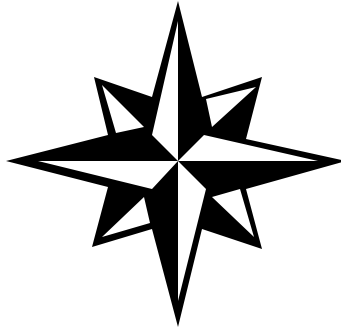


# Marine Operations Risk Guide



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A Guide to Improving  
Marine Operations by Addressing Risk

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## ACKNOWLEDGEMENTS

A substantial and sincere thank you is conveyed to the Chemical Transportation Advisory Committee (CTAC) and the Prevention Through People (PTP) Subcommittee for the latest revision of this risk guide. These groups have provided a very user-friendly, qualitative risk assessment tool to date. The entire maritime industry will benefit from their work. Special recognition is given to the organizations that piloted and advanced the *Passenger Vessel Association (PVA) Risk Guide* and the *Marine Operations Risk Guide*. We are especially grateful to those who contributed to the case study and tested the guide in their own operations. They have proved the profits of mitigating risks.

Significant appreciation goes out to the Coast Guard/PVA Partnership Action Team. They developed the original document on which this guide is based: the *PVA Risk Guide*. Although the original guide was easy to use and scientifically sound, it was more narrowly focused. Because of its niche, many mariners did not grasp the guide's applicability to their operations and lost opportunities to increase safety, productivity, and ultimately profitability. Therefore, this guide has been revised to expand the applicability to a broader scope of marine operations.

*The U.S. Coast Guard, PVA, and CTAC assume no liability for operational changes implemented as a result of the use of the Marine Operations Risk Guide. Decisions are made as a result of your own expertise and best judgment. The Marine Operations Risk Guide only provides a framework for assessing and managing risk.*

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## INTRODUCTION

### *What is Risk?*

Risk is a factor that everyone encounters in maritime operations. Decisions made everyday are based upon risk. Usually, decisions are intuitive in nature and rooted in common sense. The decision, for example, of whether or not to get a marine vessel underway entails a risk assessment of forecasted sea or river conditions. If significant tide variations may be encountered, tides should be considered in an effort to minimize the risk of grounding. To manage such a risk, the operator might choose to depart earlier, load less cargo, or delay departure until more favorable tide conditions exist. Similarly, an operator at a marine terminal may evaluate the draft required for a certain vessel before allowing that vessel to dock at the facility. If the draft is a potential problem, the operator may alter the time that the vessel is allowed to dock or the duration that it is allowed to remain at the dock.

Everyday decisions, like those made based on the tide before sailing and a vessel's draft before mooring, do not usually require the use of a formal risk assessment guide. But, suppose an operator wants to employ a new, larger vessel in a specific trade. Suppose the new vessel is to be significantly larger than what has been employed previously and will be required to moor at a particular marine terminal. There may be Coast Guard issues that must be resolved before approval for this new operation can be granted. In such a case, a risk assessment that details anticipated hazards and examines the likelihood and consequences of those hazards, and a risk management plan that specifies additional safety measures to mitigate those hazards, could organize and clarify the important issues at hand and help the Coast Guard in its consideration of that permit.

### *How Can This Guide Help?*

**This guide is designed to help you, the user, become more aware of the potential risks inherent to your operations and identify ways to control those risks.** Developed by the U.S. Coast Guard and CTAC's PTP Subcommittee, this guide provides a step-by-step means of assessing risk within any chosen operation and helps you develop ways to reduce or even eliminate those risks, thereby making your operations safer.

Use this guide to evaluate proposed operations, survey existing operations, or determine the effect of operational changes (e.g., increased traffic or low water). It is meant to address safety and environmental issues for any situation you choose to analyze. The situation can be local, confined to a single vessel, or it can be even broader, involving an entire fleet or port area. **This guide is intended to provide the mariner and operator with a tool for identifying opportunities to reduce risk exposure. This guide is not intended to provide the Coast Guard with a means to regulate at the port level.**

Risk should be addressed in terms of three activities: **risk assessment, risk management,** and **risk communication**. The relationship between these three activities is shown in Figure 1. This guide breaks these three activities into ten easy steps. Following these steps will help you identify potential problem areas in your operation, balance tradeoffs, and assist in decision making. Ultimately, this guide does not make decisions for you. Instead, it shows you what to consider in making the best decisions possible. For more information on Risk Management, please visit the U.S. Coast Guard’s Risk-Based Decision-Making website at <http://www.uscg.mil/hq/g-m/risk/>.

