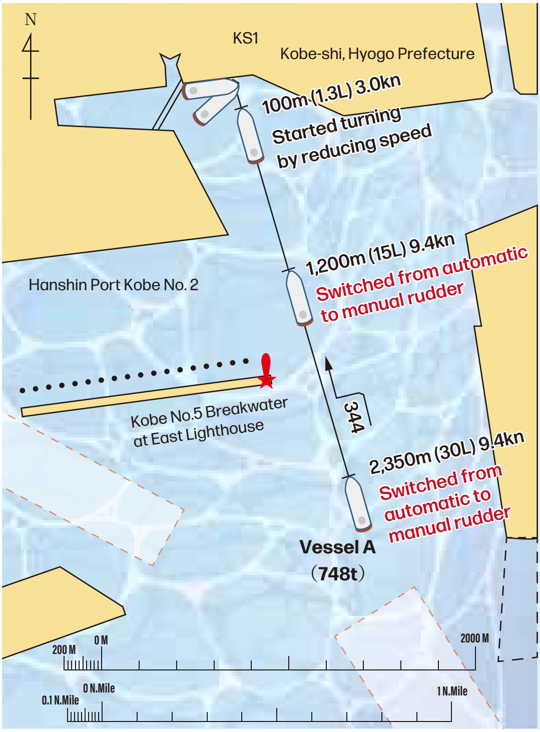


Fig. 46　VecTwin Rudder

Standard docking procedures



- After passing breakwater No.5 (approximately 1,200m from the quay), the VecTwin system manual control is switched to remote before making a final approach whilst also reducing speed.

- At a slow speed ahead and approximately 100m from the quay, the 2 rudders should be closed (put into neutral) by pulling back on the joystick.

- At approximately 80m from the quay, the joystick is pulled back further and with the propeller set in forward rotation, the vessel is brought to a halt. Docking then takes place with the use of the bow thrusters.

Fig. 47 Standard docking procedures

Fig. 48　Remote operation unit

Rudder control switch

Moving in a clockwise direction, the rudder control switch has 4 settings: Automatic, Manual, Non-follow up, and Remote Control. The joystick can be operated when this switch is in the remote-control mode.

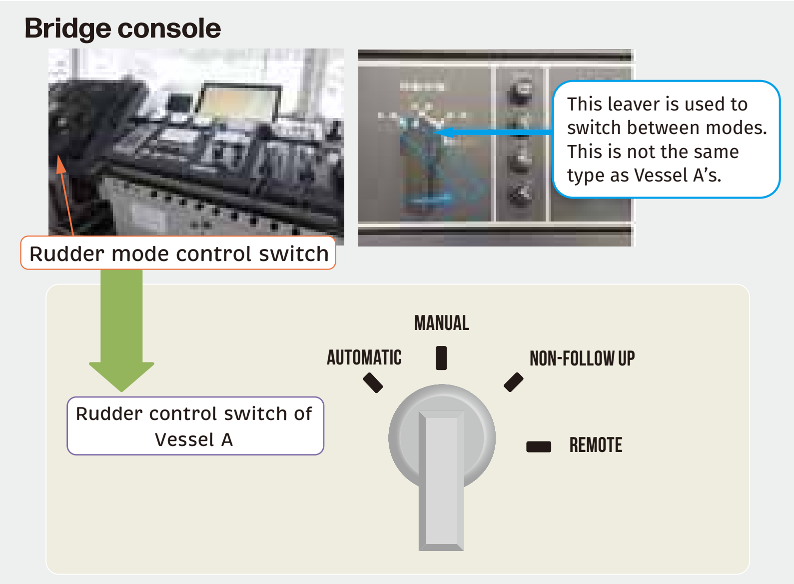


Fig. 49　Steering operation settings　Rudder control switch

In the event of turning the switch to remote mode, if the rudder switch on the control stand is not set to "Remote Control", the VecTwin Rudder will not move when trying to operate the joystick.

5-2　Timeline of events leading up to the accident

Let us take a closer look at the timeline of events leading up to the accident. For a full list, please see Attachment 15. All crew members were already engaged in the S/B (stand-by) operation for the entering of port to dock; the crew arrangement at the time was as follows.

