② Forgetful, ③ Habituation behaviour, ⑤ Unconscious acts, ⑥ Sense of urgency and sensitively, ⑦ Mental shortcuts, ⑧ Cutting corners, ⑨ Judgement based on speculation, and ⑪ Habituation phenomenon.

Also, as individual skills (insufficient knowledge), ③ Lack of a sense of urgency and awareness and ④ Mistakes regarding work procedure and forgetfulness are in commonly found in human error.

3 Accident Cause Analysis (Unsafe conditions) (Fig. 49 and Attachment 18)

Attachment 18

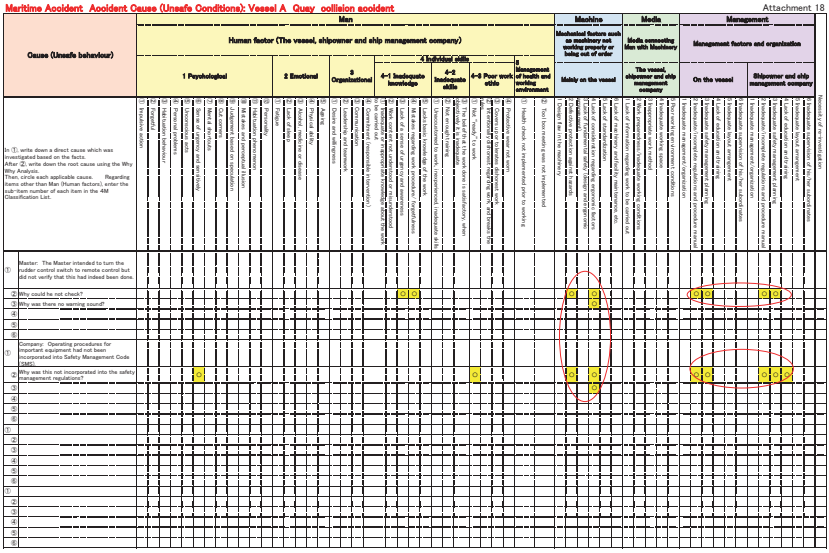


Fig. 49 Vessel A 's “Unsafe conditions” (Attachment 18)

The Unsafe conditions identified in the Summary of related facts are as follows:

The Master operates the rudder mode control switch by himself. However, considering that the safety measures for the equipment are inadequate in terms of human characteristics, ① Human beings sometimes make mistakes, ③ Human beings sometimes forget, and ⑨ Human beings sometimes make assumptions; it is considered to be unsafe (condition). Also, in terms of company management, unsafe conditions are highlighted by the lack of

procedure manuals and safety management codes. If we circle the items in Attachment 18, the following points emerge as common for both Master and company management:

- Machine (Mechanical factors such as machinery not working properly or being out of order)

  2 Defective protection against hazards and 4 Lack of consideration regarding ergonomic factors

- Management (Control factors and organization)

  On the vessel ：2 Inadequate/incomplete regulations and procedure manual and 3 Inadequate safety management planning

  Company ：2 Inadequate/incomplete regulations and procedure manual and 3 Inadequate safety management planning

4 Preventive measures for Unsafe behaviour of Master

(Fig. 50 and Attachment 19)

Attachment 19

Maritime Accident Analysis using 4M5E and Countermeasure List (Unsafe Behaviour): Vessel A Quay collision accident