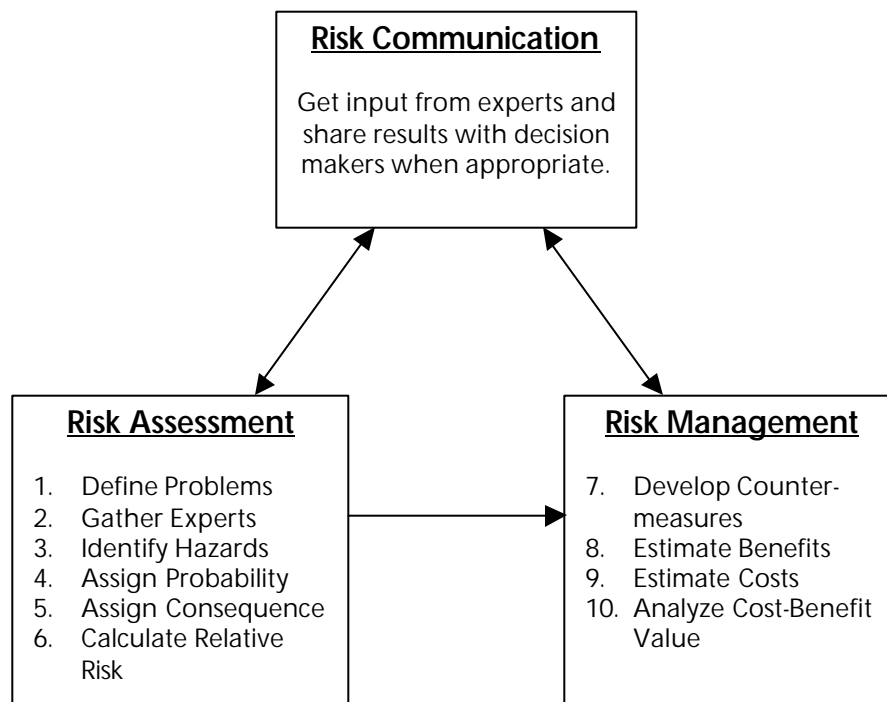


Figure 1. Process for Handling Risk.

**The following terms are used throughout this guide:**

**Accident** is an undesired event involving fatality, injury, ship loss or damage, other property loss or damage, or environmental damage (e.g., fires, collisions, etc.).

**Cause** is a reason that an incident may occur.

**Consequence** is an outcome of an accident.

**Benefit-Cost** is a measure of the risk reduction to the amount of dollars spent.

**Countermeasure** is a means of controlling a single element of risk.

**Frequency** is an actual or estimated number of occurrences of a hazard causing an accident per unit of time.

**Hazard** is a condition (actual or perceived) that has the potential to cause harm.

**Incident** is a condition that may lead to an accident.

**Risk** is a combination of the frequency and the severity of the consequence of a specific accident.

**Risk assessment** is a process for identifying hazards and assessing the risk (probability and consequence) posed by each.

**Risk communication** is a two-way process that (1) allows all stakeholders the opportunity to provide input into the process, and (2) provides a means of showing the value of decisions to others, which is particularly important when dealing with regulatory agencies or the public.

**Risk management** is a process for dealing with the assessed risks through the development of cost-effective countermeasures.

**Here is an example using a few of these terms regarding risks associated with an electrical power supply line:**

Hazard = High Voltage

Incident = Exposed Wire

Accident = Personnel Contact resulting in Shock

Consequence = Burns / Electrocution

**The following icons are used throughout this guide:**



Look for this icon for assessment advice. This guide is filled with expert tips, shortcuts, and lists to help you quickly and effectively perform each step of the assessment.



This icon points you toward the Marine Risk Assessment Worksheet located in Appendix 1. The worksheet will help organize your work for each step.

# step **1**

## **DEFINING THE PROBLEM:**

### *What areas will this risk assessment evaluate?*

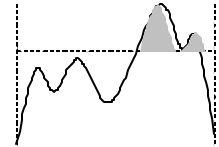
Before jumping into this process, define the scope of your assessment to help focus your efforts to determine what parts of your operation you can examine in the time you've set aside. To decide this, ask yourself a series of questions. Do you have the time to look at every aspect of your operation? The answer is *probably not*. Do you want to know where to get started in putting your greatest effort and resources in managing environmental or safety issues? Do you only want to look at certain timeframes such as during the loading of specific cargo? Perhaps you only have a specific problem you want to deal with, for instance, cleaning up a specific spilled cargo on the deck. All of these problems may be dealt with by using this guide.



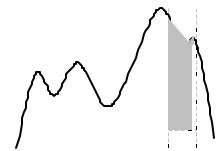
Think of your entire operation and the range of all potential problems as a mountain range.



Looking at the entire scope of your operation, you may only be able to focus on the highest of peaks within your available time frame.



However, if you choose a specific aspect of your operation (e.g., cargo loading) you can examine it in greater depth and detail. This approach is more effective for targeting specific problems.



Make a copy of the Marine Risk Assessment Worksheet located in Appendix 1. Use this worksheet as you go through the remainder of this process. In the spaces provided on the worksheet, enter the name of your company, vessel, or facility, and describe the operational phase being considered.



## step 2

### **SELECTING EXPERTS:**

#### ***Who should be involved in this assessment?***

After defining the scope of the assessment, determine who needs to be involved. This is a key part of the process. The right mix of people and experience is necessary to get the most out of your assessment. Different experts will identify different risks and produce different results. Therefore, a group representing all of the various concerned parties will provide the best basis for your risk assessment.

Does your assessment involve an entire port? If so, it might be a good idea to involve the Coast Guard, the local port authority, and harbor master. Does your assessment involve only your vessel? If so, perhaps your vessel crew and the Coast Guard are the only two parties that need to get involved. If you are concerned about deep-draft traffic, you may want to include a deep-draft operator or a local pilot. Marine terminal operators involved with your operations may also be valuable team members.

Participation will vary from assessment to assessment. For best results, recruit between three and seven participants. You may also choose to involve participants for only a particular portion of the process. For example, consider involving additional operators to answer the question “What can go wrong?” Their perspectives of the operation may be different from those in the core group.



The following list gives examples of potential participants:

- Fleet and marine terminal personnel
- Shore-staff operations, engineering, maintenance personnel, and management
- Environmental organizations
- Industry associations
- Local Coast Guard
- Local port authorities
- Local towing companies and pilots
- Coast Guard Auxiliary
- Harbor masters
- Other safety organizations (e.g., EMS personnel, fire chiefs, local hazmat groups, industry mutual aid groups, local police)
- U.S. Power Squadron
- Waterway patrol officers
- Yacht/sailing clubs
- Other interested vessel or marine terminal operators



In the spaces provided on the Marine Risk Assessment Worksheet, write the name and relevant background information of each participant.

