GUIDANCE NOTES ON

THE INVESTIGATION OF MARINE INCIDENTS

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Foreword

The marine industry experiences incidents that range from major accidents to near misses. These incidents should be investigated since many flag administration regulations require it; international agreements mandate it (such as the IMO "International Safety Management Code"); and industry initiatives encourage it. Incident investigation is a process that is designed to help organizations learn from past performance and develop strategies to improve safety.

The ABS Marine Root Cause Analysis Technique (MaRCAT) provides an effective and efficient approach for investigating marine incidents of any magnitude. ABS developed the MaRCAT methodology by customizing and combining the best techniques available and by proving and improving the overall approach through MaRCAT's application during numerous investigations. The ABS MaRCAT approach to incident investigation caters to the unique needs of the marine industry, including human element; machinery and engineering; structural and security concerns. The objectives of the ABS MaRCAT approach are as follows:

- Provide ABS clients with a technique that will guide incident investigators in the conduct of root cause analyses and in identifying, documenting and trending the causes of accidents and near misses.
- Assist clients with the investigation of a variety of types (e.g., groundings, collisions, fires, etc.) and sizes of incidents (minor to major, including near misses) related to their vessels and facilities (ashore and at sea).
- Allow analysis of losses whether they are related to safety, the environment, human element concerns, security, reliability, quality or business losses.
- Support Class-related activities such as ABS Safety, Quality and Environment (SQE) notation, as well as the International Safety Management Code (ISM Code) and the International Ship and Port Facility Security (ISPS) Code.
- Provide a technique that is sufficiently flexible to allow customization to a client's own management system, Health, Safety and Environment (HSE) programs or related initiatives.

These Guidance Notes provide instructions for the performance of incident investigation activities, including:

- Incident Investigation Initiation
- Data Gathering
- Data Analysis
- Root Cause Determination
- Generating Recommendations
- Reporting and Trending of Incident Investigation Results

The ABS *Guidance Notes on the Investigation of Marine Incidents* provide a structured approach to the investigation of incidents and near-miss events. The information contained can also assist with identifying and documenting root causes as required by the ISM Code. These Guidance Notes describe an incident investigation methodology that was expressly developed for the maritime industry, and so it reflects those elements of maritime operations and incident causation particular to the industry.

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GUIDANCE NOTES ON

THE INVESTIGATION OF MARINE INCIDENTS

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SECTION 1 Introduction

1 Background

The marine industry experiences incidents that range from major accidents to near misses. These incidents should be investigated since many flag administration regulations require it; international agreements mandate it (such as the IMO "International Safety Management Code") and industry initiatives encourage it. Incident investigation is a process that is designed to help organizations learn from past performance and develop strategies to improve safety.

The American Bureau of Shipping's (ABS's) MaRCAT™ (Marine Root Cause Analysis Technique) marine incident investigation methodology presented in these Guidance Notes is designed for use in investigating and categorizing the underlying causes of incidents, including accidents and near misses, with safety, health, environmental, quality, reliability, production and financial impacts. Although the examples used within these Guidance Notes are predominantly those having safety and health impacts, the term "incident" is used to generically identify situations that have any one or more of these types of consequences.

MaRCAT provides an effective and efficient approach for investigating marine incidents of any magnitude. ABS developed the MaRCAT methodology by customizing and combining the best techniques available and by proving and improving the overall approach through MaRCAT's application during numerous investigations. ABS's MaRCAT approach to incident investigation caters to the unique needs of the marine industry, including human element, machinery and engineering, structural and security concerns. The objectives of the ABS MaRCAT approach are as follows:

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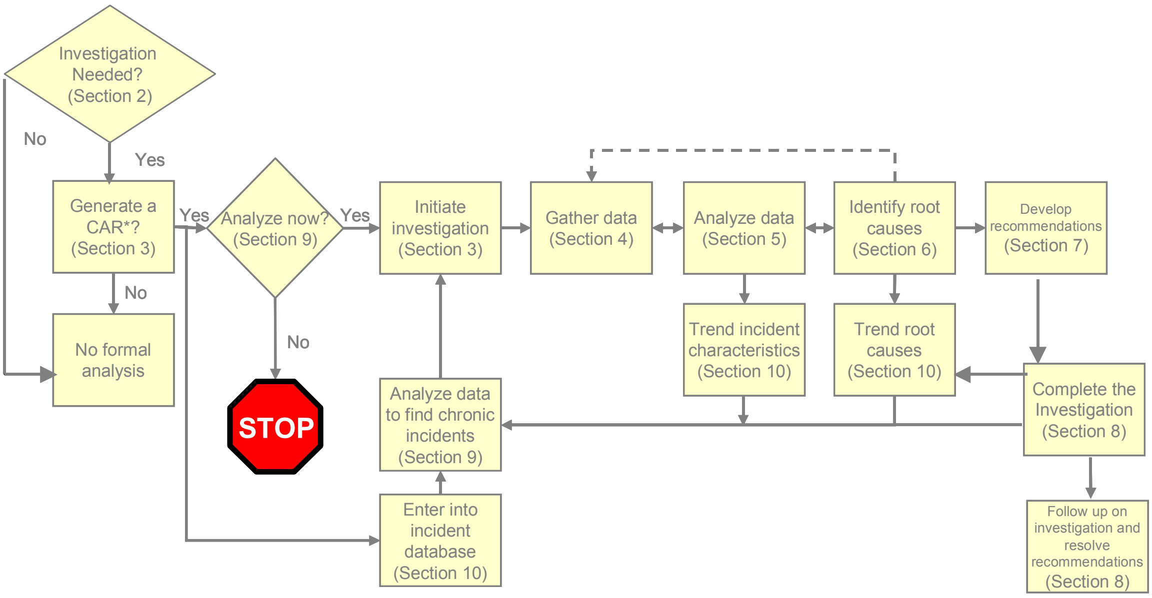
2 The ABS Incident Investigation Model: MaRCAT

The ABS Incident Investigation Model (See Section 1, Figure 1, "ABS Incident Investigation Model") encapsulates a process for conducting investigations following losses whether they are related to people, structures, machinery, equipment, outfitting or other factors.

FIGURE 1
ABS Incident Investigation Model



Note: CAR is an acronym for Corrective Action Request

3 Scope of the Guidance Notes

The focus of these Guidance Notes is on the application of structured analysis techniques, including the use of ABS's *Marine Root Cause Analysis Map*, to the incident investigation process. There are two levels of analyses that can be used as part of the incident investigation process: apparent cause analyses (ACAs) and root cause analyses (RCAs). Root cause analyses involve a deeper level of analysis than apparent cause analyses. The sections in these Guidance Notes generally apply to both levels of analyses. For example, data gathering is performed for both apparent cause analyses and root cause analyses. However, more effort is usually required to gather data for a root cause analysis than for an apparent cause analysis. This is usually true for most analysis activities.

These Guidance Notes provide instructions for the performance of incident investigation activities, including:

- *Incident Investigation Initiation.* How to determine if an incident has occurred, then how to classify and categorize the incident, and how to decide whether to conduct an in-depth investigation.
- *Data Gathering.* How to collect data related to people, processes, procedures, documents, position of the vessel and physical evidence associated with an incident.

- *Data Analysis.* How to analyze incidents to determine causal factors using tools such as causal factor charts, fault trees and the 5-Whys technique. Guidance is also provided regarding the identification of root causes, using the ABS *Marine Root Cause Analysis Map*.
- *Generating Recommendations.* How to document causal factors and root causes identified during an analysis, including how to identify what changes may be needed to enhance management systems and reduce risks.
- *Reporting and Trending.* How to archive findings and recommendations to allow review and trending of incident patterns after some period of MaRCAT use.

