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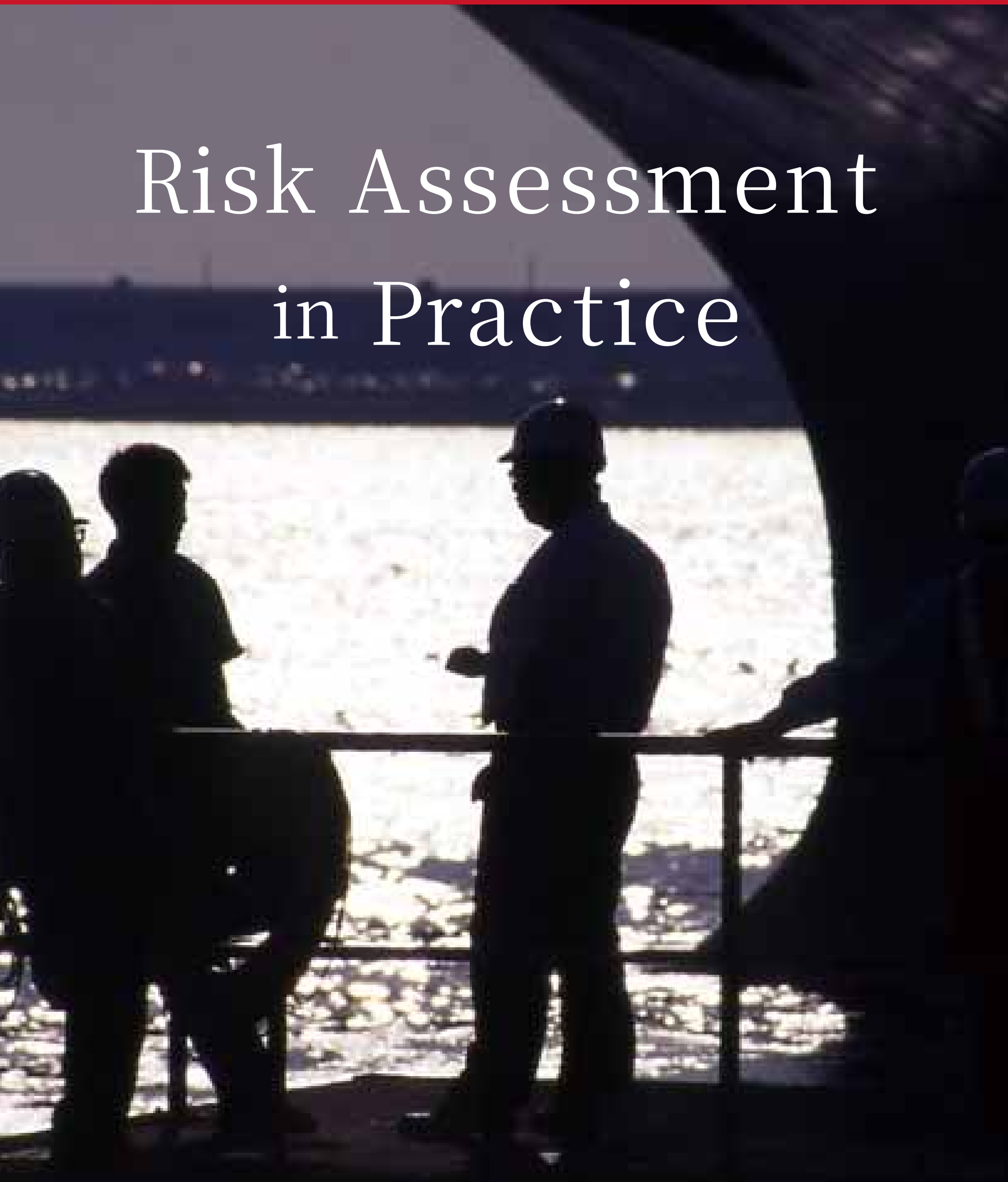
The Japan Ship Owners' Mutual Protection & Indemnity Association Loss Prevention and Ship Inspection Department

Risk Assessment in Practice



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About the author

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§ 1　Introduction

In the seminars that we conducted and in the Loss Prevention Guides, we have stated that “the root cause behind marine casualties is approximately 90% the result of a chain of human errors. However, unfortunately, it is not possible to eliminate the occurrence of human error, thus in order to prevent maritime accidents, it is important to “break the chain of sequential errors”.

When considering measures to prevent maritime accidents, we have shown that these can be chiefly classified into three specific methods (shown in Fig. 1) that are an effective means of preventing further accidents.

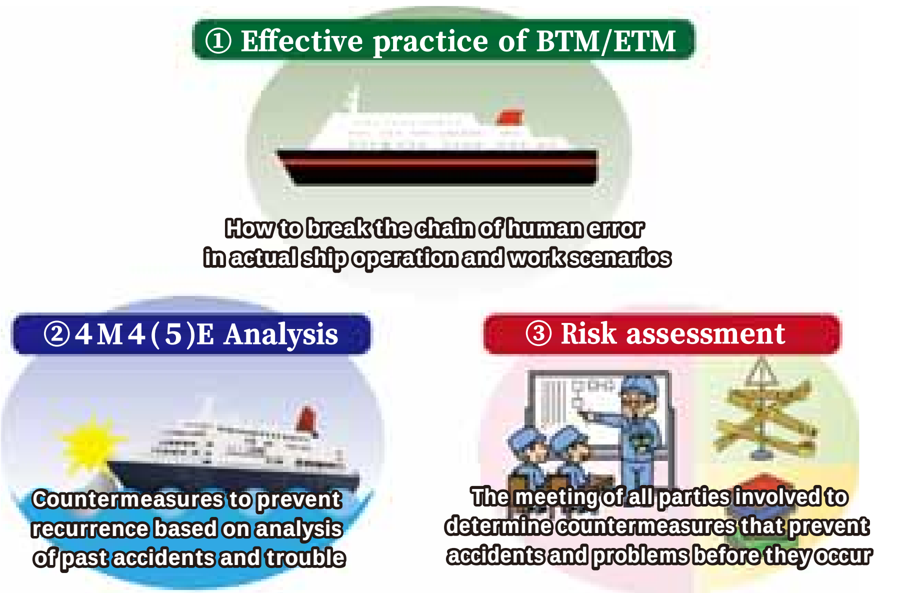


Fig. 1　Three maritime accident prevention measures

① Effective implementation of BTM/ETM (Bridge/Engine Room Team Management)

This is a method that breaks the chain of human errors on the spot. In other words, even experienced Masters and Chief Engineers (C/E) can make mistakes because they are human beings. Thus, BTM/ETM is a system that supports the duties of those involved in a cohesive manner so that one person's mistake does not cause a dangerous situation whereby team members and resources around him/her can quickly recognize and correct the mistake in time.

"Communication between each resource" serves as the basis of this and is illustrated in the M-SHELL Model (Fig. 2) above. However, unlike aeroplanes, where the skill level between the captain and co-pilot is almost equal, there is a significant difference in skill level between Master and C/E and an inexperienced navigation officer or engineer on the vessel. As a result, BTM/ETM cannot be utilized effectively, which is a notable problem. Please refer to Pages 14 to 15 of the Loss Prevention Bulletin Vol.50, "4M4(5) E Analysis".

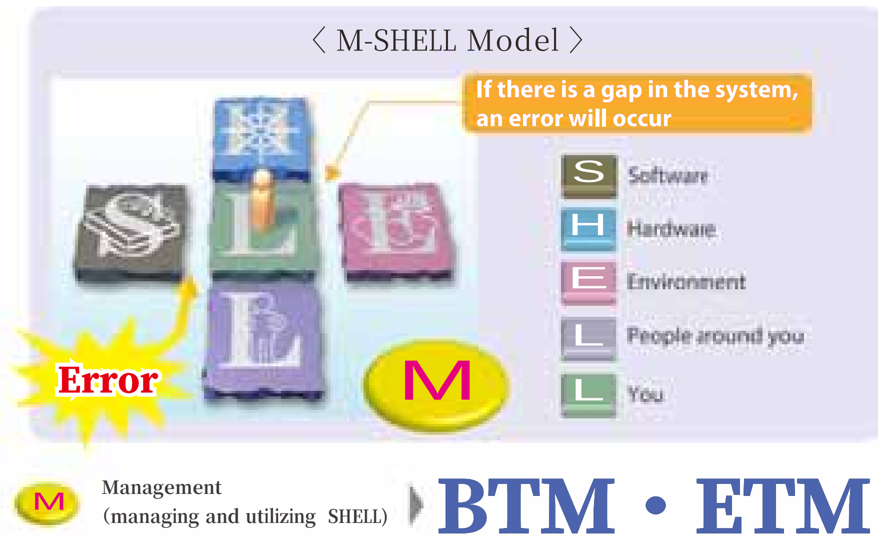


Fig. 2 M-SHELL Model

② Planning of measures that prevent maritime accidents through 4M4(5)E analysis

In the unfortunate event of a maritime accident occurring, in addition to the analysis from a physicall point of view, there is a method of developing countermeasures to prevent the same type of accident from occurring again by (1) identifying the event from the point of view of the “4Ms” of failures, i.e. Man, Machine, Media (working environment) and Management, (2) analysing the result of (1) in terms of why the “Unsafe conditions” and “Unsafe behaviour” (Fig. 3) occurred, and (3), based on the results of (2) analysis, formulating countermeasures for each of the “5Es”, i.e. Education, Engineering, Enforcement, Example and Environment. This method has been developed and adopted by NASA (National Aeronautics and Space Administration) for accident investigation.