# step 3

## **IDENTIFYING HAZARDS AND POTENTIAL ACCIDENTS: *What can go wrong?***

Once you've defined the scope of this process (step #1) and assembled a group of experts (step #2), you can get into the more specific aspects of the assessment. Ask yourself, "What can go wrong?" Develop a list of hazards and related accidents that could occur. Do not limit yourself to only those accidents that have historically occurred. An example chart of hazards and potential accidents are as follows:

<b>Hazard</b>	<b>Accident</b>
Operations in restricted waterways or near exposed reef	<ul style="list-style-type: none"><li>▪ Groundings</li><li>▪ Bottom scouring</li></ul>
Bad weather	<ul style="list-style-type: none"><li>▪ Loss of crew overboard</li><li>▪ Damage to vessel</li></ul>
Handling toxic substances	<ul style="list-style-type: none"><li>▪ Spill</li><li>▪ Personnel exposure</li><li>▪ Improper waste handling</li></ul>
Hot work started without authorization	<ul style="list-style-type: none"><li>▪ Fire</li><li>▪ Injury to personnel</li><li>▪ Vessel damage</li></ul>

When compiling this list, be sure to remain within the scope of the assessment. If you are only concerned with what happens while underway, a fire resulting from welding repairs at the dock should not be considered. If such a fire is of great concern, perhaps a separate assessment should be undertaken. Also, list only those hazards and potential accidents that are directly related to negative impacts or consequences within your operation. Be specific! It is very difficult to assign frequency ratings (step #4) and consequence ratings (step #5) to hazards and potential accidents that are too broad in scope (e.g., all groundings).



One way to identify hazards and their associated accidents is to develop a flow chart of the operation(s) you have decided to assess. List or describe each function or activity being performed (within your specific area of concern). These functions or activities will be sequential in nature and usually follow a timeline. This flowchart will give you a relatively broad picture of the operation. Suppose you decide to examine only the portion of your operation when you are carrying hazardous cargo and you are concerned about personnel exposure. A flow chart that might apply in this case is presented in Figure 2.

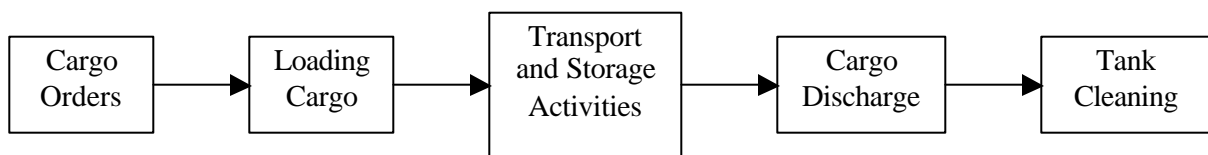


Figure 2. Flow Chart for Transporting Hazardous Cargo

From the moment that cargo orders are received in the office to when the ship's crew prepared the tanks for the next cargo, you will examine each activity of that phase of the operation and identify where the potential exposures to the hazardous cargo exist. As you analyze each activity for hazards, you want to ask yourself, "What happens if this occurs?" and "What would be the consequence if what is expected to occur does not occur?" Refer to the case study in Appendix 2 for greater detail.



Here is a partial listing of potential hazards and accidents to consider. Depending upon the problem you have defined, additional hazards may need to be added.

Personnel Casualties:

- Crew injury involving machinery
- Crew injury while alongside or getting underway (e.g., line handling injuries, dock-jumping injuries, falling into water)
- Man overboard
- Medical emergency
- Crew violence
- Slips, trips, and falls

Material Casualties – Ship:

- Allision (impact with a fixed object)

Material Casualties – Ship (continued):

- Collision due to inattention
- Collision due to mechanical failure
- Collision due to other ship's fault
- Drift grounding caused by mechanical failure
- Engine room/machinery space fire
- Explosion on board
- Galley fire
- Hard docking resulting in damage
- Powered grounding
- Other shipboard fire

Material Casualties – Shore:

- Explosion in terminal
- Fire in terminal
- Structural damage to terminal due to ship allision
- Fire on vessel
- Hose failures
- Seal and flange separations

Environmental Impacts:

- Bottom scouring
- Exhaust emissions
- Hazardous material discharge
- Noise
- Pollution due to oil discharge
- Sewage discharge
- Vapor cloud release
- Cargo emissions

Human Errors:

- Inattention
- Failure to follow procedures
- Improper maintenance
- Inadequate training
- Fatigue



In the spaces provided on the Marine Risk Assessment Worksheet, describe the hazards and potential accidents that could occur.

# step 4

## **ASSIGNING FREQUENCY: *How often will it happen?***

At this point, you are ready to discuss and establish a frequency scale. For each hazard and its associated potential accident identified in the previous step, rate the likelihood of that hazard leading to an accident. How often might it happen?



Note that this is an estimate of how often the potential accident could *possibly* occur, not how often a hazard presents itself. Just because you may encounter a certain hazardous situation every day does not mean that you will experience its associated accident every day.

Decide how frequently each of the hazards and undesirable events listed in step #3 could become reality and cause harm. Discuss each hazard and event and rate them using the Table 1 or a similar scale that has been tailored to your particular analysis.

<b>Assign a rating of</b>	<b>if the frequency is</b>
1	REMOTE = Might occur once in a lifetime
2	OCCASIONAL = Might occur every five-ten years
3	LIKELY = Might occur every one to five years
4	PROBABLE = Might occur yearly
5	FREQUENT = Might occur more than once per year

Table 1. Frequency Scale

When rating your group of hazards and potential accidents, compare them to one another to ensure consistency. You may have refined your ideas about the rating scheme in the middle of this step. Thus, some ratings may need to be adjusted to make them consistent with your new ideas. To aid in the assignment of frequency ratings, review the historical performance of your

company and/or that of your industry. These ratings will be used in step #6 to help determine which hazards and their related accidents pose the greatest risks.



If you choose to use your own frequency scale, be sure it has enough rating categories to clearly distinguish between a likely occurrence and one that is unlikely.