Attachment 19

	Man	Machine	Media	Management	
	The vessel, shipowner and ship management company	Mainly on the vessel	The vessel, shipowner and ship management company	On the vessel	Shipowner and ship management company
Risk factors (Direct cause and indirect/root cause)	All three of the Master's unsafe behaviours have a common direct cause. ① Impulsive action(single-minded focus on the vessel speed and distance to the quay) ② Forgetful(Unable to multi task) ③ Habituation behaviour: bad habit (Human beings have moments of inattention) ⑤ Unconscious acts ⑥ Sense of urgency and sensitively ⑦ Mental shortcuts(Human beings are sometimes in a hurry) ⑧ Cuts corners: breaks the rules due to extra work all of a sudden or fatigue ⑨ Judgement based on speculation: subjective decision and wishful observation (Human beings sometimes make assumptions) ⑪ Habituation phenomenon: false success experience (Human beings have moments of inattention)	No warning for incorrect operation		Inadequate handling instructions for critical equipment	Inadequate handling instructions for critical equipment
Education Education and training Knowledge, skills, consciousness, being given information, etc.	As an experienced specialist, he is to be well aware of the importance of complying with work procedures. Therefore, he needs to be trained to recognise psychological factors.				
Engineering Technology and engineering Technological countermeasures		Adjust the device so that a lamp lights up and a warning is sounded if it is operated incorrectly Equipment is installed to assist human characteristics: Human beings sometimes make mistakes and forget			
Enforcement Thorough guidance and enforcement Standardization, proceduralization, alerting, reward and punishment KYT, campaigns etc.				Creation of manuals and procedures in each vessel	Develop written procedures, such as on-site instructions for important equipment, and incorporate them into Safety Management Code (SMS).
Examples Case studies, countermeasures and rules Lead by example, experience of success Introduce model cases, "Hiyari-Hatto" (near misses), etc.	Get involved with creating procedure manual. Also, he will become an instructor for training based on his own experience to teach other Masters and other related audiences.				The carrying out of training on recurrence prevention countermeasures
Environment Working environment, office internal management, on-board organization, etc.					

Fig. 50 Vessel A's Preventive measures for "Unsafe behaviour" (See Attachment 17)

In 2 Analysis of Accident Cause (Unsafe behaviour) (Attachment 17), we analysed the causes applicable with Man, Machine (machinery and equipment) and Management (management and organization). For each of these items, it will be a requirement that the following improvement measures be considered and carried out:

① Man

Education/training: knowledge, skills, consciousness, being given information, etc.

As an experienced Master, he is to be well aware of the importance of complying with work procedures. Therefore, an effective measure will be for him to receive training that helps him recognise psychological factors.

Example
(Case studies, countermeasures and rules : Lead by example, experience of success, introduce model cases, " Hiyari-Hatto " (near misses), etc.)

The Japan Marine Accident Tribunal judged that the Master's third grade maritime officer (Navigation) certificate be suspended for one month. However, he should be fully aware of what caused the accident and how the vessel was manoeuvred to this end. Therefore, instead of letting this experience go to waste, it would be useful for him to get involved with creating procedure manuals, and becoming an instructor for training to pass on such valuable experience to other Masters and related audiences.

② Machine (machinery and equipment)

Regarding Machine (machinery and equipment), the risk factors mentioned refer to the equipment not warning the operator (e.g. alarm sounds) when it is operated incorrectly, so the following countermeasures should be considered.

Engineering (Technology and engineering : Physical countermeasures)

As human beings sometimes make mistakes and forget, equipment is to be installed to assist such characteristics, whereby a lamp lights up and a warning is sounded in case of incorrect operation (error in the output process). After this accident, the shipowner

requested the manufacturer to modify the rudder switch on the control stand so that it sounds an electronic tone for a few seconds when it is in the remote position.

③ Management (management and organization)

The vessel and the company (shipowner) are requested to create operation manuals and operating procedure manuals, in particular on-site instructions for important equipment such as rudder control and radar. In addition, such a procedure manual should be included into the safety management code and SMS manuals.

5 Preventive measures for“ Unsafe conditions ”for Master and Company

(Fig. 58 and Attachment 20)

Similar to “ 4 Preventive measures for unsafe behaviour of Master” and preventive measures for unsafe conditions will be considered here as well.