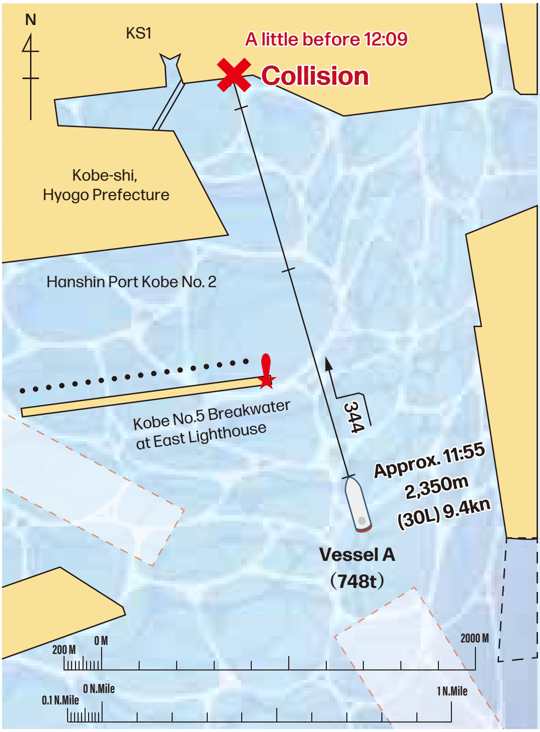
Bridge：	Master (Single-handed navigation) Chief Engineer (Engine status monitoring and engine room control at engine console)	2 personnel in total
Bows：	C/O, Bsn and OS	3 personnel in total
Astern：	3/O and 2/E	2 personnel in total
Eng.Room：	1/E	1 personnel in total

Vessel A Quay collision accident Accident timeline

CREW ARRANGEMENT	STANDARD DOCKING PROCEDURES	TIME	SPEED	DISTANCE FROM THE QUAY (SHIP LENGTH RATIO)	ACTUAL ACTIONS TAKEN	WHO
Bridge Master • C/E Fore C/Off • Bsn • Sailer Aft 2/AE • 3/Off Eng. Room 1/AE	Engine in neutral position	11:55	9.4 kts	2,350 m (30 L)	At 2,350m before the quay (30L), engine half speed to neutral operation. Speed of 9.4 knots and switched from automatic to manual rudder	Master
	D.Slow Ahead Used VecTwin rudders for speed control both sternway and headway	12:00	9.0 kts	1,160 m (15 L)	The Master intended to use the joystick device to control the VecTwin Rudder system to manoeuvre the ship to the shore, and switch the rudder control to remote control. D.Slow Ahead	Master
					However, he did not realise that the rudder switch was stuck in the non-follow-up position and moved to the port side of the bridge in front of the remote control stand. He believed that it had switched to remote rudder control by only operating the one lever.	Master
		12:06	5.0 kts	317 m (4 L)	Distance to the quay was approximately four times the length of the vessel	Master
	D.Slow Ahead He made a sternway manoeuvre. Turned using bow thruster and joystick	12:08	3.1 kts	100 m (1 L)	At 100m before the quay, he thought he had tipped the joystick backwards and made a sternway manoeuvre, but in fact it was in neutral (hover).	Master
					He was too preoccupied with the distance to the quay that he did not look at the rudder angle indicator on the VecTwin rudders to notice that the rudders were heading sternway.	Master
					As the speed to fetch headway was not decreasing, he tried to make sternway by increasing engine speed (not effective as it was in neutral (hover) and anchored.	Master
		12:09	4.3 kts	0 m (0 L)	Collided with the quay at almost a right angle, maintaining a speed of 4.3 knots	Master

Table 50 Vessel A Timeline of events leading up to the accident

① 11 : 55 (approx.)



Ship speed :
9.4 knots
Distance from the quay :
2,350m (30L approx.)
L : Distance from the quay ÷ Ship length
Same as below
Engine operation :
engine between half speed and neutral position

At 2,350m before the quay (30L), engine between half speed (9.4 knots) and neutral position; switched from automatic to manual rudder.

Fig. 51 Vessel A at 11 : 55 (approx.)

First human error

This operation itself was in accordance with standard docking procedures, but the rudder angle indicator was not checked during manual operation.

Furthermore, as there was no altered angle to the quay, and no wind tide effect, although the Master moved the steering wheel somewhat, each time he thought the rudder was moving as he operated it; he did not check the rudder angle indicator.

(Human characteristics of ③ Human beings sometimes forget, ⑤ Human beings have moments of inattention and ⑩ Human beings are sometimes lazy (See Figure 59) will be applicable.)