In the spaces provided on the Marine Risk Assessment Worksheet, fill in the frequency rating for each hazard and potential accident. Note that these ratings are subjective estimates.

# step 5

## ASSIGNING CONSEQUENCES: *What is the impact?*

In addition to the frequency scale that you just created, you must also establish a consequence, or impact, scale. For each hazard and potential accident identified in step #3, rate the impact that would result from that hazard materializing into an accident. Once again, discuss each hazard and event and rate them using Table 2 or a similar scale that has been tailored to your particular analysis.

Assign a rating of	if the impact could be
1	NEGLIGIBLE = Injury not requiring first aid, no cosmetic vessel damage, no environmental impact, no missed voyages.
2	MINOR = Injury requiring first aid, cosmetic vessel damage, no environmental impact, additional work, minor operational disruption, no missed voyages.
3	SIGNIFICANT = Injury requiring more than first aid, vessel damage, some environmental damage, longer operational disruption, or financial loss.
4	CRITICAL = Severe injury, major vessel damage, major environmental impact, major operational disruption missed voyages (up to and including the entire season).
5	CATASTROPHIC= Loss of life, loss of vessel, extreme environmental impact.

Table 2. Consequence (Impact) Scale



As in step #4, have enough ratings to distinguish the likely consequences from the unlikely to assign ratings accordingly. As in the previous step, compare the ratings for consistency to make sure they make sense. These ratings will be used in step #6 to help determine which hazards have the highest risks.



In the spaces provided on the Marine Risk Assessment Worksheet, fill in the impact rating for each accident. Note that these ratings are subjective estimates.



# step 6

## **DETERMINING RISK PRIORITY: *Where should efforts be focused?***

Now that the frequency and consequence of each hazard and potential accident have been rated, the ratings can be used to determine relative risk priority scores. These risk priority scores will identify which hazards present the greatest risks for the operation being examined.

Use Figure 3, or a similarly constructed matrix tailored to your particular analysis, to determine the risk priority score for each hazard. First, locate the frequency rating from step #4 in the leftmost column. Then locate the consequence rating from step #5 in the uppermost row. The risk priority score, located where the two ratings intersect, will fall into one of the following four general groups: Very High (VH), High (H), Moderate (M), or Low (L).

**Consequences**

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	
<b>Frequency</b>	<b>5</b>	M	H	H	VH	VH
	<b>4</b>	M	H	H	VH	VH
	<b>3</b>	L	M	H	H	H
	<b>2</b>	L	L	M	M	H
	<b>1</b>	L	L	M	M	M

Figure 3. Risk Priority Matrix

A risk priority of “VH” indicates an event or an accident that is very likely to occur and with very high consequences. A risk priority of “L” indicates an inconsequential event that is unlikely to occur. Risk priorities of “H” and “M” lie somewhere in between. The items with the same highest risk priority scores should be addressed first. Discriminating amongst risk scores within a group can be difficult because of the subjective nature of the analysis and

uncertainty of the operation. However, the panel of experts conducting the risk analysis should discuss those hazards in more depth and prioritize them. Once all hazards have been scored and prioritized, focus your efforts on the highest risk priority scores.

Figure 4 contains an example that shows risk priority scores for corresponding frequency and consequence ratings. Notice that the risk priority score for “Exposure Due to Sampling” falls in the same general group as that for “Exposure Due to Pump Seal Failure.” However, when looking at the table it is easy to determine that the “Exposure Due to Sampling” poses the greatest risk due to the higher frequency rating associated with this operation and, therefore, should be addressed first.

**EXAMPLE:** An evaluation of personnel exposure hazards led to the following results.

Event	Frequency Rating	Consequence Rating	Risk Priority Score
Exposure Due to Sampling	5	3	H
Exposure Due to Fire	1	5	M
Exposure Due to Pump Seal Failure	3	3	H

Figure 4. Risk Priority Score Example



In the spaces provided on the Marine Risk Assessment Worksheet, fill in the relative risk priority scores. Transfer the event descriptions with the highest scores to the spaces labeled “Focus Hazards.” Although there are only three entries for “Focus Hazards” on the worksheet, you may choose to consider more.

# step 7

## DEVELOPING COUNTERMEASURES:

### *What can be done to address these risks?*

Up until now, you have focused on framing the problem, identifying and rating various hazards and potential accidents, and deciding which ones should be addressed first. In this step, you will identify ways to mitigate the hazards and potential accidents that have the highest risk priority scores. Develop a list of countermeasures that can be used to prevent or reduce the consequences associated with the hazards or potential accidents. Some countermeasures may mitigate more than one hazard or potential accident.

For each hazard or potential accident, look for countermeasures that involve people, procedures, and/or equipment. The best way to find these countermeasures is by describing the hazard or potential accident in terms of a causal chain. This chain, shown in Figure 5, captures the series of events that may lead to a casualty or hazardous occurrence.

Countermeasures, applied early in the chain, that address causes and incidents are preferred to those that only reduce consequences. In other words, effective countermeasures are those break the causal chain prior to the accident occurring.

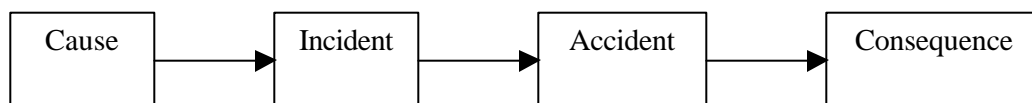


Figure 5. Causal Chain



*tip*

Remember step #2 – Gathering Experts? It helps to get assistance from people who actually perform the tasks on a daily basis. Including these people as you go through each step in the process may be more efficient in the long run.