Although this method has been commonly used in the manufacturing industry, it is not widely spread in the maritime world: because it is originally less familiar, and, unlike in the manufacturing industry, accident causes are to be often found in human nature following a deeper analysis, which is where problems arise. For more details, please refer to the Loss Prevention Bulletin Vol.50.

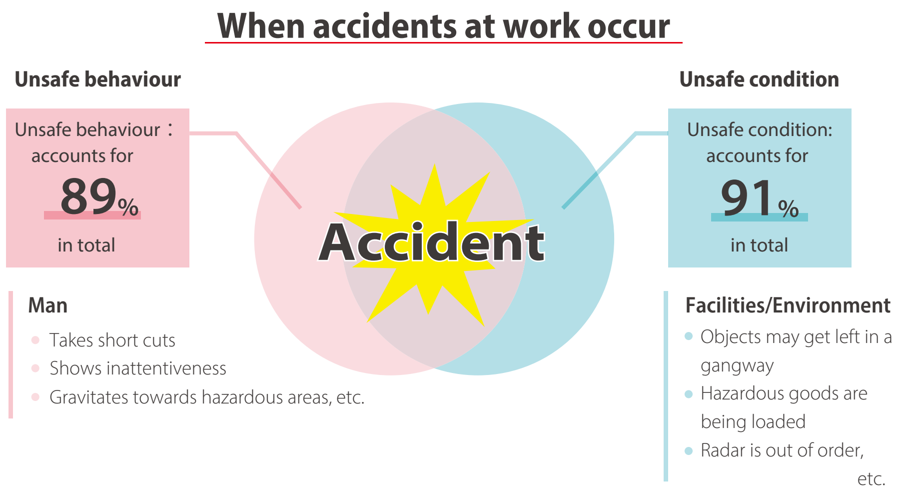


Fig. 3　Unsafe conditions and Unsafe behaviour

③ Devise countermeasures that prevent maritime accidents through risk assessment

The method is designed for crew to examine the risks involved in their duties on board the vessel, especially when carrying out irregular work, and to develop countermeasures in advance. The idea is to share this information with all parties involved, including other management personnel at the shore office such as the shipowner, ship management company, charterer and so on in order to prevent accidents before they occur.

In 1999, in the manufacturing industry on land, Guidelines on Occupational Safety and Health Management Systems (Note 1) was introduced along with the Industrial Safety and Health Act (Act No. 57, 1972) and Risk management legislation.

However, later during 2010, the International Maritime Organization (IMO) created the ISM Code (International Management Code for the Safe Operation of Ships and Pollution Prevention). When this Code was revised, many companies were recommended to introduce a Risk management approach and incorporate it into their Safety Management System (SMS) and Safety Management Code, however, these are yet to be implemented successfully.

Note 1: OSHMS stands for Occupational Safety Health Management System.

(Ministry of Labour Notification No. 53, April 30, 1999 (Guidelines on Occupational Safety and Health Management Systems)

In terms of ship operations, based on a full understanding of the above proposed approach to prevent disasters (accidents) " ② 4M4(5)E analysis" and " ③ Risk assessment", it is a requirement that related parties be aware of " ① BTM/ETM" while putting these into practice in the field. This time, the author will describe what is entailed in Risk Assessment.

§ 2 Risk Management

2-1 What is risk?

According to "Risk management principles and guidelines" of JIS Q 31000, risk is defined as follows:

Definition of risk: the effect of uncertainty on objectives

On the other hand, the International Safety Standards ISO/IEC Guide 51 defines "risk" as a "combination of the probability of occurrence of harm and the severity of that harm" and that "the probability of occurrence includes the exposure to a hazardous situation, the occurrence of a hazardous event and the possibility to avoid or limit the harm." Also, in IMO, risk is defined as the combination of the frequency and the severity in MSC-MEPC.2/Circ.12/Rev.2 (Annex, page 4).

In accordance with Japan's Industrial Safety and Health Act, the Ministry of Health, Labour and Welfare (MHLW) has established "Guidelines on Occupational Safety and Health Management Systems" (Ministry of Labour Notification No. 53, April 30, 1999), which was partially amended by the Ministry of Health, Labour and Welfare Notification No. 54 on July 1, 2019. In section 3 (implementation details), risks are defined as follows:

Risk: Severity of the injury or illness that may result from the danger (hazard) or harm and the degree of likelihood or possibility of its occurrence. (Provisional translation)

Until now, the word “risk” was a concept that has not really existed in the Japanese language. Many Japanese thought that risk meant “crisis”. However, it is necessary to understand that “crisis” means an intense difficult and dangerous situation that has already occurred, and that risk is not the same thing.

“RISK” ≠ “hazard” or “crisis”

As mentioned above, “risk” is considered to be “something uncertain that has not yet occurred” and can be expressed as a function of the degree and probability (frequency) of adverse effects resulting from the presence of a “hazard” lurking in the course of carrying out work on board: dangers that are not present now, but which can be foreseen to occur in the future.

“Risk” = “degree of impact” × “frequency”

This will be further described in chapter 3.

2-2 Risk management

The ISM Code contains the following provisions relating to risk management: Quoted from ClassNK’s amendments to the International Safety Management (ISM) Code. (The amendments entered into force on 1 January 2015.)

1.2 Objectives

1.2.2 Safety-management objectives of the Company should, inter alia:

.1 provide for safe practices in ship operation and a safe working environment;

.2 assess all identified risks to its ships, personnel and the environment and establish appropriate safeguards; and

.3 continuously improve safety-management skills of personnel ashore and aboard ships including preparing for emergencies related both to safety and environmental protection

The ISM Code refers to risk as: “We do not prescribe any particular method of risk management and it is for the company to choose the appropriate method for its organisation, its vessels possessed and its routes.” (Provisional translation). Let us examine this in detail.

2-2-1 The need for risk management

With the collaboration of the shipowner, ship management company and crew, by specifying the series of processes of the PDCA cycle: (P: Plan)→(D: Do)→(C: Check)→(A: Action)and by promoting continuously and proactively safety management activities, the aim of risk management is to reduce the potential hazards that can cause accidents and disasters and create a comfortable working environment on board, at the same time.

The absolute number of accidents has decreased since the ISM Code and the Safety Management Code was introduced, however recently that rate of decrease has slowed down. The reason for this is the decrease in the number of experienced crew who have accumulated safety management know-how. Also, the fact that it is common to have mixed boarding of foreign crew on ocean going vessels, there will be differences in culture and customs for each country, and as a result safety management know-how on board is not sufficiently passed on, leading to the fear that this may not be passed on to the next generation, which could cause further accidents.

Under these circumstances, without leaving operational safety measures to the vessel only, it is required that the shipowner and the ship management company also be responsible for <u>establishing a system of safety management to be implemented “systematically” and “continuously”, and for it to be planned and used in an integrated and appropriate manner.</u>

2-2-2 What is risk management?

As mentioned above, risk management is the process of systematically managing risks to avoid or mitigate losses.

In addition, a risk assessment structure mainly consists of “risk assessment” and “risk management (risk response)”.　Moreover, it consists of “risk identification”, “risk analysis” and “risk evaluation”. (See Fig. 4)

Risk management has been introduced as a business management technique to effectively deal with unforeseen losses caused by various hazards at minimum cost. The background to this is that, with the enforcement of the Companies Act in 2006, it became necessary for joint-stock companies to establish a “system for the management of the risk of loss”. In addition, the Japanese version of Sarbanes-Oxley (SOX) Act (Financial Instruments and Exchange Act) came into force in 2008, requiring the development of a “financial risk management system”.

As a result, it has been said that we have moved from an era of compliance to an era of risk management, and in recent years, risk management has been in the spotlight in business management, also.

Until now, it seems that risk management was implicit in the decision-making process of any company, but with the introduction of new legislation and increased awareness of risk management, risk management has moved from being implicit to being explicit (visible).

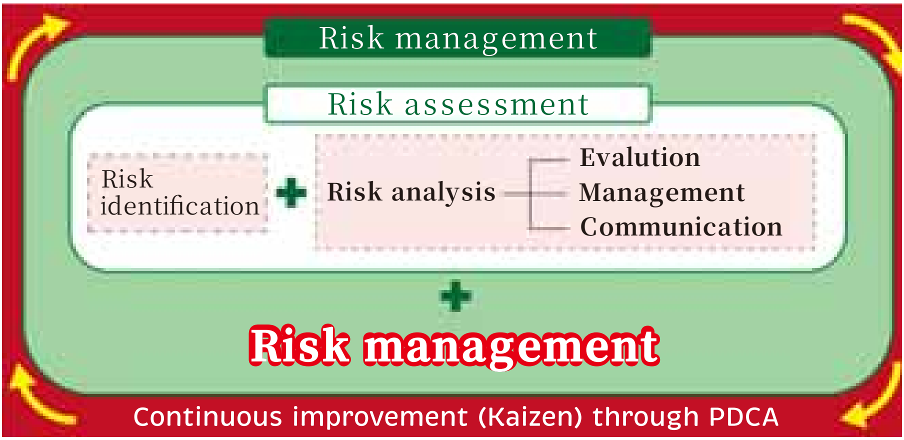


Fig. 4　Risk management conceptual diagram

§ 3 Risk Assessment

3-1 Fundamentals of risk assessment

Risk assessment is to ensure the safety of the vessel and crew's good health, and such days when people used to say, "We simply need to comply with the law," are gone. Now, the shipowner and ship management company are also expected to take all possible measures to ensure the safety of the ship and the well-being of the crew and not leave the burden of safe operation at sea entirely to the vessel.