4 Contents of the Guidance Notes

These Guidance Notes focus on ten aspects of incident investigation. These Guidance Notes also discuss the process for setting up an incident investigation program. The Guidance Notes Sections are:

- *Section 2, Basics of Incident Investigation* presents a basic overview of the MaRCAT (e.g., Marine Root Causes Analysis Technique) investigation process. It describes the reasons why an organization should perform investigations.
- *Section 3, Initiating Investigations* describes the steps the organization must perform before the actual investigation is begun, such as setting up processes for incident classification and team selection.
- *Section 4, Gathering and Preserving Data* provides guidance for gathering and preserving the different types of data that are usually collected as part of an investigation.
- *Section 5, Analyzing Data* discusses three different methods (fault tree analysis, 5-Whys analysis and causal factor charting) for analyzing the data that have been collected.
- *Section 6, Identifying Root Causes* describes the use of ABS's *Marine Root Cause Analysis Map* to assist in the identification of the underlying causes of incidents.
- *Section 7, Developing Recommendations* explains the different types of recommendations that should be developed to ensure that the highest return is obtained from the analysis.
- *Section 8, Completing the Investigation* describes the activities that should be performed to complete an investigation.
- *Section 9, Selecting Incidents for Analysis* provides guidance on selecting appropriate incidents for analysis
- *Section 10, Results Trending*, explains the factors that should be considered when setting up an incident investigation trending program. Trending will allow an organization to look across all the investigations that have been performed and see if common factors are related to different incidents.
- *Section 11, Developing Incident Investigation Programs* describes the process of setting up the overall investigation program.

Additional information that can help the reader to use the MaRCAT approach is provided in the following Appendices. The Appendices include:

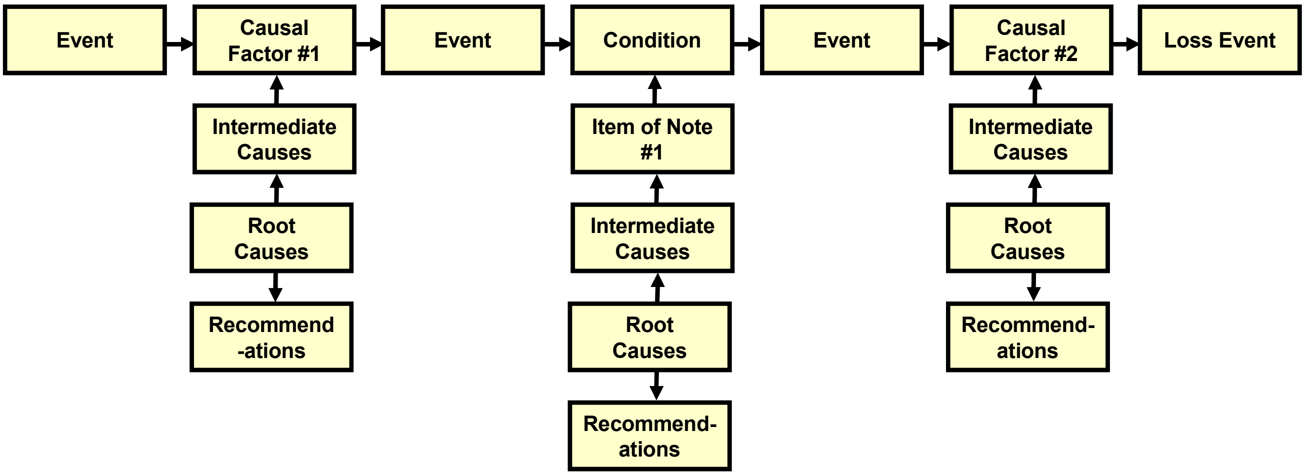
- *Appendix 1, Marine Root Cause Analysis Map Guidance* describes each segment of the Marine Root Cause Analysis Map and presents detailed descriptions of the individual items or nodes on the map. The ABS Marine Root Cause Analysis Map itself is included as an insert at the back of these Guidance Notes.

- *Appendix 2, Fault Tree Details* provides in-depth information about the use, development and construction of fault trees. Some example fault trees are also included. This Appendix supplements information provided in Section 5, "Analyzing Data".
- *Appendix 3*, *Causal Factor Charting Details* provides in-depth information about the use, development and construction of causal factor charts. Some example causal factor charts are also included. This Appendix supplements information provided in Section 5, "Analyzing Data".
- *Appendix 4, Marine Organizations of Interest* provides listings of marine organizations (and website addresses) that may provide additional information to those interested in learning more about incident investigation.
- *Appendix 5, Acronyms and Abbreviations* defines those used in these Guidance Notes.
- *Appendix 6, Glossary* provides definitions and notes on terms used within these Guidance Notes.
- *Appendix 7, MaRCAT Toolkit* provides summary guidance and resources such as checklists and forms that can be used to document incident investigation activities. This same material can be obtained electronically from the ABS website at "http://www.eagle.org/rules/downloads.html" under the publication entitled "ABS *Guidance Notes on the Investigation of Marine Incidents*".
- *Appendix 8, Cross References between ABS Root Cause Analysis Map and Industry Standards* provides a cross-reference between the *ABS Root Cause Analysis Map* and industry standards such as ISM, ISO documents API RPTS and OCIMF TMSA.

5 Terminology

The same terms, relating to incident investigations, are often used differently by different investigators, different organizations or sometimes within the same organization. For the purpose of clarity, a listing of terminology complete with definitions and notes is provided so that the user of these Guidance Notes can better understand the information within the context in which it was created. Section 1, Figure 2, "Relationship of Incident Investigation Terms," is provided to show the interrelationship of the various terms defined here.

FIGURE 2
Relationship of Incident Investigation Terms



5.1 Incident

An unplanned sequence of events and/or conditions that results in, or could have reasonably resulted in, a loss event.

Notes:

- This definition includes both accidents and near misses (defined below).
- Incidents are a series of events or conditions that contain a number of structural/machinery/equipment/outfitting problems, human errors, external factors as well as positive actions and conditions.
- An incident can be depicted using a timeline that includes the events and conditions that occurred during the incident. However, it also includes information about the context in which the events and conditions were performed.

5.2 Consequences

Undesirable or unexpected outcomes may result in negative effects for an organization. These consequences can range from minor injuries to major events involving loss of life, extensive property loss, environmental damage, and breaches related to security.

Notes:

- Negative effects can include property damage or loss, personnel injury or illness, spills, loss of marine commerce, loss of reputation, etc. Consequences can be of different magnitudes. For example, grounding can result in no damage to the vessel and just a short delay in completing the voyage. Another grounding can result in hull damage and a large release of cargo. The same level of effort may be put into investigating these two incidents, the first based on the potential consequences (a near miss) and the second based on the actual consequences (an accident).
- The consequences and potential consequences of the incident should determine the level of effort to invest in the analysis.

5.3 Loss Event

Undesirable consequences resulting from events or conditions or a combination of these.

Notes:

- Loss events will appear as statements within fault trees, 5-Why trees or causal factor charts. They are developed by the investigator/investigation team to define the scope of the investigation or analysis.
- The way the loss event is stated and understood will define the scope of the incident analysis. For example, selecting engine failure as the loss event will result in focusing on the engine failure. Selecting vessel grounding after engine failure as the loss event will result in focusing on the engine failure as well as the grounding incident. Selecting oil release after grounding following engine failure as the loss event will result in the investigation of all three aspects of the incident. Because of this, the loss event should be stated carefully and be precisely defined. A loss event definition that only includes the immediate consequences results in recommendations that are fairly narrow in scope. A loss event definition that also includes the subsequent consequences of the incident results in recommendations that are broader in scope.
- Multiple loss events may be identified as part of a single investigation. Multiple loss events are usually needed when there are different types of consequences and/or the consequences affect different stakeholders.
- Consequences of loss events can be realized immediately, or they can be delayed (for example, future expenses incurred during repairs and costs of lost time of a vessel in service).

5.4 Accident

An incident with unexpected or undesirable consequences. The consequences may be related to personnel injury or fatality, property loss, environmental impact, business loss, etc. or a combination of these.

5.5 Near Miss

i) An incident with no consequences, but that could have reasonably resulted in consequences under different conditions.

OR

ii) An incident that had some consequences that could have reasonably resulted in much more severe consequences under different conditions.