The example shown in Figure 6 is a continuation of the example presented in Figure 4. In this example, we look at some of the potential countermeasures that could be implemented at various points along the causal chain to mitigate the adverse effects of personnel exposure

while sampling a hazardous cargo. Keep in mind the importance of considering countermeasures that involve people, procedures, and equipment. For instance, conducting training in sampling techniques, performing hazardous materials training, and refreshing medical notifications are countermeasures that focus on people. Modifying a sampling procedure, creating a new hazardous materials handling procedure, and developing new medical notification procedures are countermeasures that focus on procedures. Finally, employing a new sampling system and upgrading personnel protection equipment (PPE) are countermeasures that focus on equipment.

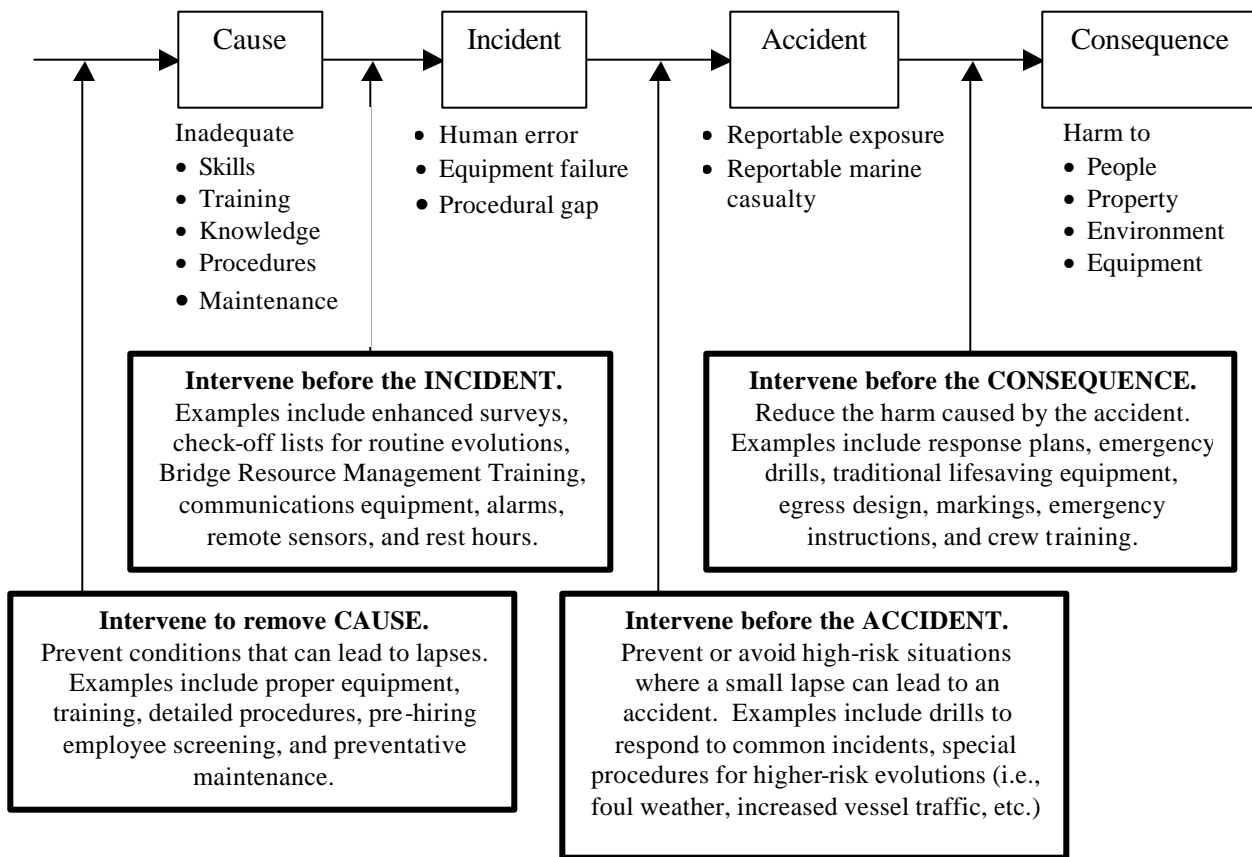


Figure 6. Countermeasures and the Causal Chain Example



In the spaces provided on the Marine Risk Assessment Worksheet, enter possible countermeasures for each focus hazard.

# step 8

## **ESTIMATING BENEFIT:**

### *How effective are these potential solutions?*

A countermeasure is considered effective if it reduces the relative risk priority score determined in step #6. The relative risk priority score can be reduced by decreasing the frequency rating from step #4, the consequence rating from step #5, or both. Discuss each countermeasure and assign an effectiveness value using Table 3 or a similar scale that has been tailored to your particular analysis. Refer to the case study in Appendix 2 for a more in-depth look at this step.

<b>Estimate of Effectiveness</b>	<b>Description</b>
1	NONE = Countermeasure results in no reduction of Frequency OR Consequence rating.
2	LOW = Countermeasure results in reduction of Frequency OR Consequence rating by 1.
3	MEDIUM = Countermeasure results in reduction of Frequency OR Consequence rating by 2.
4	HIGH = Countermeasure results in reduction of Frequency OR Consequence rating by 3 or more.

Table 3. Benefit Estimation Scale



In the spaces provided on the Marine Risk Assessment Worksheet, fill in the effectiveness value for each of the countermeasures that you recorded in step #7.

# step 9

## ESTIMATING COST:

*What are the estimated costs of these potential solutions?*

Estimating the cost of each countermeasure that was identified in step #7 is undoubtedly an important part of this process. While some countermeasures may be relatively cost free, other may be cost prohibitive. You are not expected to come up with hard numbers. A realistic rough estimate should be sufficient. Estimate the cost of each countermeasure using Table 4 or a similar scale that has been tailored to your particular analysis.