Therefore, shipowners and ship management companies need to ensure that their ship management incorporates "methods that maximise health and safety standards wherever possible", and one of the most effective ways to achieve this is through risk assessment.

In recent years, many shipping companies have developed and set up their own crisis management and specialised risk management departments. Meanwhile, internal audits, potential accident reports and risk prediction (KY: Kiken Yochi) activities have been commonly used to identify the risks existing on board and to establish safety measures in advance.

In a broad sense, these activities are part of risk assessment. However, risk assessment is, in addition to these empirical activities, characterised **by a systematic and logical approach to the development of safety measures.**

3-2　Why risk assessment is necessary

In the past, the basic approach to prevent a disaster (accident) on board was to investigate the cause of an accident, formulate measures to prevent recurrence of similar accidents, and ensure that all ships were aware of these countermeasures. This was a so-called "responsible pursuit type" measure or a "grave-post type" measure in which the person involved in the accident was punished, the relevant parties briefed on the accident and then the case closed.（For details, please see "Thinking Safety", Loss Prevention Bulletin Vol. 35）.
However, it has been recognised that learning from past disasters (accidents) is not enough when it comes to formulating recurrence preventive countermeasures.

When a crew member, who is a professional operator of the vessel, causes an accident despite being aware of the potential danger, the preventive measure is to ask "Why did the crew member behave in such an "unsafe" way? Based on the fact that 90% of the root causes of marine accidents are a chain of human errors, we have "identified technicians' common characteristics", "human characteristics", "psychological factors" and "human brain capacity" that may cause human errors. Therefore, it has become necessary to analyse the causes of accidents in terms of such factors which cause human errors, and carry out "preventive countermeasures" to find out what can be done to avoid such situations. Thus, the need for "preventive countermeasures" has increased.

It is therefore necessary to introduce a risk assessment approach that pays attention to potential hazards and one that takes proactive countermeasures, in order to eliminate or reduce the risks that exist on board, and to further promote fundamental safety on board, thereby improving safety standards. Figure 5 illustrates this.

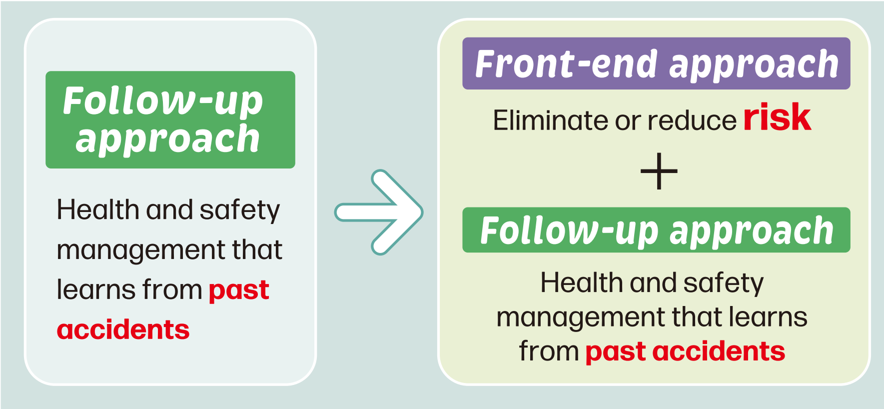


Fig. 5 From Follow-up approach to Front-end approach Source: Risk Assessment Training Materials by Japan Industrial Safety and Health Association (JISHA)

In addition, in Article 5 of the Labour Contracts Act (Consideration to the Safety of a Worker), the duty of care for safety is set out in the following.

> ＝ **The Labour Contracts Act (Article 5)** ＝
> In association with a labour contract, an Employer is to give the necessary consideration to allow a Worker to work while ensuring the employee's physical safety.

That is to say that, as mentioned above, in recent years we have moved from an era of "compliance" to an era of "risk management". Figure 6 illustrates this.

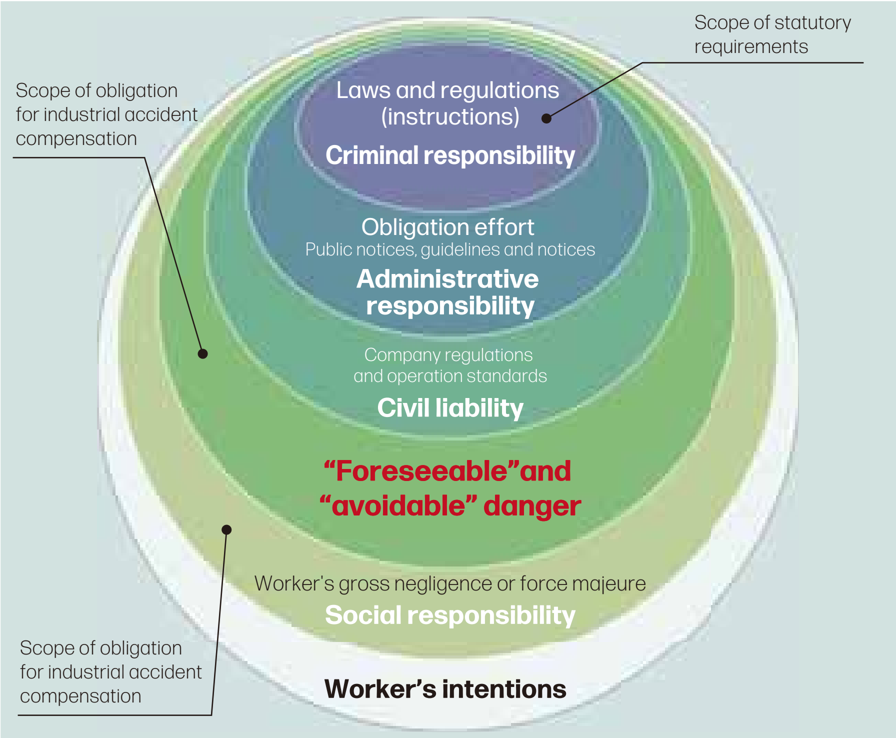


Fig. 6　Source: Scope of the duty of care for safety from " Practice of duty of care for safety from court cases " (Provisional translation). From the Japan Industrial Safety and Health Association (JISHA), ed.

In other words, the following two duties are needed in order to fulfil the duty of care to maintain safety:

1　Duty to warn Worker of any danger

To foresee hazards on board, especially potential hazards around the crew.

2　Duty to avoid foreseeable consequences

Risks to be eliminated or isolated/mitigated. Or, for " residual risks " that still remain, the crew needs be aware of their existence in order to take countermeasures in " daily shipboard health and safety " to prevent accidents from occurring.

3-3 Effectiveness of risk assessment

By carrying out a risk assessment, we can expect the following benefits:

1 Not only crew but also shipowner and ship management company can share their“ perception ”of risk

By carrying out a risk assessment on board and reporting it to the shipowner or ship management company, there is a common understanding of the risks existing on board.

2 Increased sensitivity to risks

This increases the sensitivity of everyone involved to better understand risk, and enables them to deal with risks that might otherwise have been overlooked.

3 Enable physical countermeasures to be taken with a focus on fundamental safety

By sharing safety measures that were previously left to the vessel or on-board, it will be possible to establish safety measures in advance that correspond to the risk level. In particular, it will enable the promotion of physical countermeasures that focus on fundamental safety (see below).

4 Reasonable prioritisation of safety measures

Countermeasures taken to eliminate, reduce or isolate risks to below an acceptable level of risk, and the results of the risk assessment etc. can also determine the order of priority.

5 Reasonable countermeasures taken in terms of cost-effectiveness

In the event of ③ taking any physical countermeasures as in the above cases, costs will also be incurred. By specifically considering the urgency and funding of each risk countermeasure, it will also be possible to select those that are reasonable from a cost-benefit perspective.

6 The reasons from a“ management approach: what to follow, etc. ”are clear for residual risks

Residual risk inevitably remains, even after elimination, reduction or isolation. In such cases, the response must be left to the ship's crew, with the necessary management measures put in place. If the crew is involved from the beginning, as they will understand the reasons, such as why they have to work with care, what needs to be followed will be observed.