Attachment 20

Maritime Accident Analysis using 4M5E and Countermeasure List (Unsafe conditions): Vessel A Quay collision accident — Attachment 20

	Man The vessel, shipowner and ship management company	Machine Mainly on the vessel	Media Work and environment by Media connecting Man with Machinery The vessel, shipowner and ship management company	Management	
				On the vessel	Shipowner and ship management company
Risk factors (Direct cause and indirect/root cause)		No warning for incorrect operation		Inadequate handling instructions for critical equipment	Inadequate handling instructions for critical equipment
Education Education and training Knowledge, skills, consciousness, being given information, etc.					
Engineering Technology and engineering Technological countermeasures		Adjust the device so that a lamp lights up and a warning is sounded if it is operated incorrectly. Equipment is installed to assist human characteristics: Human beings sometimes make mistakes and forget.			
Enforcement Thorough guidance and enforcement Standardization, proceduralization, alerting, reward and punishment KYT, campaigns etc.				Creation of manuals and procedures in each vessel	The carrying out of training on recurrence prevention countermeasures Develop written procedures, such as on-site instructions for important equipment, and incorporate them into Safety Management Code (SMS).
Examples Case studies, countermeasures and rules Lead by example, experience of success, Introduce model cases, “Hiyari-Hatto” (near misses), etc.					
Environment Working environment, office internal management, on-board organization, etc.					

Fig. 51 Vessel A's Preventive measures for “Unsafe conditions” (See Attachment 20)

① Machine (machinery and equipment)

Similar to Unsafe behaviour, there was no warning sound or warning light to indicate that the equipment was being operated incorrectly, so it was in an Unsafe condition. The remedy is the same as for Unsafe behaviour.

② Management (management and organization)

There were deficiencies in handling procedures etc. for important equipment, which had not been incorporated into the Safety Management Code (SMS), thus, it was determined to be in an Unsafe condition. In order to prevent the recurrence of unsafe conditions, unlike unsafe behaviour, the creation of procedures and operation manuals and their incorporation into the Safety Management Code (SMS) have been incorporated into Enforcement (thorough guidance).

5-6 Accident cause from the perspective of human error

Let us analyse the Master's unsafe behaviour that caused the accident with 12 Human characteristics and 5 Psychological factors (Figure 52) which invite human error, introduced in Loss Prevention Bulletin Vol.50.

Twelve human characteristics

1. Human beings sometimes make mistakes
2. Human beings are sometimes careless
3. Human beings sometimes forget
4. Human beings sometimes do not notice
5. Human beings have moments of inattention
6. Human beings sometimes are able to see or think about only one thing at a time
7. Human beings are sometimes in a hurry
8. Human beings sometimes become emotional
9. Human beings sometimes make assumptions
10. Human beings are sometimes lazy
11. Human beings sometimes panic
12. Human beings sometimes transgress when no one is looking

Five psychological factors

1. **Psychological reactance (self-efficacy)**
   This is when people do not wish to do something that is not of their own volition. They may be inclined to say, "I won't do what you tell me."
2. **Entrainment phenomenon and peer pressure**
   This is when people follow the crowd, e.g., "What will the neighbours think?"
3. **Normalcy bias ➡ justification, cognitive dissonance**
   When people believe, "I'm special, nothing can hurt me!"
4. **Confirmation bias**
   People are unconsciously prone to believe only "what they want to believe" and "information that supports what they believe" rather than purposefully seeking information to the contrary. They may say something like, "Stop exaggerating!" or "Everything will be fine!"
5. **Social loafing**
   This is when someone does not choose to take the initiative. They may say, "Someone will do it for me."

Fig. 52　12 Human characteristics and 5 Psychological factors

The items corresponding to the "12 Human characteristics" and "5 Psychological factors" shown in Figure 52 are summarised in Table 53 (Attachment 21) corresponding to the human errors described in 5-2 Timeline of events leading up to the accident.