Cost Estimate	Description
1	NONE = No cost (e.g., procedural changes).
2	LOW = Minimal cost (e.g., procedural changes, purchasing low level PPE, conducting minor training).
3	MEDIUM = Significant cost (e.g., purchasing high level PPE, refitting hardware, hiring additional personnel).
4	HIGH = Large capital investment.

Table 4. Cost Estimation Scale

The cost estimates should be consistent with the size of your organization's budget. A medium cost for a small company may be a low cost for a larger company. As done in previous steps, compare all of your cost estimates to ensure consistency. A minimal cost, like that of purchasing low level PPE, should be roughly the same as another minimal cost, like that of conducting minor training.



In the spaces provided on the Marine Risk Assessment Worksheet, enter the cost estimate value for each of the countermeasures that you recorded in step #7.

# <sup>step</sup> 10

## **ANALYZING BENEFIT-COST (VALUE):** *Which potential solutions should be considered?*

In this final step, you will combine your results from steps #8 and #9 to produce Benefit-Cost ratios. These ratios will identify the most cost effective countermeasures – those that will give you the most “bang for your buck.” To calculate these ratios, simply divide the estimate of effectiveness value (step #8) by the cost estimate (step #9) for each countermeasure. This step is illustrated in Table 5 using fictitious effectiveness and cost estimate values for the countermeasures labeled A, B, C, and D.

Countermeasures (Step #7)	Estimate of Effectiveness (Step #8)	÷	Cost Estimate (Step #9)	=	Benefit-Cost Ratio
A	1	÷	1	=	1
B	1	÷	3	=	0.33
C	2	÷	3	=	0.66
D	3	÷	1	=	3

Table 5. Calculating Benefit-Cost Ratios

Maximize your safety benefit and minimize your cost by implementing the countermeasures that have the highest Benefit-Cost ratios. In Table 5, countermeasure D appears to offer the greatest Benefit-Cost ratio. It reduces the frequency or consequence rating by 2 at no cost. Also, recognize that some countermeasures may decrease the risk associated with more than one hazard or potential accident at a time. You should consider these countermeasures first.



In the spaces provided on the Marine Risk Assessment Worksheet, enter the Benefit-Cost ratios. Write down the countermeasures having the highest ratios in the spaces provided.

## **CONCLUSION**

This process may have taken a good deal of time and effort your first time through. However, the more familiar you become with this process, the easier it will be to use. You are encouraged to use this risk guide to continually assess your operations and to monitor the progress of your risk management program. Once you have completed this process for an operation of importance to you, it is your responsibility to communicate the results to those who are in a position to implement the appropriate changes.

### **Please send us your thoughts!**

Let us know how you have improved your operations for safety and environmental performance and how your risk management operations have changed as a result of using this risk guide. For the benefit of other mariners and to aid in future revisions of this guide, please provide us with feedback. We look forward to hearing about your personal experiences with this process. Contact us at

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## **MARINE RISK ASSESSMENT WORKSHEET**

STEP #1: Company Name \_\_\_\_\_  
 Vessel(s) Name \_\_\_\_\_  
 Phase of Operation Assessed \_\_\_\_\_

STEP #2: Participant Name	Function/Title/Organization
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

STEP #3: Hazard Description	STEP #4: Frequency Rating	,	STEP #5: Impact Rating	?	STEP #6: Relative Risk Score
_____	_____	,	_____	?	_____
_____	_____	,	_____	?	_____
_____	_____	,	_____	?	_____
_____	_____	,	_____	?	_____
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## **MARINE RISK ASSESSMENT WORKSHEET**

Focus Hazard	STEP #7: Countermeasure	STEP #8: Estimate of Effectiveness	STEP #9: Cost Estimates	STEP #10: Overall Score
A. _____	1. _____	_____	_____	= _____
	2. _____	_____	_____	= _____
	3. _____	_____	_____	= _____
	4. _____	_____	_____	= _____
	5. _____	_____	_____	= _____
B. _____	1. _____	_____	_____	= _____
	2. _____	_____	_____	= _____
	3. _____	_____	_____	= _____
	4. _____	_____	_____	= _____
	5. _____	_____	_____	= _____
C. _____	1. _____	_____	_____	= _____
	2. _____	_____	_____	= _____
	3. _____	_____	_____	= _____
	4. _____	_____	_____	= _____
	5. _____	_____	_____	= _____

STEP #10 (CONTINUED): Choose those countermeasures with the highest Benefit-Cost ratios.

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## *CASE STUDY: Product Tanker*

### **Problem Definition (STEP #1)** **Product Ship Conversion to Carry Benzene**

#### Discussion

As a special project, a tanker company was requested to modify an existing product tanker to routinely carry benzene as a cargo from a refinery in Puget Sound, WA, to the Gulf Coast of the United States. As a part of this process to convert the tanker and modify operating procedures, a risk assessment was warranted to determine what safety modifications needed to be made to current operating practices to protect vessel personnel.

Where will this operation take place? and Which geographic areas need to be examined?

Puget Sound, WA, to the Gulf Coast of the United States.

Which operations are going to be considered in this assessment?

Loading Operations  
Transit Operations  
Discharging Operations  
Tank Cleaning Operations  
Spill Response Operations

What safety and other concerns are to be addressed?

Personnel safety  
Vessel / physical plant safety  
Environment  
Regulatory compliance

This risk assessment focuses on personnel safety during loading, transit, discharging, and tank cleaning operations.

### **Selection of Experts (STEP #2)**

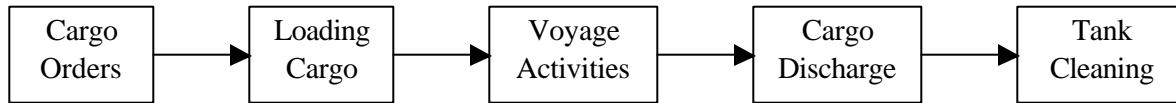
The tanker operator gathered two senior captains, the operations manager, three senior engineers, the Environmental Health & Safety (EH&S) manager, and a senior EH&S advisor.