3-4 Risk assessment structure

Risk assessment starts with identifying hazards (harmful events) and then analysing the risks identified. The analysis is then assessed, and the impact of risks (severity), and measures (controls) are then put in place according to the required level of risk, which is the product of frequency of occurrence and impact. It is a series of processes comprising of the effective communication of these measures to relevant parties. (See Fig. 7)

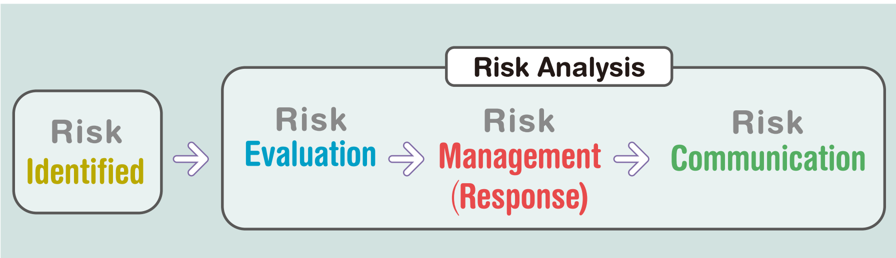


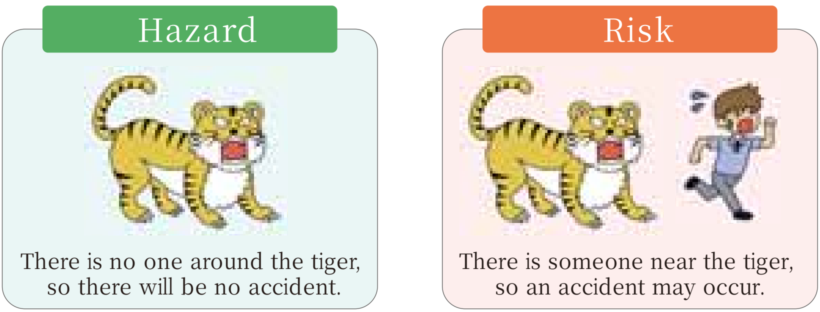
Fig. 7 Risk assessment process

3-4-1 Identifying hazards

The first step in risk assessment is to identify the hazard and the source of the hazard of the machinery, equipment, work activities and environment in question (work activities, work location, etc.) This is the most important task in carrying out a risk assessment.

Knowing the differences between hazards and risks

In Japanese, hazards are often lumped together under the meaning of the word "danger", however it is important to distinguish the difference. A "**hazard**" can be defined **as "anything that has the potential to cause injury or trouble"**. This includes not only the ship's equipment and machinery, but also environmental and human factors. However, no matter how many of these hazards exist on board the vessel, no injury or trouble should occur. It is only when the crew are exposed to these hazards that the possibility of trouble or an accident involving people arises. This "combination of the severity of an accident caused by the hazard and the likelihood of it occurring" is called the "risk". Therefore, even if the hazard exists, if the crew or operator is not present, or if the crew or operator is not involved in the operation, then the risk does not exist. Figure 8 shows the materials used when the author took a risk assessment training course.



If anyone approaches the tiger, they may be attacked and injured.

Fig. 8　Hazards vs risks

The left-hand diagram in Figure 8 shows a "tiger" as the hazard. The tiger can move around freely, but this alone does not lead to injury. However, if a person is present, as shown in the picture to the right, he may be attacked and injured by the tiger, and the tiger then changes from a hazard to a risk. This risk needs to be clearly distinguished from the hazard in order to understand it.

Now, let us closely examine a "dangerous situation". Figure 9 shows a conceptual diagram of a dangerous situation in terms of the relationship between a human and a hazard. As shown in the diagram, when a person's area of activity enters a hazardous area, where the two overlap, is referred to as a "dangerous situation".

The term "dangerous situation" tends to be interpreted as a dangerous situation where there is a risk of an accident occurring due to safety measures or faulty equipment, or when the ship itself could be involved in an accident, or when the cause of an accident is generated; but this is not the way it should be interpreted.

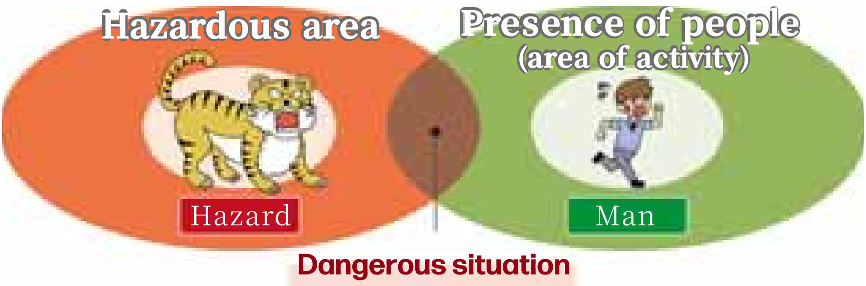


Fig. 9　Dangerous situation

Process leading to personal injury or trouble

The process leading to personal injury or trouble is shown in the Figure 10. Personal injury or trouble occurs when the Hazard and Man or Machinery (the vessel's equipment etc.) meet. This type of thinking is also used in risk prediction (KY) activities to assess the current situation.

A "dangerous situation" occurs when a person or piece of equipment is exposed to (or approaches) a hazard, and a hazardous event occurs when safety measures are insufficient/inappropriate/faulty. And, when hazardous events occur and "avoidance" fails, trouble or an accident involving people occurs.　As you can see from this process, there are four possible ways to prevent trouble and accidents involving people. For details, please see P.25 3-4-2 (2) Risk management (response), to be described later.

- Eliminate the hazard
- Ensure that man and machinery (ship's equipment) are not exposed to (or approach) the hazard
- Have appropriate and sufficient safety measures in place
- That the " hazardous event " is successfully avoided when it occurs

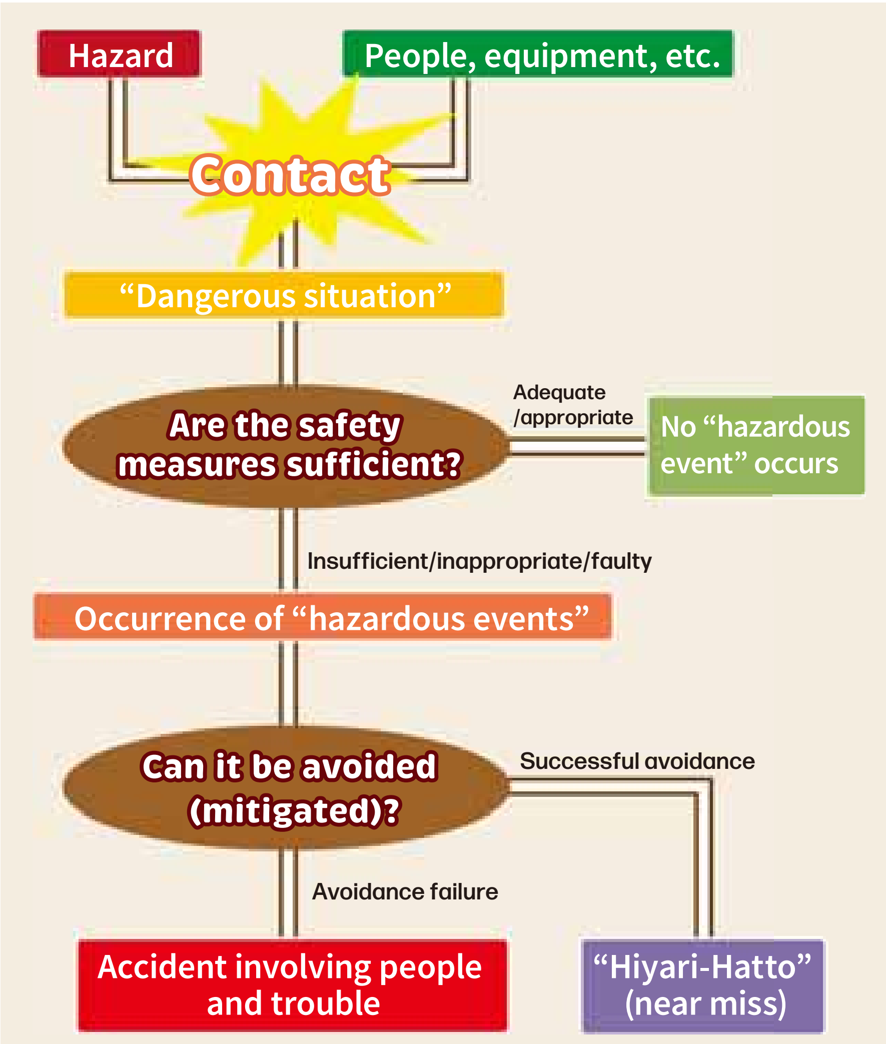


Fig. 10 Process leading to personal injury or trouble

Some remarks when identifying hazards on a vessel

Risk assessment begins with identifying the hazard. The following points should be taken into account when identifying hazards on the vessel.

Hazards are to be identified among all related persons

The more familiar experienced operators are with their duties, the more difficult it is to identify hazards. It is also necessary to involve the senior officers (Master/ Chief Engineer and Chief Officer/First Engineer) and the crew who will be doing the work, rather than having only the crew, who will be doing the work, perform hazard identification.

In addition, the identification of hazards from the point of view of inexperienced crew members is often a blind spot for experienced personnel. It is therefore also important to check the work site with all concerned before starting the risk assessment meeting.

Collecting information

Wherever possible, reference information should be obtained from the ship management company or other sources, such as risk assessment reports, accident reports and potential accidents on other ships.

Review of legislation and company rules

Grasp the relevant laws and regulations, safety management codes and SMS manuals etc., and start work on the basis of them until covering all manner of work, even if there are no procedures available (inc. irregular work).

Prioritisation

Where there is more than one task or process, the plan should be developed sequentially, starting with those that are considered to pose the greatest risk.

Although collecting information is an important part of the above work, it should be noted that the crew changes every few months. Therefore, it is imperative that information gets passed on, since risk assessment tends to be based on the discretion and knowledge/experience of individual crew members, and becomes ad hoc.