Notes:

- An incident can be both an accident and a near miss, an accident because it has immediate consequences, but also a near miss because the incident could have resulted in more severe consequences.
- Everyone in the organization needs to have an understanding of how near misses are defined by the organization so that they can report appropriate incidents that meet the definition. An incident can not be investigated if it is not reported. Examples of what is and what is not a near miss are usually required. To define a event that "almost was" is difficult, but near misses can be operationally defined, for example, a near miss can be operationally defined as:
    - Passing a ship or fixed structure by 50 meters
    - Touching soft bottom without grounding or stranding
    - Restarting a lube oil system before vital system damage or failure occurs.
- It should be evident that there are very many possible operational definitions for a near miss. More global definitions are more easily achievable, such as:
    - An unexpected deviation from a passage plan
    - A period of operations where emergency or unusual rapid action is required
    - An event that, under more usual circumstances would have resulted in a loss

5.6 Event

A happening caused by humans, automatically operating equipment/components, external events or the result of a natural phenomenon.

Note: Event descriptions typically include action verbs such as walked, turned, opened, said, radioed, discovered, decided, saw, etc. If negative (an error, failure or external factor), then the event may also be a causal factor, intermediate cause or root cause.

5.7 Condition

A state of being.

Notes:

- Includes process states, such as pressure, temperature, composition and level. Also includes the state of training of an employee, the condition of supplies and cargo and the state of equipment/structure/outfitting. If negative, then it can be a causal factor, intermediate cause or root cause.
- These typically include passive verbs such as "was" and "were". No time is typically associated with a condition.

5.8 Causal Factor

Structural/Machinery/Equipment/Outfitting problems, human errors and external factors that caused an incident, allowed an incident to occur or allowed the consequences of the incident to be worse than they might have been.

Notes:

- For a typical incident, there are multiple causal factors.
- Causal factors are identified during the first stage of the analysis.
- Each causal factor is an event or condition for which steps should be taken to reduce or mitigate its occurrence.
- For each causal factor, underlying causes will be identified and recommendations will be developed.

5.9 Structural/Machinery/Equipment/Outfitting Problems

Structural/Machinery/Equipment/Outfitting performance that deviates from the desired performance of the item.

Note: The definition is not failure to perform as designed, but failure to perform as desired. This means that items can perform as designed and still fail or be degraded, because it fails to perform as desired (i.e., there is a gap between actual and desired performance). By defining failures in this way, structural/machinery/equipment/outfitting design issues can cause failures/degradations.

5.10 Human Errors

Performance of humans that deviates from the desired performance.

Notes:

- This definition is not a failure to perform as directed, but failure to perform as desired. An individual can follow the procedure precisely and still perform a human error, because the individual does not perform as desired (i.e., there is a gap between actual and desired performance). In this situation, the procedure specifies the incorrect method for performing the task.
- Human errors that are causal factors are might be performed by frontline personnel on the vessel. Human errors performed by support organizations and management are commonly classified as root causes.

5.11 External Factors

Issues outside the control of the organization. Examples include uncharted/unknown hazards to navigation, some sea or weather conditions, suicides or homicides and external events.

5.12 Intermediate Cause

An underlying reason why a causal factor occurred, but it is not deep enough to be a root cause.

Note: Intermediate causes are underlying causes that link causal factors and items-of-note to root causes.

5.13 Item-of-Note (ION)

A deficiency, error or failure that is not directly related to the incident sequence that is discovered during the course of the investigation.

Note: IONs are usually at the causal factor or intermediate cause level. IONs are similar to audit findings. If left uncorrected, these IONs may become causes of future incidents. Underlying causes and recommendations can be developed for IONs as part of the investigation. Some organizations assign responsibility for causal analysis of IONs to the individual departments.

5.14 Root Cause

Deficiency of a management system that allows the causal factors to occur or exist.

Notes:

- Root causes must be within the control of management to address. For a typical causal factor, there are one to four root causes.
- Root causes are usually as deep as a typical root cause analysis will go in attempting to identify the underlying causes of an incident. Organizational culture issue, which are deeper than root causes, could also be identified and addressed, but most root cause analyses do not go to this level because developing effective recommendations at the organizational culture level may be difficult.

5.15 Management System (MS)

A system put in place by management to encourage desirable behaviors and discourage undesirable behaviors.

Note: Examples of management system elements include policies, procedures, training, communications protocols, acceptance testing requirements, incident investigation processes, design methods and codes and standards. Management systems strongly influence the behavior of personnel in an organization.

5.16 Safeguard

A physical, procedural or administrative control that prevents or mitigates consequences associated with an incident.

Note: These are physical, procedural and administrative systems controlled by the organization's management systems. For example, a design process (the management system) will result in installation of dual electric generators (the safeguard). The procedure development process (the management system element) will result in a procedure on how to perform vessel loading of fuel (the safeguard).

5.17 Recommendation

A suggestion to develop, modify or enhance management systems or safeguards.

Note: Recommendations can be made to address the causal factor, intermediate cause and/or root cause levels of the incident. Recommendations are the most important product of the analysis. They are what will be implemented to change the organization's behavior and prevent recurrence of the incident or to minimize the consequences of the incident.

5.18 Resolution

The disposition of a recommendation.

Note: Often, recommendation resolution results in implementation of the recommendation. However, resolution could also result in implementing an alternate recommendation or no action at all.

5.19 Root Cause Analysis (RCA)

An analysis that identifies the causal factors, intermediate causes and root causes of an incident and develops recommendations to address each level of the analysis.

5.20 Apparent Cause Analysis (ACA)

An analysis that identifies the causal factors for the event and develops recommendations to address them, but does not necessarily identify the root causes of the incident.

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SECTION 2 Basics of Incidents and Investigations

1 The Need for Incident Investigation

Question: If an organization has never had a means for formally investigating incidents and yet still learns something from past mistakes, why is a structured approach needed? Why should time be invested in performing an incident investigation?

Answer: While something may be learned from every incident by performing even a cursory investigation, much more can be learned by using a more structured approach. If the structured approach is efficient, the user can obtain an increased level of learning without much additional effort.

1.1 Rationale for Taking a Structured Approach to Incident Investigation

Unstructured approaches can allow an organization to prevent the same incident from recurring, but often unstructured approaches simply delay the recurrence (or change the specifics of) the incident.

Example 1. A bearing on a pump fails. During an unstructured analysis, when it is discovered that a pump failed because of a bad bearing, the bearing would be replaced and the pump started again. But with this approach was anything learned from this failure? No. How might something be learned? One means would be to ask questions in a structured fashion, such as:

- Why did the bearing fail?
- Was the correct bearing for the pump used?
- Was it installed correctly?
- Was the bearing made of the correct material?
- If it is made of the wrong material, how did our organization allow that to occur?
- Why did a bearing of the wrong material get installed?
- How is it determined which bearings to use when a repair is needed?

The answers to all of these questions allow a more thorough analysis of the incident.

Example 2. A deckhand slips and falls on the deck. Once medical treatment is administered, is there anything else that should be done? How can something be learned from this incident? Applicable questions that could be used to further examine the situation could include:

- Where did the person fall?
- What were the deck conditions?
- What was the weather like?
- What shoes did the person have on?

- Did any of these factors contribute to the incident?
- Are there conditions like this on other vessels in our fleet that could prove problematic?
- What can be done by the organization to prevent or minimize the consequences of this type of incident?

Yet many within an organization might question, “Why should we take the time to answer these questions? The equipment has been repaired and the deckhand is working again. In addition, the deckhand has been told not to fall down anymore (to be more careful). Aren’t we done?”

1.2 Depths of Analyses

A structured or systematic approach to incident investigation allows a deeper look into management and work processes to determine the underlying causes of incidents. This allows more fundamental changes to be made in processes. Section 2, Figure 1, “Task Triangle Showing Possible Depths of Analyses,” shows potential levels of analyses. At the top, human errors, problems (including those related to structure, machinery, equipment or outfitting items) and/or external factors are analyzed. Farther down in the triangle are more fundamental causes and aspects of organizations. These include controls for the task and for the process. Eventually management systems and the organization’s culture can be analyzed. Analyzing deeper into the triangle allows organizations to increase the level of learning about how the organization functions and, therefore, develop corrective and preventative actions that are more fundamental in nature and broader in scope. These fundamental changes allow problems to be solved once instead of several times.