Attachment 21

Human characteristics, Human error and Psychology : Vessel A Quay collision accident

Date and time	Movement	Who?	Human error	Human characteristics	Psychological factors
12:00	Before passing breakwater No. 5	Master	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. However, he did not realise that the rudder switch was stuck in the non-follow-up position (not switching to remote rudder) and moved to the port side of the bridge in front of the control stand.	① Human beings sometimes make mistakes: A mistake is apparent ④ Human beings sometimes do not notice: Switch position ⑥ Human beings are sometimes only able to see one thing at a time: Moved without checking ⑦ Human beings are sometimes in a hurry: He was distracted by the berthing manoeuvre	④ Confirmation bias: Human beings ignore information that is inconvenient for him or her.
12:08	At approximately 160m from the quay	Master	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). 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.	④ Human beings sometimes do not notice: Rudder indicator ⑥ Human beings are sometimes only able to see one thing at a time: Moved without checking? ⑦ Human beings are sometimes in a hurry: He was distracted by the berthing manoeuvre ⑩ Human beings sometimes make assumptions: Thought he had tipped the joystick backwards and made a sternway manoeuvre	⑩ Confirmation bias: "I' m special, nothing can hurt me!" ④ Confirmation bias: Human beings ignore information that is inconvenient for him or her.
			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.	④ Human beings sometimes do not notice: Rudder indicator ⑥ Human beings are sometimes only able to see one thing at a time: Tried to make sternway by increasing engine speed ⑪ Human beings sometimes panic	④ Confirmation bias: Human beings ignore information that is inconvenient for him or her.
12:09	Accident occurs	Master	At a speed of 4.3 knots, the ship hit the quay at almost a right angle.		

Table 53 Accident cause from the perspective of human error

The numbers given in the table in “Human characteristics” and “Psychological factors” columns correspond with the numbers in Figure 52.

Human characteristics

The human characteristics regarding incorrect rudder switch control on the control stand, and the subsequent behaviour up to 12:08 (100m from the quay), can be summarised as follows:

① Human beings sometimes make mistakes :
The erroneously operated rudder control switch

④ Human beings sometimes do not notice :
Did not notice switch position and did not notice the indication on the rudder angle indicator

⑥ Human beings are sometimes only able to see one thing at a time :

Without checking the rudder control switch, moved to the port side of the bridge in front of the control stand. Focussed on the operation of the joystick only.

⑦ Human beings are sometimes in a hurry:
He was distracted by the berthing manoeuvre.

⑨ Human beings sometimes make assumptions：
VecTwin Rudder was in the neutral (hover) position, so the speed was only reduced naturally, yet he believed that the ship speed had decelerated due to his own manoeuvring.

⑪ Human beings sometimes panic：
When the quay was so close this caused a panic, and the situation could not be calmly judged.

Psychological factors

③ Normalcy bias：I always use the same ship-handling techniques and I never fail. This is when people believe,“ I'm special, nothing can hurt me! ”

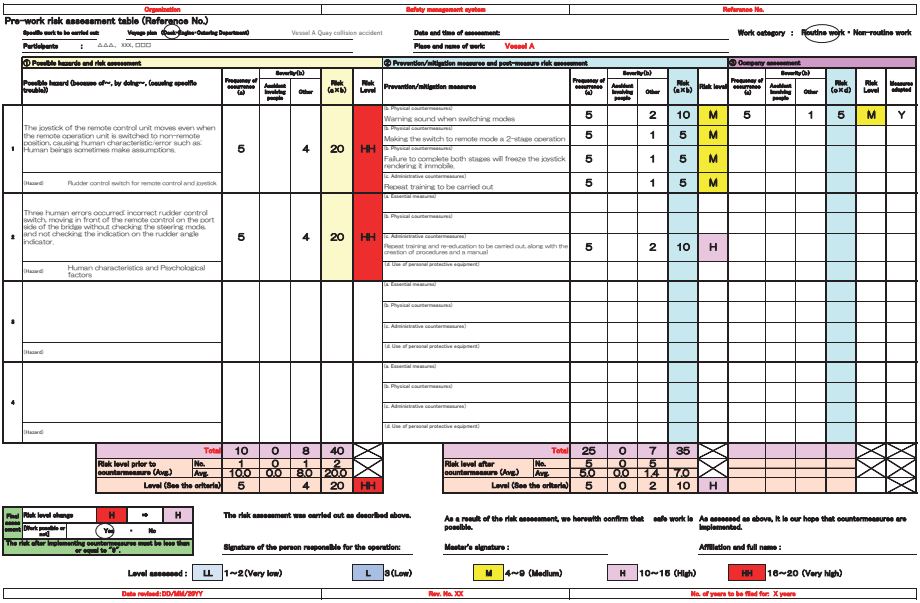
④ Confirmation bias：People are psychologically prone to believe only“ what they want to believe ”and“ information that supports what they believe ” rather than purposefully seeking information to the contrary (Did not check the indication of each display panel).