### **Hazard and Potential Accident Identification (STEP #3)**

This is a key step in the process. It can be done offline by a knowledgeable individual(s) and then verified and corrected by the group of experts. Doing this ahead of time can make the risk assessment process much easier.

## *CASE STUDY: Product Tanker*

### Step #3a: Establish Flow Chart of Operations



### Step #3b: List Operational Activities (sequentially)

#### Cargo Orders:

1. Load cargo into tanks 4 port and starboard

#### Loading Cargo:

1. Vessel tied up
2. Notifications signs placed on deck
3. Cargo tanks inerted to 8% O<sub>2</sub>
4. Cargo tanks at normal IG pressure
5. Make Chicksan arm connections
6. Start pump room ventilation
7. Shoreside provides physical properties
8. Close accommodation doors
9. Seal pump room sea valves
10. Make log entries
11. Place house ventilation on recirculation
12. Connect vessel to shoreside vapor recovery
13. Open shoreside manifold valves
14. Make shoreside notifications
15. Monitor and record ullages
16. Conduct leak checks
17. Monitor cargo pressures
18. Record tank temperatures and gravity
19. Perform controlled venting
20. Conduct vessel stress checks
21. Close isolation valves
22. Conduct radio check
23. Shoreside stops transfer
24. Close shoreside manifolds
25. Obtain sample
26. Conduct final gauging
27. Close ullage caps
28. Disconnect Chicksan arms
29. Reinstall manifold blanks
30. Dispose of all NLS waste

#### Voyage Activities:

1. Open house ventilation
2. Start IG blower
3. Vent tanks

## ***CASE STUDY: Product Tanker***

### Cargo Discharge :

1. Vessel tied up
2. Pump room sea valves pressure tested
3. Cargo tanks at pressure
4. Cargo tanks inerted
5. Make Chicksan arm connections
6. Restrict access to deck
7. Turn on pump room ventilation
8. Seal pump room sea valves and record
9. Close all accommodation doors
10. Open cargo tank to manifold
11. IG system running on recirculation
12. Shoreside communication
13. Check for leaks
14. Draw line sample
15. Verify ullage
16. Increase rate
17. Record cargo temperature
18. Monitor cargo tank pressures
19. Check pump room for leaks
20. Monitor pump room LEL
21. Record cargo temperature last 30 min
22. Strip cargo tanks
23. Perform cargo checks
24. Strip lines ashore
25. Stop cargo pumps
26. Close ship's manifold valves
27. Drain Chicksan arms
28. Reinstall manifold blanks
29. Clean up leaks or drips
30. Dispose of all NLS waste

### Tank Cleaning:

1. Put house on recirculation
2. Restrict deck activities
3. Notify engine room
4. Close all accommodation doors
5. Open purge pipes
6. Start IGS system
7. Initiate gas testing
8. Put IGS on recirculation
9. Connect hoses to hydrants
10. Check electrical conductivity of hoses
11. Open Butterworth plates
12. Lower hoses into tanks
13. Restart IGS into tanks
14. Water wash tanks
15. Strip tanks of water
16. Test tank atmosphere

### Step #3c: Identify Hazards and Potential Accidents for Each Phase of the Operation

#### Cargo Orders – Hazards:

1. No MSDS
2. Not enough planning time

#### Loading Cargo – Hazards:

1. New Crew
2. Unauthorized personnel on deck
3. Inspector not benzene certified
4. Sampling exposure
5. Engine room exposure due to vent system
6. Incorrect air monitoring
7. Benzene waste not properly stored
8. Open accommodation doors
9. Crew not wearing proper PPE
10. Deck spill
11. Pump room spill
12. Warning signs not posted
13. Benzene splashing on person

## ***CASE STUDY: Product Tanker***

### Voyage Activities – Hazards:

1. Venting exposures on deck
2. Unauthorized personnel on deck
3. House ventilation not on recirculation while venting

### Cargo Discharge – Hazards:

- |                                    |  |
|------------------------------------|--|
| 1. Unauthorized personnel on deck  | 8. Draining of benzene from Chicksan arms onto deck      |
| 2. Sampling mishap                 | 9. Warning signs not posted                              |
| 3. Personnel exposure              | 10. Piping leak  |
| 4. Spill on deck                   | 11. Benzene waste not stored properly                    |
| 5. Pump room spill                 | 12. Crew not wearing proper PPE                          |
| 6. Improper air monitoring         | 13. House ventilation not on recirculation while venting |
| 7. Inspector not benzene qualified |  |

### Tank Cleaning – Hazards:

- |   |   |
|---|---|
| 1. Unauthorized personnel on deck                       | 7. Engine room pulls in benzene vapors              |
| 2. House ventilation not on recirculation while venting | 8. Draining of benzene from Chicksan arms onto deck |
| 3. Personnel exposure                                   | 9. Warning signs not posted                         |
| 4. Spill on deck  | 10. Piping leak                                     |
| 5. Benzene / water disposed of improperly               | 11. Benzene waste not improperly stored             |
| 6. Improper air monitoring                              | 12. Crew not wearing proper PPE                     |

### Step #3d: Consolidate List of Hazards and Potential Accidents

The tanker operator narrowed the comprehensive list of hazards and potential accidents that was created in step #3c down to a list of seven. In doing so, the operator remained focused on personnel safety.

### Personnel Exposure – Hazards:

1. Vapors entering house, engine room, and lingering on deck
2. Liquid cargo spills
3. Waste mishandling
4. Inspector not benzene qualified
5. New crew
6. Improper clean up of residual cargo / spill
7. Improper sampling

**Assign Frequency Ratings, Consequence Ratings, and Risk Priorities (STEPS #4 , #5 & #6)**

Utilizing the scales in Steps #4 and #5 and the matrix in step #6, the following chart was developed.