Vessel operations actually consist of many hundreds or thousands of these triangles, one triangle for each task. Section 2, Figure 2, “Overlap of Multiple Task Triangles,” shows three task triangles. The triangles have some areas in common and some that are not. At the bottom levels of the triangles, the three task triangles have more in common with each other. All share the same organizational culture. The different tasks have many management systems in common. As one moves to higher levels, there is less and less in common between the tasks.

To demonstrate how the commonality of management systems could affect different tasks, suppose that there is a problem with one aspect of a management system. For example, a limitation in a maintenance scheduling system could make it difficult to assign personnel to tasks. As a result, some maintenance tasks may not get completed on schedule. This could affect not only the proper performance of the maintenance tasks, but it could impact operational tasks too. If an equipment failure occurs because of lack of proper maintenance, operational workarounds might be used that could also lead to losses. If this management system issue is situated at Location 1 on Section 2, Figure 2, then it is in the task triangles for all three tasks. This management system problem will make performing all three tasks difficult, resulting in an increased potential for human errors and failures for all three tasks.

Traditional problem solving would try to correct the situation at the human error, failure/degradation or external factor level. To do so requires solving the problem multiple times (whenever an error is committed during performance of any of these tasks).

What if an incident investigation went deeper into the task triangles and solved the problem at the management system level? This only requires solving the problem once. Solving the problem once is much more efficient than solving it three times.

FIGURE 1
Task Triangle Showing Possible Depths of Analyses

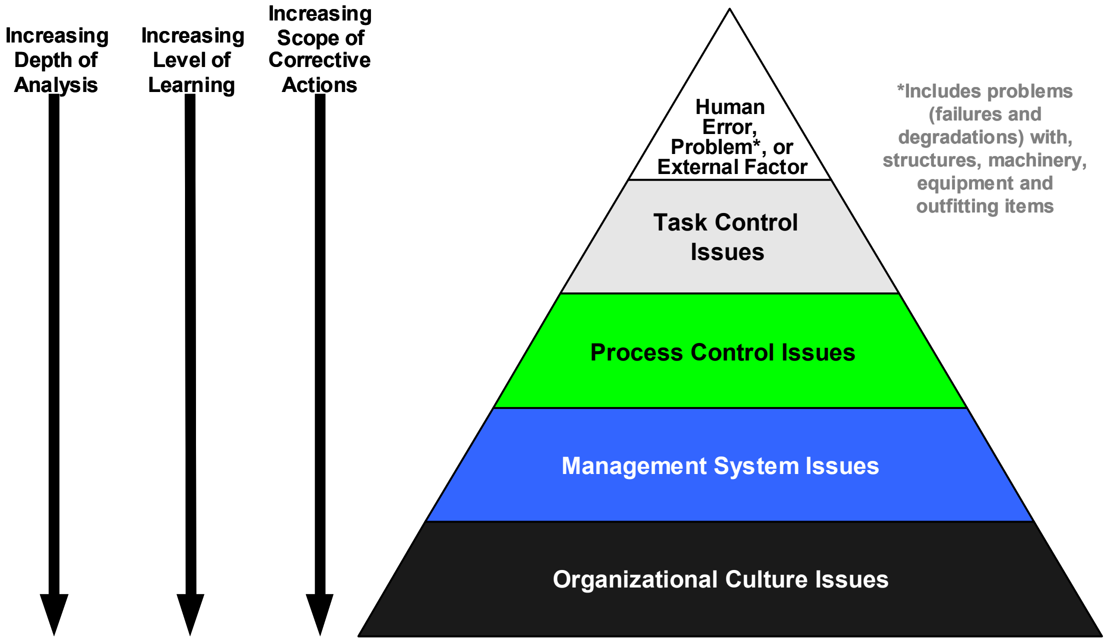
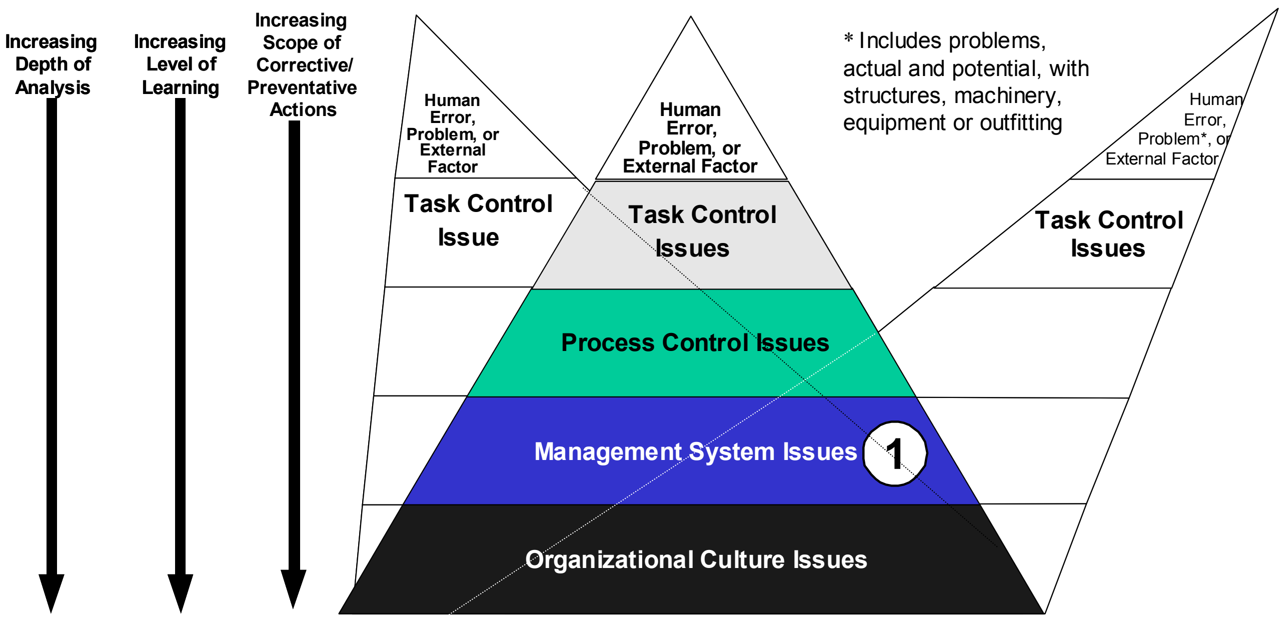


FIGURE 2
Overlap of Multiple Task Triangles



① Indicates position of Location 1

1.3 Structured Analysis Process

First, the problems at the top of the task triangle almost always make themselves known without having to do in-depth analysis. For example, a human error results in a failure of the pump or the failure of the pump itself causes a loss of propulsion. In both cases, not much investigation has to be done to figure out what to correct. In the case of trying to solve the problem at the management system level, some investigative work will need to be done. The symptom (the failed pump or loss of propulsion) can be seen at the top of the task triangles, but the causes are buried within deeper levels of the triangle. Some work (an investigation) will need to be done to identify what is happening at these deeper levels. The question, "What is it about the way we operate our business or vessel that caused or allowed this to occur?" must be answered. If an answer to this question can be found, the investigation will have dug deep into the task triangle. This will allow the issue to be addressed once, not three times. In addition, the problem will be solved the first time so that the other two failures can be avoided.

So the tradeoff is this: do more work now to understand the underlying causes and solve them. In return, solve one problem instead of many and avoid future failures. Avoiding failures allows (vessel) operations to run more smoothly, allows personnel to plan with more confidence and reduces the stress associated with always having to "fight the latest fire."