These were the root causes behind the chain of human errors that led to the accident.

5-7 Risk assessment (Fig. 54, see Attachment 22)

Now let us carry out a risk assessment based on the report from the Japan Transport Safety Board in hindsight of the accident.

Attachment 22



Organization | Safety management system | Reference No.

Pre-work risk assessment table (Reference No.)

Specific work to be carried out: Voyage plan (Coast/Anglo-Outside Department) — Vessel A Quay collision accident — Date and time of assessment: — Work category : Routine work・Non-routine work

Participants : △△△、×××、□□□ — Place and name of work: Vessel A

① Possible hazards and risk assessment | ② Prevention/mitigation measures and post-measure risk assessment | ③ Company 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	Prevention/mitigation measures	Frequency of occurrence (c)	Severity(b) Accident involving people	Severity(b) Other	Risk (a×b)	Risk level	Frequency of occurrence (c)	Severity(b) Accident involving people	Severity(b) Other	Risk (a×d)	Risk Level	Measures adopted
1	The joystick of the remote control unit moves even when the remote operation unit is switched to non-remote position, causing human characteristic error such as: "Human beings sometimes make assumptions. (Hazard) Rudder control switch for remote control and joystick	5		4	20	HH	b. Physical countermeasures): Warning sound when switching modes	5		2	10	M	5		1	5	M	Y
							b. Physical countermeasures): Making the switch to remote mode a 2-stage operation	5		1	5	M						
							b. Physical countermeasures): Failure to complete both stages will freeze the joystick rendering it immobile.	5		1	5	M						
							c. Administrative countermeasures): Repeat training to be carried out	5		1	5	M						
2	Three human errors occurred: incorrect rudder control switch, moving in front of the remote control on the port side of the bridge without checking the steering mode, and not checking the indication on the rudder angle indicator. (Hazard) Human characteristics and Psychological factors	5		4	20	HH	a. Essential measures): b. Physical countermeasures): c. Administrative countermeasures): Repeat training and re-education to be carried out, along with the creation of procedures and a manual d. Use of personal protective equipment):	5		2	10	H						
3	(Hazard)						a. Essential measures): b. Physical countermeasures): c. Administrative countermeasures): d. Use of personal protective equipment):											
4	(Hazard)						a. Essential measures): b. Physical countermeasures): c. Administrative countermeasures): d. Use of personal protective equipment):											
	Total	10	0	8	40		Total	25	0	7	35							
	Risk level prior to countermeasure (Avg.) No.	1	0	1	2		Risk level after countermeasure (Avg.) No.	5	0	5								
	Risk level prior to countermeasure (Avg.) Avg.	10.0	0.0	8.0	20.0		Risk level after countermeasure (Avg.) Avg.	5.0	0.0	1.4	7.0							
	Level (See the criteria)	5		4	20	HH	Level (See the criteria)	5	0	2	10	H						

Final assessment: Risk level change H ⇒ H; Work possible or not: Yes / No

The risk after implementing countermeasures must be less than or equal to "8".

The risk assessment was carried out as described above.

Signature of the person responsible for the operation:

As a result of the risk assessment, we herewith confirm that safe work is possible.

Master's signature :

As assessed as above, it is our hope that countermeasures are implemented.