<b><u>Hazard: Personnel Exposure to Benzene</u></b>	<b>Frequency Rating</b>	<b>Consequence Rating</b>	<b>Risk Priority Score</b>
Vapors entering house, engine room, and lingering on deck	3	3	H
Liquid cargo spills	2	4	M
Waste mishandling	2	3	M
Inspector not benzene qualified	2	2	L
New crew	5	4	VH
Improper clean up of residual cargo / spill	5	4	VH
Improper sampling	5	3	H

This is a subjective process. To determine which of two hazards having the same risk priority score was more significant than the other, the group turned to the frequency and consequence ratings and ranked each hazard appropriately.

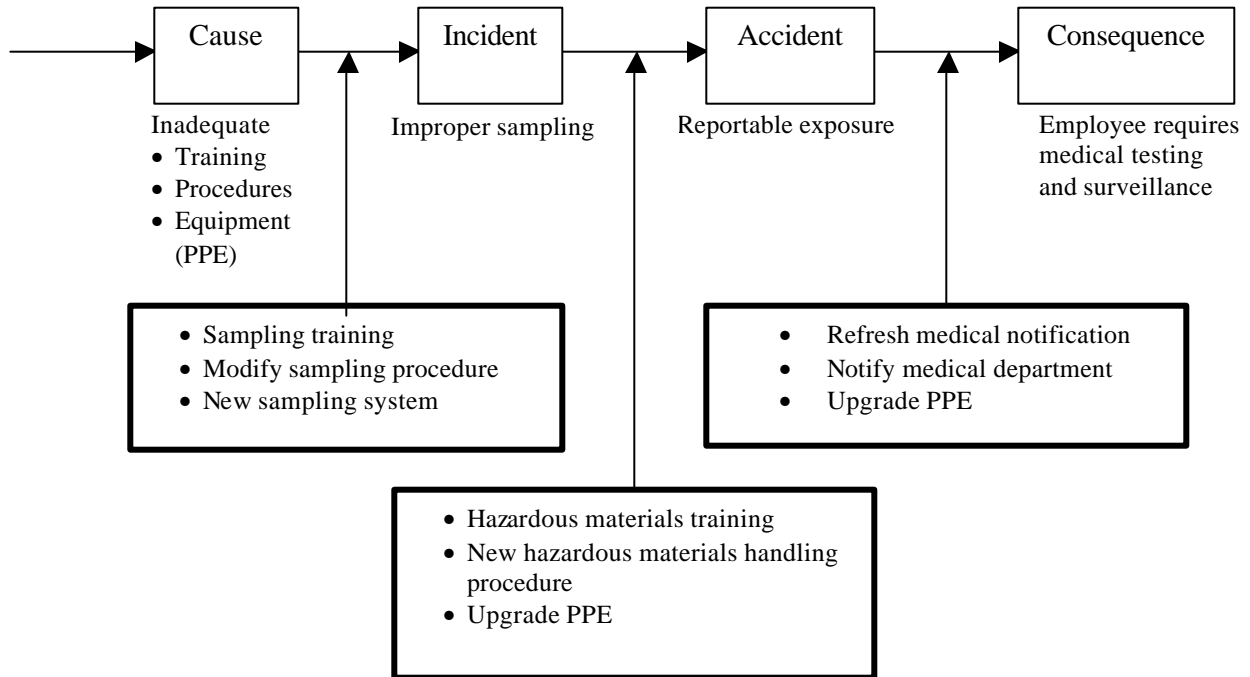
<b><u>Hazard: Personnel Exposure to Benzene</u></b>	<b>Frequency Rating</b>	<b>Consequence Rating</b>	<b>Risk Priority Score</b>
New crew	5	4	VH
Improper clean up of residual cargo / spill	5	4	VH
Improper sampling	5	3	H
Vapors entering house, engine room, and lingering on deck	3	3	H
Liquid cargo spills	2	4	M
Waste mishandling	2	3	M
Inspector not benzene qualified	2	2	L

Other factors, such as the potential for more than one person to be exposed or an additional environmental problem, can be used to distinguish between two hazards having the same risk priority score. It's all up to the risk assessment team. Review your results for consistency.

## CASE STUDY: Product Tanker

### DEVELOPMENT OF COUNTERMEASURES (STEP #7)

The causal chain shown in this step applies only to personnel exposure to benzene due to improper sampling. Similar causal chains were created by the assessment team for the remaining six hazards that were analyzed.





## *CASE STUDY: Product Tanker*

### **BENEFIT-COST ANALYSIS (STEPS #8, #9, and #10)**

<b>Countermeasure (Step #7)</b>	<b>Estimate of Effectiveness (Step# 8)</b>	<b>Cost Estimate (Step #9)</b>	<b>=</b>	<b>Benefit-Cost Ratio</b>
Sampling Training	3	2	=	1.5
Hazmat Training	3	2	=	1.5
Modify Sampling Procedure	3	1	=	3.0
Refresh Medical Notification	2	1	=	2.0
Notify Medical Department for testing	2	1	=	2.0
New Sampling System	4	3	=	1.33
Upgrade PPE	4	3	=	1.0

#### Conclusion:

This case study is not fictitious. It was actually conducted and the results were used. All of the countermeasures listed at the end of step #7 were implemented. Many of these countermeasures addressed more than one of the hazards or potential accidents that were identified in step #3. The risk assessment team, including all vessel personnel involved, were very satisfied that the process provided them with a comprehensive review and felt prepared to carry the new cargo. The training techniques developed as a result of this process served to refresh vessel personnel each time a benzene cargo was carried. The cargo was carried without incident until sale of the vessel.