2 Selecting Incidents to Investigate

Although root cause analysis (RCA) is a good process, sometimes the investment in the up-front analysis will not provide enough return in the end to justify the investment in an investigation. For example, suppose that a light in a passageway burns out. Should a root cause analysis be done? Will digging deeper into the levels of the task triangle help solve the problem once and avoid future losses? Will it help with understanding how to change our operations to prevent or minimize the consequences of this failure? Probably not. When bulbs fail after an expected lifetime, they are replaced. Even if one or two burn out prematurely, there is probably not much to be learned from an investigation into why this occurred. For lights in passageways, the consequences of the failure of the bulb are small enough that the failure can be tolerated for a short period. For this particular failure, one could choose to wait for the failure to occur and then respond to it by replacing the bulb. Could some proactive strategy be identified for preventing bulb failures? Maybe, but it probably would not be worth the effort because the consequences of the failure are so small.

So, rather than investigate every incident, when should investigations be undertaken? There are three types of incidents that should be analyzed in depth.

- The *first* type is the large consequence incident. For these incidents, the actual consequences are large enough that a single incident is intolerable to the organization. Examples of this type of incident would be groundings, allisions, collisions, fatalities, lost-time accidents and environmental spills.
- The *second* type of incident is a near miss to one of these large consequence incidents. Often these are referred to as near-miss (or near-hit) incidents. The actual consequences of the actual experienced incident are small, but there is a reasonable potential for a large consequence. Examples of these types of incidents might include near-miss allisions, near-miss groundings, medical treatment incidents and small spills with the potential for a much larger spill. Individuals involved in such incidents may say, "It was lucky that …" or "I'm glad this happened out at sea. If this had happened during close maneuvering, we would have rammed something for sure" or "We're lucky this happened when we were empty. If we had been full, we would have been leaking stuff all over." For these types of incidents, it is prudent to investigate proactively before a large loss occurs.

- The *third* type of incident is actually a set of incidents. In this case, there are a number of small incidents that collectively add up to something big. As with the example above, if a passageway light burns out, there probably wouldn't be too much thought about it and a root cause analysis would not be performed. On the other hand, if 150 lights all burned out in the last week, there would probably be enough concern to warrant an analysis. Something new is going on in the lower levels of the task triangle, and it would be important to figure out what it is before replacing another 150 bulbs.

3 The Investigation Thought Process

Incident investigations require a different thought process than is often used in solving the small daily problems that are encountered. This section describes the differences between incident investigations and traditional problem-solving approaches, as well as the approach needed to perform a good analysis.

3.1 Differences Between Traditional Problem Solving and Structured Incident Investigation

Not only are the outcomes of an incident investigation fundamentally different from traditional problem solving, the overall approach is different, too. Section 2, Figure 3, "Differences Between Traditional Problem Solving and Structured Root Cause Analysis," shows some of the differences between the two approaches.

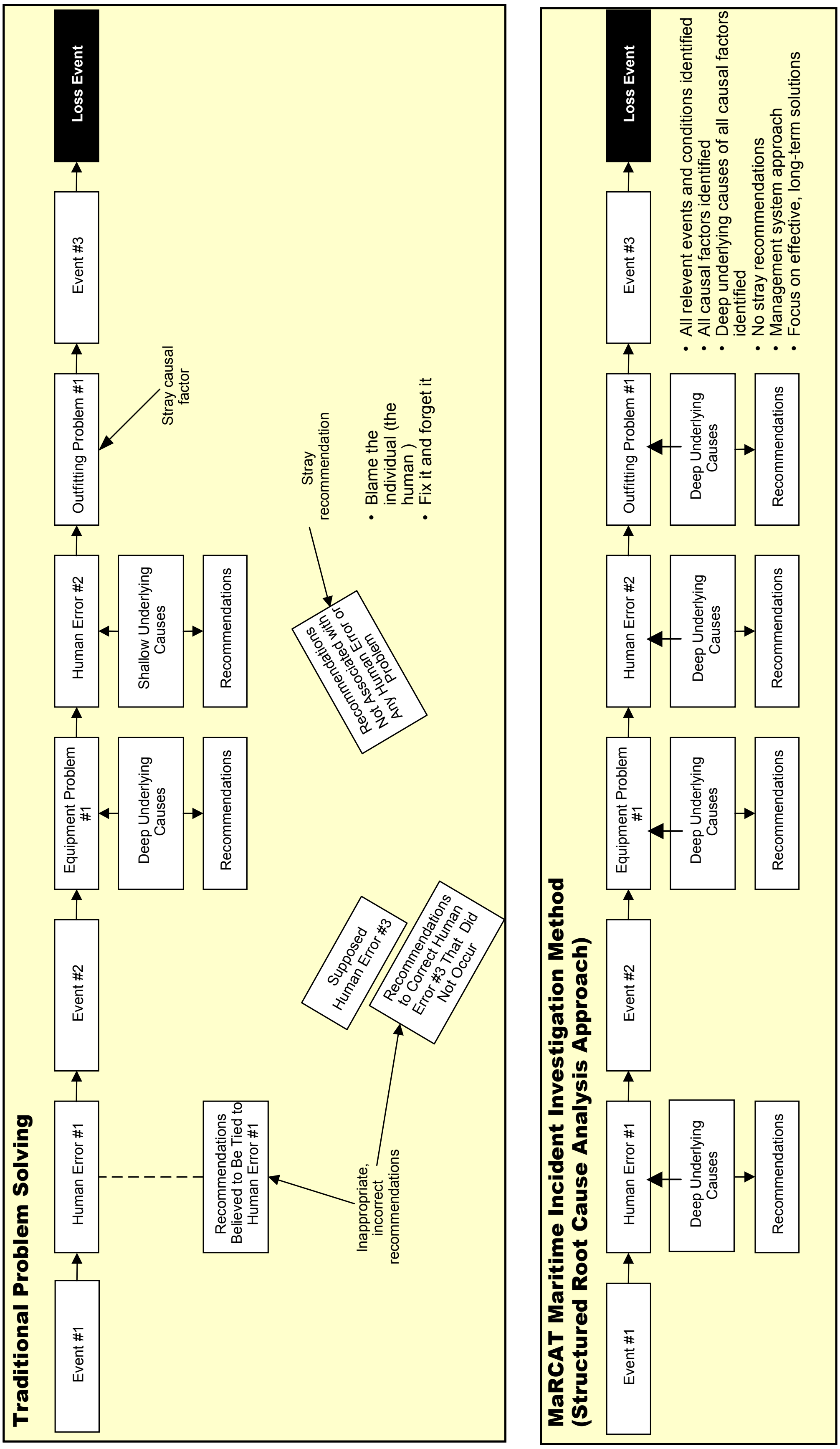
In traditional problem solving, the approach to gathering, organizing and analyzing data is usually unstructured. As a result, the conclusions and recommendations that are generated are often ineffective in preventing or mitigating the incident. In addition, the recommendations usually focus on correcting the individual and ignore the environment in which the individual performs the task.

An incident investigation approach looks at all of the factors that affect the performance of the task: the individual, the work environment and processes, the structure, the machinery, the equipment, the outfitting and external factors. Effective solutions often involve changes to the way the organization functions or how it deals with external factors. Traditional problem-solving approaches lack the structure and rigor to ensure the identification of effective solutions that are logically connected to the causes of an incident.

3.2 An Incident Investigation Approach to the Analysis

When performing an incident investigation, the investigator must question many of the "givens" of a situation. In a proactive analysis, such as a process hazard analysis or reliability analysis, many assumptions are made to expedite the analysis. However, assumptions should be questioned when performing incident investigations.