Therefore, it is necessary not to collect information only when the risk assessment is conducted, but to organize it on a daily basis, considering it to be useful as a material for conducting risk assessment, and to prepare a list of materials so that appropriate information can be provided promptly when the risk assessment is actually conducted. It is also necessary to prepare a list of materials so that appropriate information can be provided promptly at the stage of risk assessment and handed over to the successor. For example, one way to sharpen keen insight and observation will be through daily near misses. The ship management company is also expected to compile information on each vessel and provide it to the vessel on a regular basis.

3-4-2 Risk analysis

A "risk analysis" related to safety on a vessel is a framework for preventing the occurrence or minimising the risk of an accident occurring, rather than cleaning up after the accident, where the ship's operations or crew may be adversely affected by a "hazard" on board or during operations.

This means that all crew members involved in the various operations to be carried out on board the vessel will hold a briefing before starting work to identify the hazards that can be expected during the operation, and the kinds of accidents involving people or trouble that may occur.

Risk analysis consists of three elements: Risk evaluation, Risk management (response), and Risk communication, which interact to improve the results of risk analysis.

Remarks: The above explanation is based on the "Definition of Risk Analysis" publicized on the website of the Ministry of Health, Labour and Welfare.

1 Risk assessment

The risk assessment assesses the impact of risk posed by a potential hazard on board or at work, in terms of what type of personal injury or trouble is likely to occur and at what rate (likelihood or degree of likelihood), and if they do occur, how serious are they likely to be (severity or degree of seriousness). Then, based on the magnitude of the assessed risk, determine the priority of reducing the risk and take measures to eliminate or reduce the risk according to that priority.

Risk is a combination of the probability and severity of a hazard causing personal injury or trouble. Then, in order to effectively utilize a risk assessment for it to lead to the elimination of risks and reduction measures, it is necessary to determine the criteria for the “degree of likelihood” and “impact of severity” of risks in the assessment, which are then divided into several levels.

Moreover, depending on the extent of the likelihood and severity categories obtained from the risk assessment, the impact of the risk (risk level) posed by the hazard is determined. The higher the likelihood and the greater the severity, the higher the risk level. We then set “priorities for reducing the risk”, starting with those with the highest level of risk.

Risk assessment setting methods

For classifying the elements of risk, there are largely two main methods in order to assess risk and set priorities: the **non-quantified method and the quantified method**.

1) Non-quantified method

This is a matrix of severity and probability, and is widely used as an evaluation method when establishing prevention countermeasures against accidents involving people in the manufacturing industry on land. Examples are shown in Tables 11-1 and 11-2.

Non-quantified assessment and priority setting criteria

Likelihood \ Severity	Significance	Severely injured	Minor injury
Highly likely	IV	III	II
Likely	IV	III	I
Not very likely	III	II	I

Table 11-1　Example of non-quantified assessment and priority setting criteria

Non-quantified risk level and how to proceed with countermeasures

Risk level	Risk	Approach for risk mitigation
IV	There is a serious health and safety issue	Immediate risk reduction measures Stop work until action is taken (Note 1)
III	There is a health and safety issue	Prompt risk reduction measures
II	There are some health and safety issues	Systematic risk reduction measures
I	There are only a few health and safety issues	Risk reduction measures where necessary (Note 2)

(Note 1) Risk level IV is a risk level that is unacceptable for the workplace
(Note 2) Risk level I is a level that is broadly acceptable for the workplace

Table 11-2　Non-quantified risk level and how to proceed with countermeasures
Extract from the Japan Industrial Safety and Health Association (JISHA)

2) Quantified method (Attachments 1, 2 and 3)

This method of numerically assessing risk in terms of two factors, "likelihood/frequency of occurrence" and "severity", has been widely adopted in safety management codes and SMS manuals in the shipping industry.

The likelihood and frequency of occurrence are taken into account comprehensively and are often classified into three to five levels. The severity of the hazard is usually categorized into one to four levels in order to understand the severity (impact) of the personal injury or trouble that is expected to occur as a result of the hazard.

A risk assessment is made by multiplying the values obtained from the "Probability and Frequency of occurrence" and "Severity" assessments. The risk level is then assessed on a scale of 5 levels: LL (very low risk) ~ HH (very high risk) , and each onboard operation is identified as belonging to one of the risk categories. Finally, the assessment as to whether or not work can be carried out is based on a comparison of the risk level reduction between "Before" and "After" measures are implemented. Examples are shown in Tables 12-1, 12-2 and 12-3.

Quantified risk assessment index guidelines (criteria)

【Frequency of occurrence evaluation criteria】 Attachment 1

Frequency of occurrence	Nominal frequency of occurrence	Probability of occurrence
5	Level of repeated encounters in a lifetime (occurring in less than 3 to 6 months)	3/10
4	A level that has more than one encounter in a lifetime (occurring about once every six months to a year)	3/100
3	A level that has several encounters in a lifetime (occurring in less than 3 to 5 years)	3/1,000
2	A level that has very few encounters in a lifetime (occurring about once every 5-20 years)	3/10,000
1	A level that is close to zero encounters in a lifetime (occurring once in more than 20 years)	3/100,000

Table 12-1 Example of criteria for setting a quantified assessment (frequency of occurrence)

Quantified risk assessment index guidelines (criteria)

【Severity evaluation criteria】 Attachment 2

Level	Health and safety	Public concern	Environment impact	Economic loss	Management system
4	Death/public impact	Worldwide media coverage	Large-scale and long-term pollution	100 mm yen above	Complete shutdown
3	Serious injury or illness, limited public impact	National press coverage	Serious pollution	10 - 100 mm yen	Possible shutdown
2	Minor injury, small impact on public	Reported in local press	Medium-sized pollution of medium duration in a limited area	5 mm - 10 mm yen	Affected
1	Minor injury/ no public impact	Rarely broadcasted	Minor pollution or no pollution	Less than 5 mm yen	No impact

Table 12-2 Example of criteria for setting a quantified assessment (severity)

Risk assessment Risk index (criteria)

【Risk severity assessment classification】 Attachment 3

<table>
<tr><th colspan="2">Risk severity assessment</th><th>Level</th><th>Region</th><th>Assessment as to whether or not work can be carried out</th></tr>
<tr><td>1</td><td rowspan="3">LL</td><td rowspan="3">Very low risk</td><td rowspan="4">[Region of safety]</td><td rowspan="9">[Work possible]
Ensure that risk mitigation measures are implemented and that work is carried out in line with this</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td>L</td><td>Low risk</td></tr>
<tr><td>5</td><td rowspan="5">M</td><td rowspan="5">Medium risk</td><td rowspan="5">[Region of uncertainty]
(Permissible and ALARP region)</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td><td rowspan="6">H</td><td rowspan="6">High risk</td><td rowspan="11">[Hazardous region]
(Region whereby permission is not allowed)</td><td rowspan="11">[Work not possible]
Where it is necessary to carry out work in order to respond to an emergency or for other reasons, the work must not be carried out without the permission of the manager, notwithstanding the safety management regulations.</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td></tr>
<tr><td>13</td></tr>
<tr><td>14</td></tr>
<tr><td>15</td></tr>
<tr><td>16</td><td rowspan="5">HH</td><td rowspan="5">Extremely high risk</td></tr>
<tr><td>17</td></tr>
<tr><td>18</td></tr>
<tr><td>19</td></tr>
<tr><td>20</td></tr>
</table>

ALARP AREA：As low as Reasonably Practicable

Table 12-3 Example of criteria for setting a quantified risk level assessment

2 Risk management (response)

Following a risk assessment of the work on board, proactive countermeasures are put in place for each task. There are chiefly five risk countermeasures: Risk Aversion, Risk Reduction, Risk Sharing, Risk Isolation and Risk Holding and so on.

1 Risk Aversion (Fundamental Safety)

This is a method to avoid the risk itself. It means to eliminate the causes of risks.

2 Risk Reduction (Functional Safety)

This is a method to minimize the frequency of occurrences and the impact of damage.

3 Risk Sharing

Sharing the risk with organisations other than the vessel (e.g. ship management companies, shipowners, charterers etc.)

Risk transference and dispersion are two methods of sharing risk. It is important to prepare for compensation of loss, when a risk becomes apparent as this is an effective countermeasure when insuring. In this case, it is also referred to as the transference of risk to an insurance company.

4 Risk Isolation (Physical Countermeasures)

A method that does nothing about the risk itself, but rather isolates it with protective measures.

5 Risk Holding

There is no countermeasure against risk.

This can be said to be accepting the risk, and is used for risks that occur infrequently and causing little damage, but on the vessel, it is necessary to share risk information among the crew.

Figure 13 illustrates the relationship between these measures. The graph shows the probability of a risk occurring on the vertical axis and the severity of the risk on the horizontal axis; by placing each measure in the graph it is possible to observe any response method tendencies.