Affiliation and full name :

Level assessed : LL 1~2 (Very low) | L 3 (Low) | M 4~9 (Medium) | H 10~15 (High) | HH 16~20 (Very high)

Date revised: DD/MM/20YY — Rev. No. XX — No. of years to be filed for: X years

Fig. 54 Quay collision accident risk assessment

The following two items are identified as hazards:

① Rudder control switch for remote control and joystick

② Human characteristics and Psychological factors

Since people have 12 Human characteristics, such as making mistakes and assumptions, and 5 Psychological factors that induce Human error (Fig. 59), we have identified " Man: Master " as a hazard.

5-7-1 Physical countermeasures

As to ways to improve the system, from an engineering point of view, it is a question of how to make ***"the operator aware of their own human error"***.

① Warning sound when switching modes

The ship owners had employed this system on vessel A, but since crew would

sometimes miss the sound, it was not deemed to be sufficient.

② Making the switch to remote mode a 2-stage operation

③ Failure to complete both stages freeze the joystick rendering it immobile

② and ③ are based on the concept of foolproofing.

Foolproofing

This is the idea of making machine operations "foolproof" by designing and incorporating mechanisms whereby operational errors do not lead to hazardous situations. Concepts relating to safety engineering and design.

In cases like this, either the Master or the AB would be standing in front of the control stand when switching modes.

When changing from manual mode to automatic, it is necessary to set a course manually and then set the course heading automatically. It is therefore thought to be not so necessary to build in a foolproof mechanism in this case.

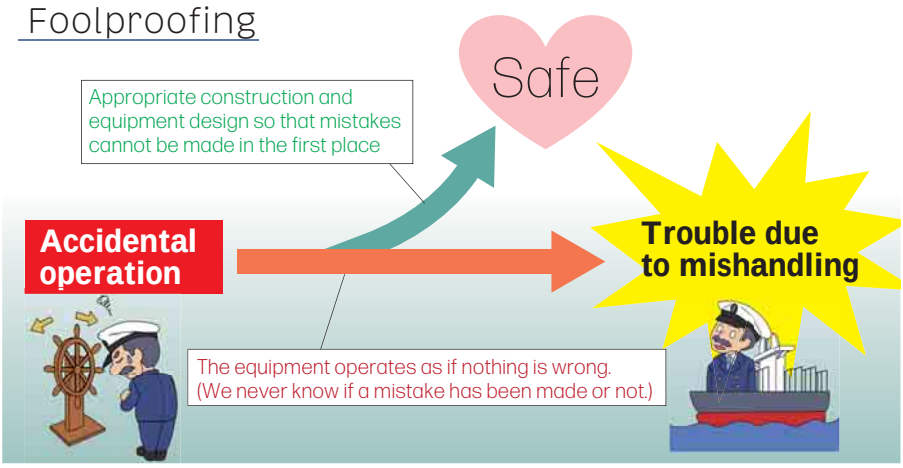


Fig. 55 Foolproofing

Similarly, it is also thought to be of minimum necessity when switching from automatic to manual or from manual to non-follow up mode since either the Master or the AB is

directly operating the rudder at that time.

However, in cases like this the Master is handling the vessel alone. When he switches to remote control mode he must move from the steering pedestal to the remote control stand on the port side of the bridge. There is plenty of scope for human error and as such it is necessary to build in some kind of foolproofing mechanism.

Rather than ② simply switching from one mode to the next, one option would be to make the switch to remote mode a 2-stage operation requiring the pulling (or pushing) of a lever to engage. Another alternative would be to build in some kind of required verification check at the remote control stand.

"③ By modifying the system so that the joystick stays fixed unless it is switched to remote control", or alternatively, the joystick could be locked when not switched to remote control.

For ocean going vessels which have both a Navigation Officer and an AB stationed inside the bridge to operate the rudder, even if the Master makes a mistake, his actions still need to be verified by the other officers on duty. Therefore, putting good BRM (Bridge Resource Management) into practice makes it possible to break the chain of sequential errors.

However, for most coaster vessels, the Master is generally working alone. Considering the limitations of BRM in these solo conditions, there is a need to incorporate some kind of engineering mechanism to make the system more foolproof.