FIGURE 3
Differences Between Traditional Problem Solving and Structured Root Cause Analysis



The following are examples of common questions that must be asked when performing an incident investigation to prevent making assumptions about the organization:

- *Have changes to vessel design been adequately addressed?* Often changes are made to a vessel after initial design work is completed or delivery has been taken. Such changes can affect how the vessel operates or responds or how the machinery systems work. Changes in procedures may also affect operations. Have such changes been made?
- *Have changes in operation been adequately addressed?* Changes to structure, machinery, equipment or outfitting may have been made to address changes in organizational needs and economic pressures to haul different cargo or operate under different environmental conditions than originally anticipated.
- *Are personnel well trained?* It is assumed that personnel are well trained to perform the majority of the tasks they encounter. However, changes from the normal situations and practices are often not addressed in the training or procedures provided to personnel.
- *Are written procedures accurate and clear?* Procedures are always clear to those who wrote the procedures. However, they are often vague and unclear to those who use them. As a result, users are forced to interpret the procedures for situations not explicitly covered by the procedures.
- *Are policies enforced?* Many policies are written but not enforced by the organization. As a result, there are often many deviations from these written and unwritten policies.

In addition, there may be other items that are not properly understood by personnel. Two examples of such circumstances are provided below.

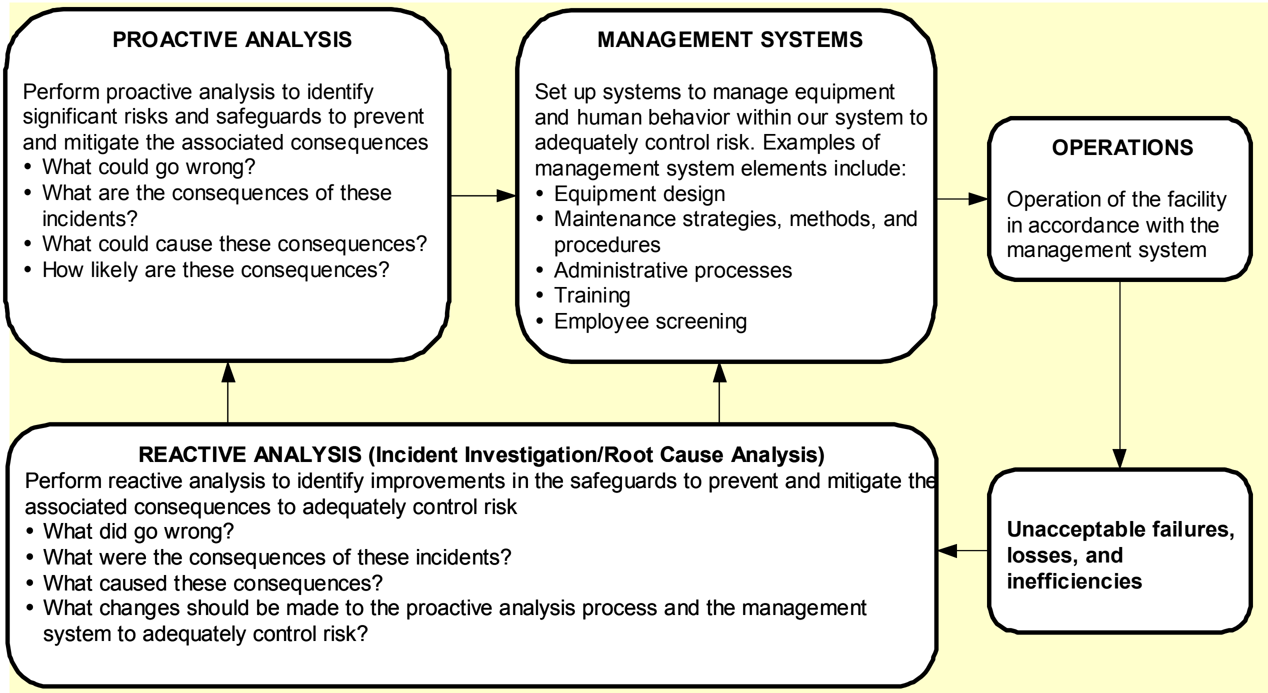
- *Example 1*. A tank has two level sensors, one for normal operations and one for a safety cutoff. The normal indication has a span that is the same as that of the tank. However, the safety system has a much narrower range; it can only detect level in the top 25% of the tank. This is fine because the only function of the safety system is to provide an independent cutoff of flow into the tank to prevent an overflow. Maintenance personnel are directed to set the safety system to 80%. The person who wrote the procedure meant this as 80% of the tank level (20% of the output of the level sensor). However, the maintenance personnel assumed this to be 80% of the span of the detector (80% of the output of the sensor), so they set the system to actuate at 95%. As a result, a small spill occurred.
- *Example 2*. Personnel have two temperature detectors to monitor the temperature of the cooling oil. When the temperature gets too high, they are supposed to operate an auxiliary oil cooler. However, too much cooling of the oil is also a problem, so the auxiliary cooler should not be used when it is not required. The procedure only tells the personnel to operate the auxiliary cooler "when the local temperature indicators read more than 130°F (55°C)" It is clear that when both indications are above 130°F (55°C), the auxiliary cooler should be turned on. However, what about the situation where one indication is above 130°F (55°C) and one is below 130°F (55°C)? What should the personnel do under these conditions? What will the personnel do? Will different personnel respond to this situation differently?

No possibilities within the scope of the investigation should be prematurely excluded. Often the root causes of incidents are deficiencies in the management systems that are designed to ensure that these assumptions will be valid. The investigation process is designed to ensure that assumptions are questioned and confirmed by the investigator.

4 Incident Investigation within a Business Context

Root cause analysis (RCA) is just one of many activities that an organization should undertake. Section 2, Figure 4, "Relationship Among Proactive Analysis, Reactive Analysis and Management Systems," shows three general activities that an organization needs to operate: proactive analysis, reactive analysis and management systems.

FIGURE 4
Relationship Among Proactive Analysis, Reactive Analysis and Management Systems



Proactive analysis is designed to determine what might go wrong and how can strategies be developed to avoid these losses or reduce the losses to acceptable levels. Proactive analysis methods include failure modes and effects analyses, reliability-centered maintenance analyses, what-if analyses and human reliability analyses. The results of these assessments are usually implemented through management systems, such as design control processes, maintenance strategies, procedure development processes and human resources policies.

The management systems are designed to minimize the probability and/or the consequences of a loss. In addition, they are designed to maximize efficiency, profitability and employee satisfaction. The results of using these management systems are the procedures, training, equipment, communications protocols, procurement processes and maintenance strategies that are used in daily vessel or dock operations.

If the proactive analysis has been done well and the resulting management systems have been implemented perfectly, there would be no need to do reactive analyses. Because it is impossible to perform a perfect proactive analysis or implement management systems perfectly, losses do occur. When they occur, these can be investigated using reactive analysis methodology, Root Cause Analysis. The results of root cause analyses are fed back into the first two types of activities described above. Root cause analyses result in improvements in how proactive analysis is performed or lead to changes in management systems used to control work processes. All of these tools are closely related to each other. Having a great incident investigation program is not enough. Unless the results of the investigation are fed back to improve the proactive analyses and management systems, the effort put into the investigation will be wasted.

Incident investigation methods are typically used to discover underlying reasons for poor or undesirable performance. However, these same methods can be used to discover the underlying factors that contribute to positive aspects of the operations. For example, if it is found that the methods used to track crew qualifications on one vessel are working very well, the incident investigation technique could be used to discover what factors contribute to this positive performance. Then, improvements can be made with proactive analysis and management systems to take advantage of this knowledge on other vessels and in other parts of the organization.

5 The Elements of an Incident

Every process has a number of key stakeholders. A key stakeholder is anyone who is interested in the performance of the system. Key stakeholders can be interested in safety, environmental, quality, reliability and financial performance. An incident is an unplanned sequence of actions and conditions that results in, or could have reasonably resulted (a near miss) in, consequences for a system stakeholder.

Incidents result in unintended consequences. They occur as the result of a combination of human errors, structural/machinery/equipment/outfitting problems and/or external factors that occur within the context of the work environment. These incidents have significant impacts on equipment/property, business continuity, safety/health and the environment. Generally, they have underlying causes that create error-likely situations for people and vulnerabilities for equipment.

Organizations have many methods for protecting themselves against these loss events, including hardware, procedural and administrative controls. The types and complexity of the controls depend on the perceptions of the risks. The proactive analyses influence the organization's perceptions of the types and magnitudes of the risks. Incidents occur when the safeguards for unacceptable risks are deficient, missing or fail. Sometimes safeguards are not incorporated because the proactive analysis did not result in the proper identification or understanding of the risks.