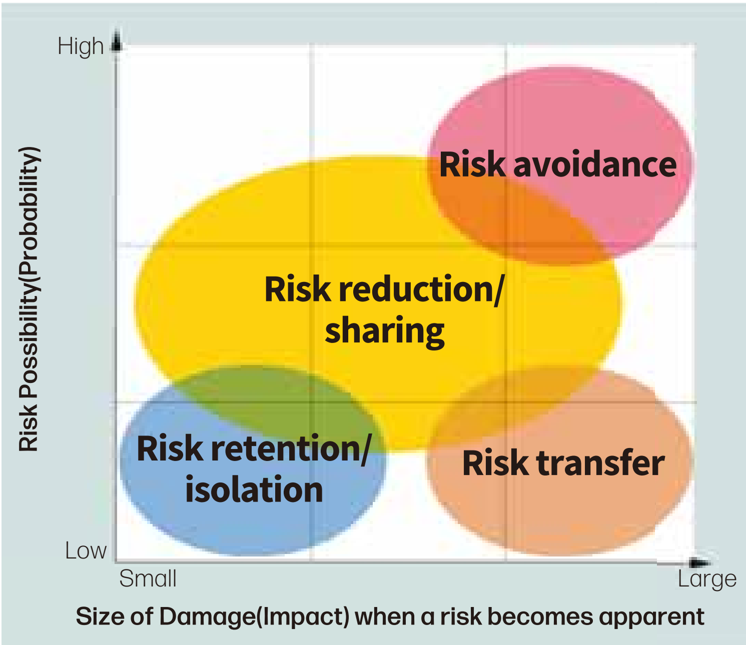


Fig. 13 Risk management correlation diagram

Source: Information security management and the PDCA cycle：Information-technology Promotion Agency, Japan (IPA)

An illustration of the existing risks when carrying out work on board is shown in Figure 14.

In this example, the diagram on the left shows that there are five risks on board. Then, a risk assessment was implemented on board before the start of operation, and as a result of the above mentioned countermeasure in place, three risks remained on board, as shown in the below diagram.

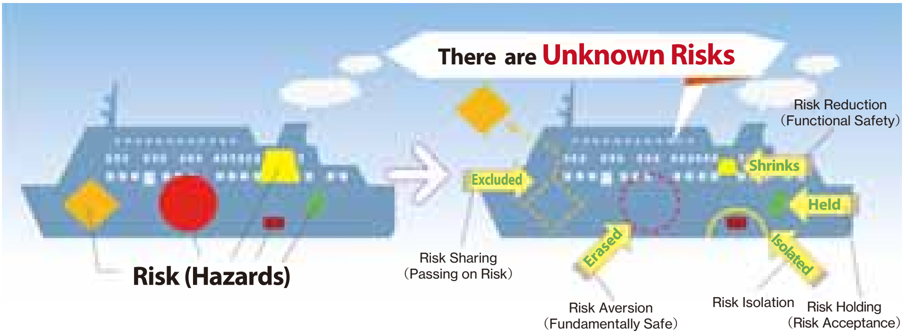


Fig. 14　Diagram of risk management

However, the reality is that it is difficult to eliminate or remove risks in actual on board operations. Therefore, it seems that most of the countermeasures are “managing residual risk”, such as reduction, and risk holding by sharing information among the crew, or isolating it by means of shipboard work. However, even with these countermeasures in place, it is a must to be aware that there is still a potential unknown risk that none of the crew will be aware of. These countermeasures can be prioritised as shown in Figure 15.

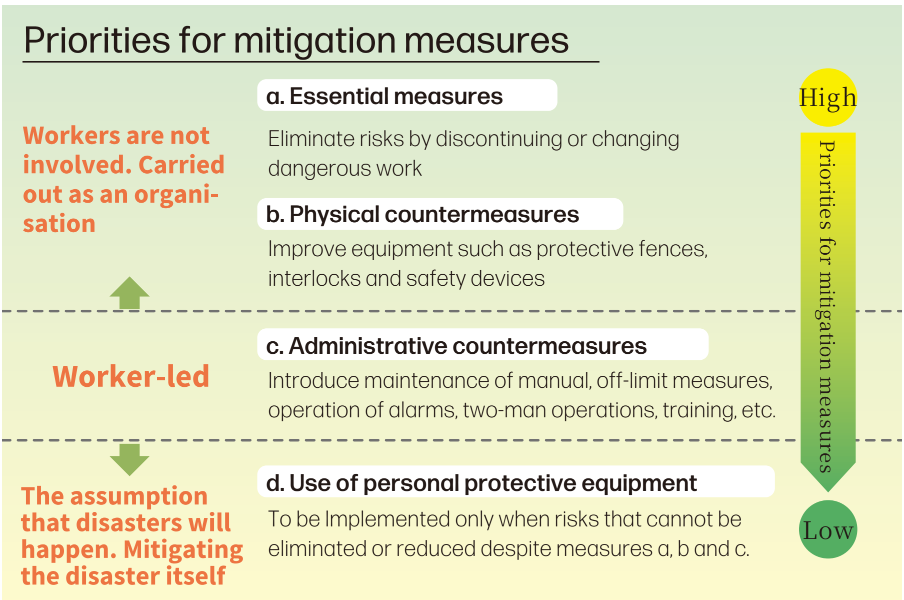


Fig. 15　Priorities for reduction measures

In Figure 15, “a. Essential measures” refers to the measures mentioned in Figure 14, such as removing or eliminating the risk. If these measures are implemented, the risk itself will disappear from the vessel and safety will be maintained instead.

In addition, “b. Physical countermeasures”, also shown in Figure 14, is a measure such as isolation, which can be simply dealt with by shipboard work, but it is often difficult to implement on board in practice because of the cost.
Therefore, these two countermeasures require a response from the company, with little or no crew involvement.

On the other hand, countermeasures “c. Administrative countermeasures” and “d. Use of personal protective equipment” refer to the reduction and holding of risks in Figure 14, which shows the above mentioned “managing residual risk”. In “c. Administrative countermeasures”, these are to be considered by both the ship management company or shipowner and the crew and, possibly incorporated into the safety management code and SMS manual. However, these countermeasures do not eliminate the risk from the vessel.

In addition, countermeasure “d. Use of personal protective equipment” is only applicable if the risk level is low and the risk held is determined as is. This is a reactive measure, which assumes that a disaster will occur and mitigates the damage.
Obviously, the priority is higher for “a. Essential measures”, but from the crew’s point of view, the idea of differentiating risk levels in this way has never been applicable before, and they may not be accustomed to the idea of prioritisation per se either.

Residual risk management

Residual risk is defined in the ISO/IEC Guide 51 as “risk (3.9) remaining after risk reduction measures (3.13) have been implemented”.

As mentioned above, the limited and special working environment of a ship makes it difficult to take essential and physical countermeasures. For residual risks, the concept of "ALARP" as described below is less familiar to the vessel. However, the vessel and the shipowner and ship management company must be fully aware of these residual risks.

ALARP

ALARP: As Low As Reasonably Practicable

As explained in 10(2) of the "Guidelines and Commentary on the Investigation of Danger or Hazards, etc." (provisional translation) by the Safety Division of the Industrial Safety and Health Department, Ministry of Health, Labour and Welfare (MHLW) in 1999, risk is the "concept of reducing risk appropriately to as low a level as is reasonably practicable (ALARP) by implementing higher priority risk reduction measures as far as reasonably practicable." (Provisional translation)

Risk can be divided into the following three areas:(Figure 16)

(a) An area of risk where the risk is too great to be tolerated at all (Intolerable).

(b) An area where the risk is considered to be small or too small. A generally acceptable risk (Broadly acceptable).

(c) Area between (a) and (b), and it is required to be reduced to a level that is realistic, taking into account both benefits of accepting that risk level and the costs of further reducing it (ALARP region).

There are a large number of explanations regarding the ALARP region, but it has not (and cannot) been defined as to what risk level reduction is acceptable, as it varies from case to case.

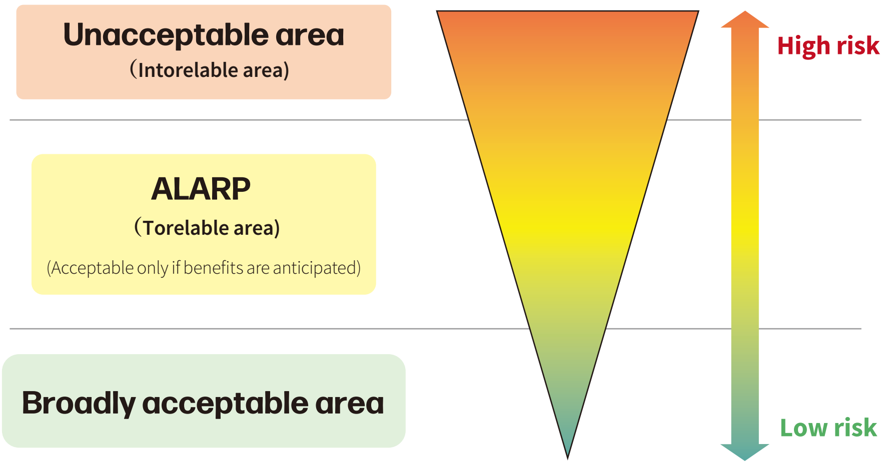


Fig. 16　ALARP region

Please note that the acceptable risk level is not future-proof, but constantly changing, as it is determined by the below factors:

- The values of today's society
- The search for the best balance between the ideal of absolute safety and what can be achieved
- Requirements/specifications that are compatible with the task (system)
- Optimality factors for objectives and cost effectiveness
- The level of acceptability and unacceptability is in a sense a matter of social consensus (consensus: laws and regulations, and standards)

Remarks on risk management(countermeasures for risk reduction)

The following points should be noted when considering and implementing countermeasures for risk reduction.