5-7-2 Administrative countermeasures (How to break the chain of human error)

In section 5-2 Events that led to the accident, it has been explained that the accident occurred as a result of a chain of following three human errors that could not be broken.

1. The erroneously operated rudder control switch should have been changed from automatic to manual, but was mistakenly stuck in the non-follow-up position and was not checked afterwards.
2. Furthermore, the Master intended to switch from automatic to manual rudder, but in fact switched from non-follow up to manual, and without realising it, moved to the remote control stand on the port side.
3. The Master thought he could control the course and speed by remote control with the joystick lever. In fact, however, the vessel was heading straight ahead with no wind tide effect and the VecTwin Rudder was in the in neutral (hover) position, so the speed was only reduced naturally. Also, the Master was operating the joystick without checking the rudder angle indicator.

Summing up these three human errors, as explained in Figure 52 “12 Human characteristics and 5 Psychological factors” of 5-6 Causes of accidents in terms of human error, the rudder switch lever on the control stand was operated incorrectly and this triggered the Master to operate it without checking the rudder indicator (He was too preoccupied with the distance to the quay：Human beings are sometimes only able to see one thing at a time). By chance, the vessel was heading straight ahead unaffected by external forces and the VecTwin Rudder was in the neutral (hover) position, so the speed was only reduced naturally, but the Master thought he was controlling the course and speed by remote control with the joystick lever.

As administrative countermeasures, we have to implement countermeasures such as repeat training on how to operate the rudder control switch and a method of confirmation.

§ 6 Conclusion

As described in Chapter 2, risk management is advocated by the Ministry of Health, Labour and Welfare (MHLW) for the manufacturing industry on land, in line with the Industrial Safety and Health Act (Act No. 57, 1972), as a business management technique to effectively deal with unforeseen losses caused by various hazards at minimum cost. Also, the enforcement of the Companies Act 2006 requires joint-stock companies to have "systems related to management of the risk of loss" in place. In addition, the Japanese version of Sarbanes-Oxley (SOX) Act came into force in 2008 and a "financial risk management system" has been required since then.

As a result of this, the shipping industry has been required to incorporate risk management in safety management codes and SMS manuals since around 2010, but this has been difficult for ship management and the vessel to adopt in practice. One of the reasons why risk management has not permeated this industry is because the Master, Chief Engineer and experienced crew both on Deck and in the Engine departments have already been practising risk assessment implicitly as part of their work.

However, it is now customary that a crew of several nationalities with different cultures and customs be on board to achieve the safe operation of a ship. In this context, the approach (top down) mentioned above, on board a vessel, where risk assessments are practised individually and implicitly by following orders from experienced crew members, may actually reduce the level of safety.
It is important that the management at the shore catering department, such as the ship

owner or ship management company, understand what has been explained in this guide. As explained in section 4-3 “Risk assessment procedures”, for example, regarding countermeasures for rough weather, management is not to be left solely to the discretion of the Master/Chief Engineer or Chief Officer/First Engineer, but that all crew members take time to participate in the discussion and share their opinions and countermeasures. It is recommended that risk assessments are practised in a relaxed and systematic manner, where unexpected oversight or other problems can be identified by evaluating them numerically in writing. As a result, we believe that the safety level of the vessel will surely be improved.

References

- Japan Industrial Safety and Health Association (JISHA)
  - Risk assessment duties for person in charge
  - Workplace risk assessment case studies
  - Practical risk assessment training materials for health and safety staff

A range of training resources in risk assessment is available by the Japan Industrial Safety and Health Association (JISHA). For details, please refer to the association’s homepage below.

- Introduction to System Safety (Provisional translation) :
  System Safety Engineering, Nagaoka University of Technology (Yokendo Ltd.)
- The Forefront of Safety Engineering - The Concept of System Safety -
  (Provisional translation) The Japan Society of Mechanical Engineers, ed.
  (Kyoritsu Shuppan Co., Ltd.)