Another common cause is the result of changes that introduce unidentified risks or defeat safeguards (failure in management of change). Management of change programs can often control the risks associated with single changes. However, proactive analysis of the synergy of the changes is very difficult to perform. Therefore, reactive analyses are often required to understand these adverse cumulative effects.

6 The Goal of the Incident Investigation Process

The overall goal of the incident investigation process is to ensure that the proper safeguards are in place and functioning to prevent and mitigate incidents. If adequate safeguards are provided, any losses that do occur will be acceptable losses. This is the same goal as proactive analysis.

Individuals in the organization may have specific investigation objectives, such as the following:

- Protect the safety and health of workers and the public
- Preserve the organization's human and capital resources
- Improve quality, reliability and productivity
- Ensure continued service to clients and customers
- Comply with regulatory and insurance requirements

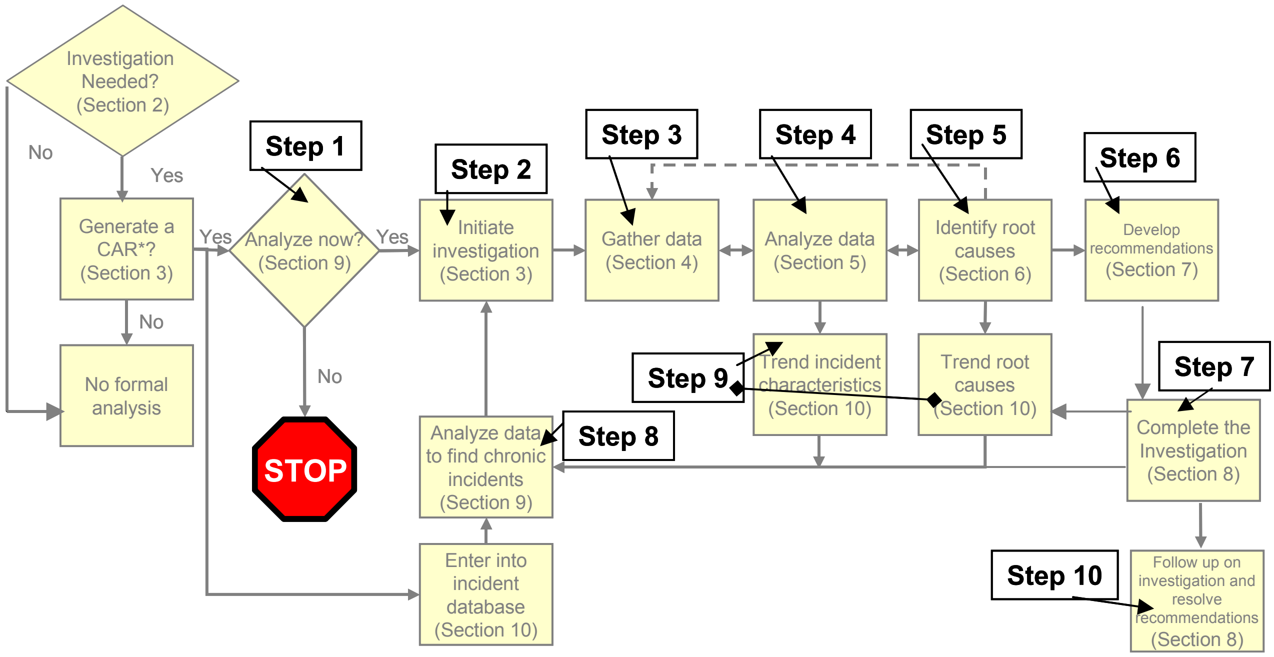
- Comply with organizational and industry policies
- Respond to legal, regulatory, organization, community and/or employee concerns
- Educate management, staff and employees
- Demonstrate management concern and promote employee involvement
- Advise others of unrecognized risks and/or more effective risk management strategies

All of these specific objectives are enveloped by the overall goal of ensuring that adequate safeguards are developed and are functioning within the organization.

7 The MaRCAT Marine Incident Investigation Process

Section 2, Figure 5, "The MaRCAT Marine Incident Investigation Process," shows an overall process diagram for the MaRCAT Marine incident investigation process. This process applies to incidents of all types (safety, quality, reliability, environmental) although the implementation of the individual steps may be somewhat different for each type of incident. The steps also apply to incidents of various magnitudes. In other words, the process applies to small investigations that involve one person and last a few minutes and also to those that involve a large team and last for several weeks or months. Again, the steps in the process will be implemented differently, depending upon the depth of the analysis. An overview of each step is provided below:

FIGURE 5
The MaRCAT Marine Incident Investigation Process



*CAR is an acronym for Corrective Action Request

7.1 Step 1: Should the Incident Be Analyzed Now?

The first decision to be made is whether an incident merits an investigation on its own. After documenting some cursory information about an incident (e.g., Who? What? Where? Extent), a decision should be reached as to whether an incident should be investigated. When the actual or potential consequences of the incident are small, it may be sufficient to just enter the incident into a database. If the decision is for "No Investigation Necessary", relevant facts will be documented and filed.

If the incident is deemed worthy of further investigation, a corrective action request (CAR) should be started. Following the generation of a corrective action request (CAR) that formally reports an incident, a decision needs to be made whether the incident should be analyzed now or if a later time could be more appropriate.

The decision about whether to launch a full formal investigation or merely document facts is needed in order for the organization to use its investigation resources wisely; that is, on those incidents where the potential return on the investment is believed to be sufficiently large so as to justify a formal investigation.

7.2 Step 2: Initiating the Investigation

In this step, preparation for conducting an investigation occurs. Activities in this step include ensuring that there is a precise and agreed-upon definition of the issue, determining how much effort to invest in the investigation, putting together a team and gathering the resources needed to perform the investigation.

7.3 Step 3: Gathering and Preserving Data

In this step, data is gathered. There are five basic types of data: people, paper, electronic, physical and position. Methods are available for efficiently and effectively gathering each type of data. These data are vital for ensuring that an understanding can be reached about what, how, and eventually, why the incident occurred. Some initial data analysis is also performed at this time.

7.4 Step 4: Analyzing Data

The MaRCAT methodology uses three basic tools to perform this step: the causal factor chart, the fault tree and the 5 Whys technique. However, other tools can also be used, such as hazard and operability analysis. Any of these analysis techniques can be used to organize the data that has been collected in Step 3. The data analysis techniques also help identify the data that still needs to be collected and the questions that need to be answered to understand the incident and its causes. By specifically identifying the needed data, the data gathering and preservation step (Step 3) is made more efficient. As a result, the data analysis step often sends us back to Step 3 to gather more data. This loop may occur many times during an investigation. The end goal of this step is to identify the causal factors.

7.5 Step 5: Identifying Root Causes

Once the who, what, where and when of the incident is understood and the human errors, structural/machinery/equipment/outfitting problems and external factors that led to the incident have been identified, the underlying causes of the incident can be understood. Root cause identification methods assist us in probing deeply enough to understand the underlying causes of the incident.

7.6 Step 6: Developing Recommendations

Identifying causes is not enough. Changes need to be made that address each of the underlying causes that have been identified. In this step, short-term, medium-term and long-term recommendations are developed to address the causes identified in Steps 4 and 5. Measures to assess the effectiveness of the recommendations are also developed.

7.7 Step 7: Completing the Investigation

To complete the investigation process, everything needs to be pulled together in a report. In this step, the results of the analysis are communicated to those who were not on the team. Then it needs to be ensured that the recommendations developed in Step 6 are implemented. Finally, the investigation process itself is critiqued and improved.

7.8 Step 8: Selecting Problems for Analysis

In this step, a method to select incidents for analysis is determined. Guidance is provided for determining if an immediate analysis is performed or if the incident data are only documented or trended. Investigation of near misses and chronic event analyses are also addressed.