When formulating

- This is to be carried out mainly by supervisors such as the Master/Chief Engineer and Chief Officer/First Engineer. If necessary, a draft proposal is drawn up, with advice from the ship management company and other experts.
- It is important that a broad range of risks is extracted. The first step in this process is to specify the differences between " direct and deliberate actions and reasonably foreseeable misbehaviours or error in operation ". Then, based on the purpose of the work and the environmental conditions of the workplace, the work process then needs to be clarified. At the same time, naturally assuming that " people make mistakes and errors ", we need to be able to anticipate the kinds of mistakes and errors that people will make, to get a full picture of these and to identify weaknesses in advance.
- It is important to check if the draft conforms with the standard of laws and ordinances, safety management codes and SMS manuals.
- In addition, any mitigation measures that have been formulated need to be checked that they have not created any new risks.
- The possibility of transferring the risk through Essential or Physical countermeasures is to be also considered.
- The mitigation measures (a draft proposal) prepared by the supervisors such as Master/Chief Engineer or Chief Officer/First Engineer are to be explained to the crew and all ideas that can be put forward are discussed and refined. The final risk reduction measures are then shared with the shipowner and ship management company.
- The shipowner and ship management company should re-evaluate the risk reduction measures developed by the vessel and feed back the results to the vessel.
- No mitigation measures should be taken that intentionally (or arbitrarily) reduce the risk level. Also, verify which risk factors (hazards) are affected by the mitigation measures to be implemented.
- Countermeasures that rely on Man/People (crew here) do not, in principle, reduce the risk level.

- We have to think more on the safe side, bearing in mind that skill levels vary from person to person.

While working

- A supervisor must be present during the work to oversee its implementation. A record, including photographs, must be kept. It is also a recommendable idea to create a format for the report form.
- Regarding operations in the context of risk reduction and holding, it is possible that some of the mitigation measures developed cannot be implemented immediately, or may not function effectively. In this case, either provisional measures (obviously more safety-oriented) must be implemented on board with the approval of the supervisor, or the work must be terminated. In the event of any provisional measures taken or work terminated, it is a requirement that it be reported immediately to the shipowner or ship management company to receive advice as well.

After completing the operation

- It is important to have a Review Meeting every time to check that there was no trouble.
- The results should be shared with the crew and a record made and reported to the shipowner and ship management company. The reports from each ship are accumulated as company know-how and become a technical resource for the creation of a strong workplace on board.

  The company's management of the database enables it to provide information to each ship and workplace on board in a timely manner.

3 Risk communication

The definition of risk communication is given in “Efforts for risk communication concerning food safety” in the Ministry of Health, Labour and Welfare’s homepage.

Definition of risk communication

This is the mutual exchange of information and opinions between risk assessors, risk managers, consumers, operators, researchers and other interested parties during the entire risk analysis process. It includes an explanation of the results of the risk assessment and of the risk management decisions.

- “Sense of security”, which is present progressive [continuous] in form, is placed on top of “safety”, consisting of a sequence of events in the past (including risks acceptable according to science, technology and technicians). (Fig. 17)
- Regarding the structure of risk communication, “safety” is formed by science, technology and technicians; the next level consists of “risk assessment” and risk management, then on top of that comes risk communication supporting the “sense of security” in the shape of two “wedges” which mean trust.
- The vessel, the ship management company and the shipowner are all interchangeable. It is important to reassure clients (owner and charterer) through risk communication about the “safety measures” that have been established.
- In the case of actual work on board, the crew must be able to carry out their work with a “sense of security”.

In other words, it is not possible to maintain safety if the Master/Chief Engineer or Chief Officer/First Engineer is left holding on to the prevention countermeasures, against accidents, that have taken so much effort and time to be established, and it is not possible for the crew to carry out the work with a sense of security.
Therefore, we must communicate the countermeasures we have developed to all parties involved, and that the risks which are shared, reassurance, and a sense of security supported by mutual trust, are firmly established. Risk communication is the method to achieve this.

Fig. 17 Risk communication connecting safety and sense of security

Figure 14 on P.27 shows five risk countermeasures on board. Inevitably, with on board operation, it is difficult to take essential countermeasures that exclude or erase risks; we can only reduce or hold the residual risks that remain. In addition, there are unknown risks that no one on board will be aware of, and it is in these fluctuating conditions that the safety of the ship is maintained. This means that shipowners, ship management companies and charterers etc. have to be prepared for any possible trouble that may occur on board at any time.

It is necessary to make these risk measures (reduced or held) visible and to share information between crew members and between the ship and the shipowner or ship management company, in order to support each other through mutual trust via risk communication.

But is there still a lack of risk communication within the vessel and between the shipowner and the ship management company?

The approach of increasing the level of safety through risk communication is known as the Johari Window. As was introduced in a previous Loss Prevention Bulletin, the Johari Window is a psychological model used for self-analysis. By analysing information about the self as seen by the self and the self as seen by others, we can understand the self in the following four ways.

The Johari Window model

1. Personality known by the person as well as by others (Public : Open window)
2. Personality known about the person by a group that the person is unaware of (Blind spot window)
3. Personality that a person knows about themselves that is kept unknown to others (Hidden window)
4. Personality that is unknown by the person about themselves that is also unknown by others (Unknown window)

Let us consider how this might apply to risk assessment. When blind spots, secrets, and unknown areas are reduced and risks that are existing are shared via risk communication, the public (Open window) area is expanded. And by reducing these unknown risks as much as possible, the safety level is steadily increased. (See Figure 18)

In other words, the Open area specifies that all members within the range of activity, including the vessel and its land management department (shipowner and ship management company), are equally aware of the danger, thus proactive measures can be taken.

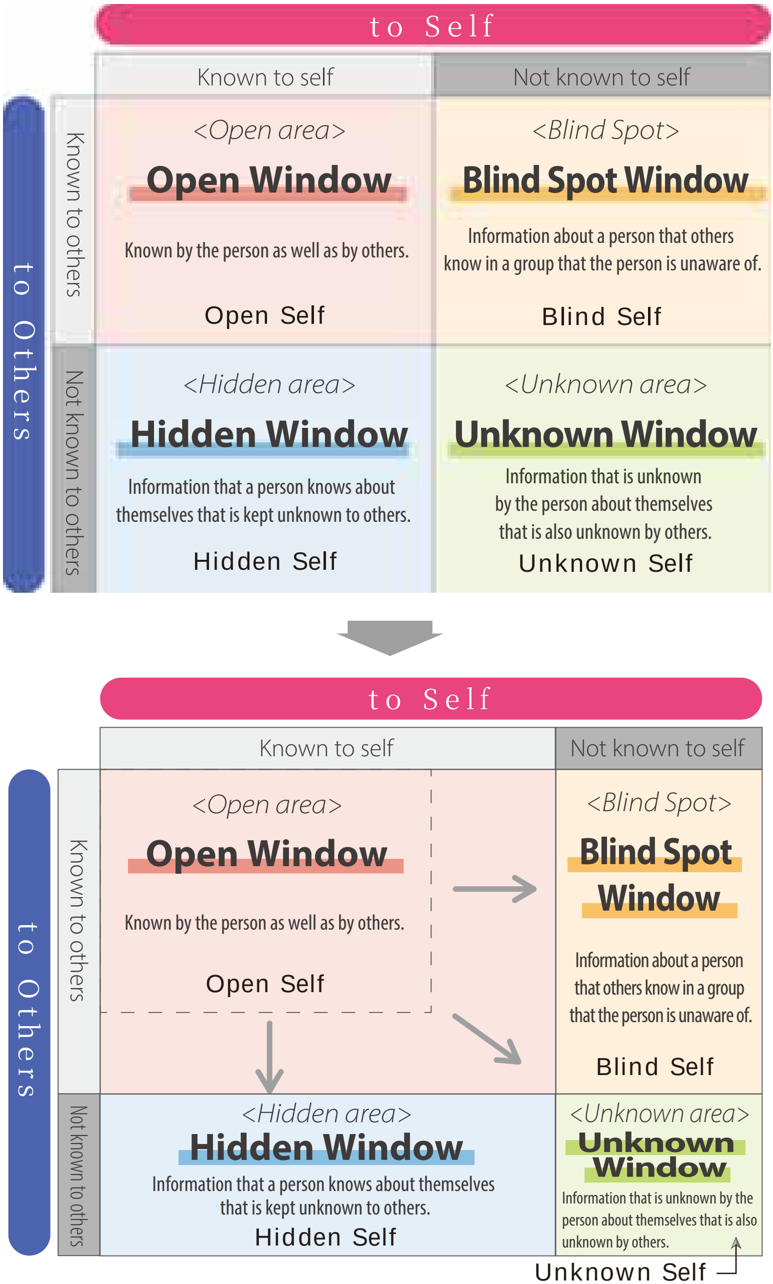
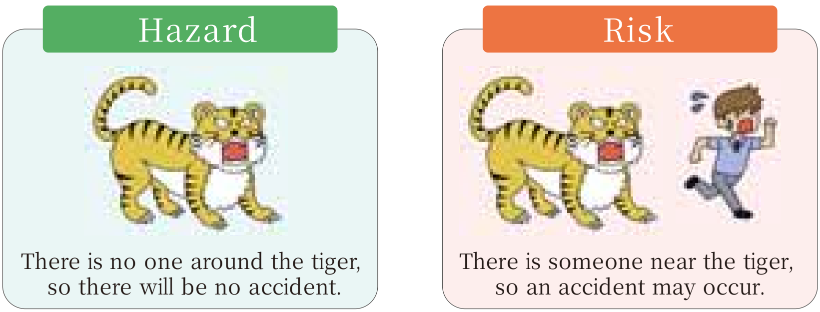


Fig. 18 Johari Window

So far, we have described hazard identification and risk analysis (assessment, management and risk communication) as a process of risk analysis. However, when I attended a risk assessment training course, I found it difficult to understand simply reading the text and listening to the lecturer's explanation.
As the importance of risk communication has already been described earlier, it will be easier to understand the otherwise basic aspects of hazard identification, risk evaluation and management, as can be seen in the diagram below. (Extracted from a set of documents related to a risk assessment training course the author attended as a Master.)

◆ Hazard identification (See P.16 and Fig. 8 Hazards vs risks for details)

There is a tiger that can move around freely, but this only means that there is a hazard, not a risk. When a human approaches this free-roaming tiger, the risk of being attacked arises and turns into a risk in itself.



If anyone approaches the tiger, they may be attacked and injured.

Fig. 8 Hazards vs risks (reprinted)

Risk assessment

Let us attempt to assess the severity and likelihood of personal injury in the case of a person being attacked by a tiger, using 2) Quantified method (P.22) explained in 3-4-2 Risk assessment setting methods.

- Likelihood : It is not certain that the human will be attacked by a tiger, but it is most likely: level“ 5 ” (Table 12-1 Frequency of occurrence evaluation criteria).

- Severity : An attack by a tiger can result in serious injury or death, so the risk level for“ health and safety ”is“ 4 ” , the highest, according to Table 12-2 Example of criteria for setting a quantified assessment (severity).

Therefore, the value obtained by multiplying “Frequency of occurrence evaluation criteria” and “Severity evaluation criteria” is “20”, which, when compared to Table 12-3 Risk severity assessment classification, results in a risk assessment of “HH：very high risk”. This applies to the intolerable area of risk in Figure 16: ALARP region. Therefore, risk management requires the “implementation of countermeasures for risk reduction immediately”.

Risk management

As shown on P.27 Fig. 15 Priorities for reduction measures, the following ① and ② are measures taken primarily by the land management department such as the shipowner or the ship management company.
Also, ③ is more of a vessel (crew) driven measure, but it requires support from the shore side as well. In addition, ④ can be seen in the diagram of ALARP region (P.30 Fig. 16), and this belongs to “broadly generally acceptable risk level”. Then, without taking countermeasures from ① to ③ , this is a measure that can be implemented on board the vessel, while Holding the hazard.

① Essential measures:　Risk avoidance

Countermeasures to eliminate the hazard itself or reduce the severity of the risk by removing the danger or replacing a hazardous material (essential improvement) at the time of planning or design.
In this situation, the option would be to stay away from areas where tigers can move around freely (or, in the case of on-site work on the vessel, to not do so). Alternatively,

replacing the tiger with a less dangerous or harmful “cat” would be an essential measure (Figure 19).

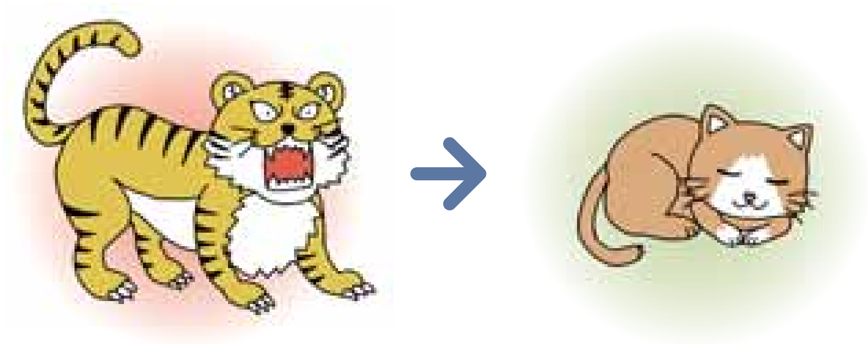


Fig.19 Essential measures

② Physical countermeasures

Putting in place safety measures and additional protection, such as the installation of protective fences, interlocks and various safety devices, the hazard itself is still there, but the countermeasures render it physically inaccessible.

The risk level is higher as the tiger can move around freely, but if the tigers are kept in cages as in a zoo, the human will not be attacked (Figure 20).

Fig. 20 Technical countermeasures

③ Administrative countermeasures

Introduce maintenance of manual and revision of work behaviour procedures, off-limit measures, operation of alarms, two-man operations, training, etc. as countermeasures. In other words, this measure is to implement corrective action related to the duty of care for safety when carrying out work against residual risks in order to ensure that the crew are not involved in the hazard. These include deck markings, posters and hazard tape (black and yellow stripes) and sponge protection, as is common practice on board. (Figures 21-1 and 21-2)

Fig. 21-1　Administrative countermeasures

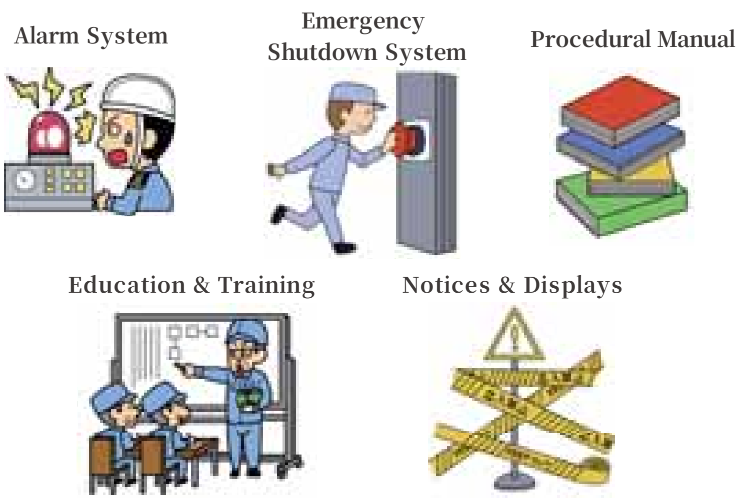


Fig. 21-2　Administrative countermeasures

④ Use of personal protective equipment

When it is assumed that a disaster will occur and that, if it does, it will not result in serious injury or damage. These are low-level residual risk measures that cannot be eliminated or reduced by the risk reduction measures described above, (from ① to ③). For example, in Tool Box meetings held on board, the wearing of helmets and non-sparking shoes is a matter of course, additionally, instructions and compliance for the use of safety harnesses for working at high places and the use of safety glasses for painting rust are also required as a countermeasure (Figure 22).

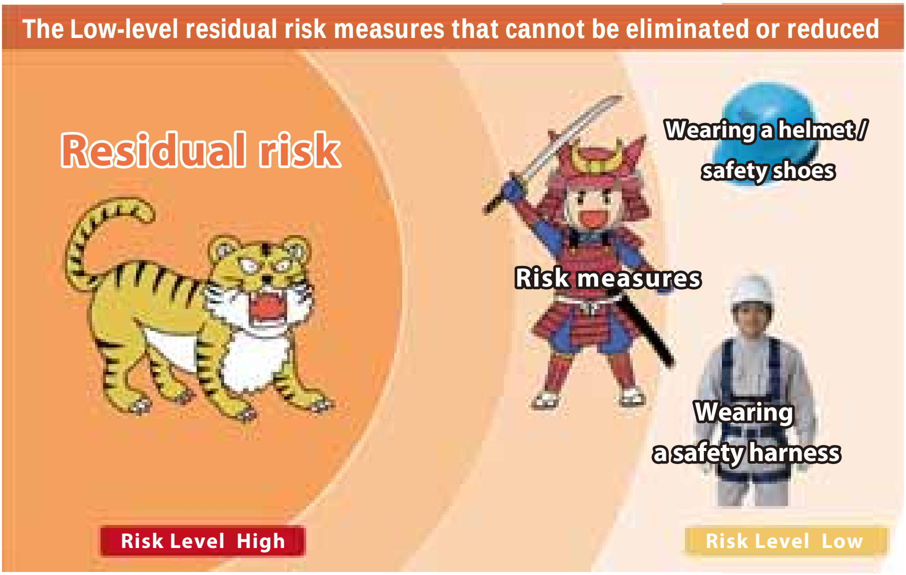


Fig. 22 Use of protective wear

3-5 Why is risk assessment not effectively utilized on a vessel and/or by ship management companies? ＝ Problem areas ＝

Problem areas

As described above, it is understood that the combination of risk assessment and BTM/ETM described at the beginning of this guide is an effective means of prevention (through countermeasures) against accidents, especially when carrying out any unusual (unfamiliar) work on board. Therefore, why are we not able to carry it out effectively, despite the fact that we are aware of this?

Seemingly, there are mainly four reasons why risk assessment is not effectively utilized on a vessel and/or by ship management companies:

- It is not easily incorporated on board
- Psychological factors
- The ambiguity between safety and danger
- Human resource problem: The need to train personnel who can identify risks

The combined effect of these four factors is that risk communication, which is based on trust among crew members and between ship and shore, does not work effectively and becomes more difficult to carry out.

3-5-1 The difficulty of incorporating risk assessment on board a vessel

In the first place, risk assessment is one management tool used in corporate management such as compliance and fraud prevention.

As shown in Figures 6 (on P.13) and 23, the social context in which companies operate