7.9 Step 9: Trending

Steps 2 through 8 were performed on those incidents that had sufficiently large actual or potential consequences to warrant an investigation on their own. This step looks at all the data from incidents that have been analyzed, as well as all of those that it was decided not to analyze, to see if a group of incidents should be analyzed together. Are the same types of problems occurring repeatedly? If so, it may be decided that an investigation of this group of incidents is warranted.

7.10 Step 10: Following up an Investigation

Finally, once an investigation is completed and recommendations accepted, follow-up is needed to determine the effectiveness of the implemented preventative and correction actions. No matter how thorough the analysis, it is possible that the recommended actions are not completed or that they were not effective is solving the original problem.

7.11 Developing an Overall Incident Investigation Program Management Issues

This step really surrounds the remaining steps. It asks, "Are the management systems put in place to ensure that the other steps are properly performed?"

8 Levels of the Analysis: Root Cause Analysis and Apparent Cause Analysis

Section 2, Figure 6, "Levels of Analysis," shows the various levels of the analysis in a flow diagram format. The analysis begins with an understanding of the sequence of events that led up to the incident. The underlying causes (or the causal factors) of the losses are structural/machinery/ equipment/outfitting problems; human errors and external factors. Underlying these are the root causes. However, it is not possible to move directly from causal factors to the root causes since there will be a number of intermediate causes between the causal factors and root causes.

The analysis requires the identification of intermediate causes to connect the causal factors to the root causes. Section 2, Figure 7, "Connection Between Causal Factors and Root Causes," shows the typical progression of the analysis down to the root cause level. This is consistent with the view of the organization through the task triangles examined earlier.

Root cause analyses investigate the causes of the incident down to the root cause level. Apparent cause analyses only investigate the causes of the incident down to the causal factor level. Apparent cause analyses are typically performed on events with smaller consequences. Apparent cause analyses may be time driven. In other words, a certain level of effort is allocated to the analysis. Root cause analysis efforts are typically goal driven. The level of effort is determined by what it takes to achieve the goal of the analysis.

FIGURE 6
Levels of Analysis

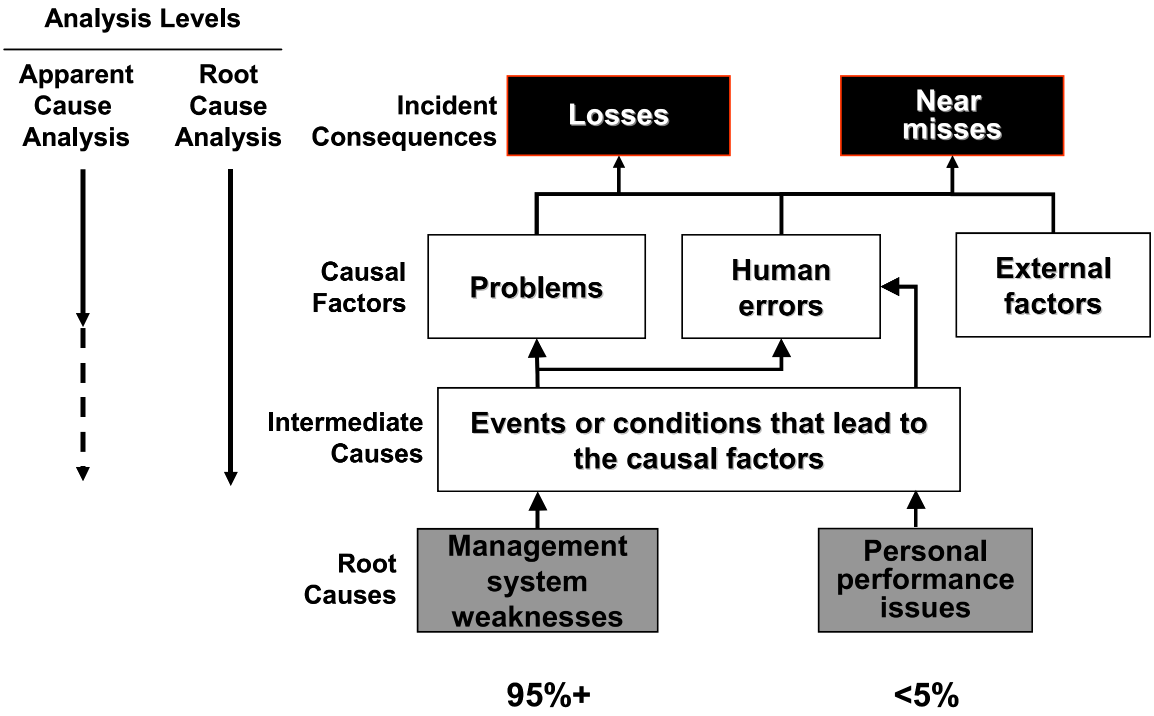
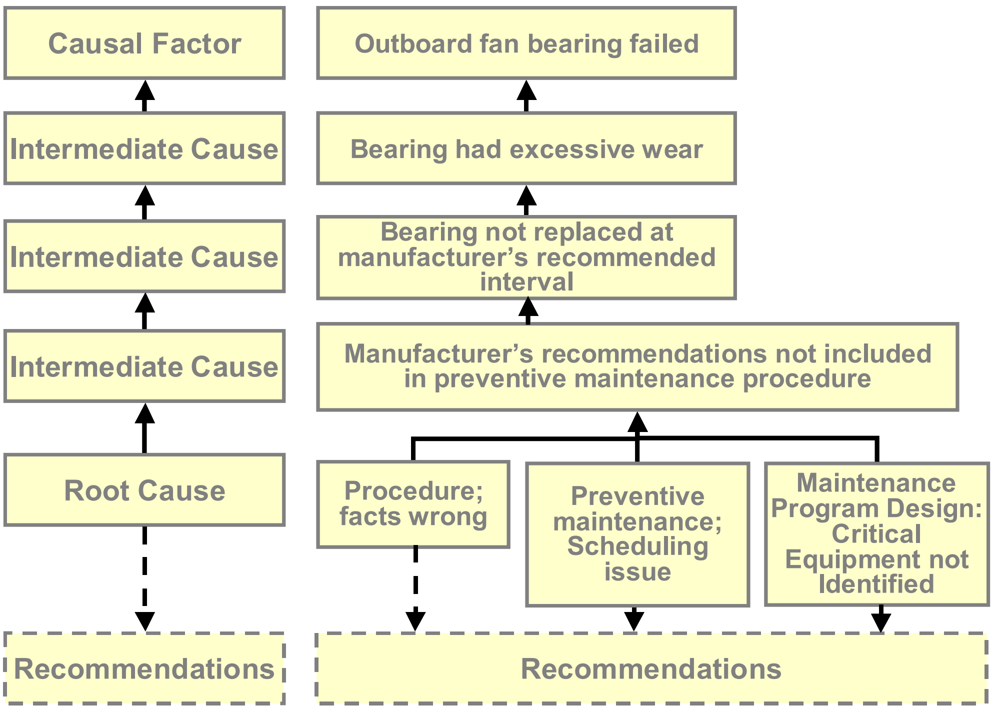


FIGURE 7
Connection Between Causal Factors and Root Causes



9 Summary

The goal of incident investigation is not only to understand the "what" and "how" of an incident, but also why it happened. The analysis of an incident begins with the gathering of data. As the data are gathered, they are organized and analyzed using causal factor charting, fault tree analysis or the 5-Whys technique (or other appropriate tools). The goal is first to identify the causal factors for the incident. Causal factors are those contributors (human errors, problems and external factors) that, if eliminated, would have either prevented the occurrence or reduced its severity. Once the incident is understood, root causes are identified for each causal factor. Root causes are deficiencies of management systems that allow the causal factors to occur or exist. Finally, recommendations are developed and implemented to eliminate the root causes and prevent the causal factors from occurring again.

Two levels of analysis can be performed. For an apparent cause analysis, the analysis only goes to the causal factor or intermediate cause level. Root cause analyses identify deeper underlying causes.

Root cause analysis differs from traditional problem solving in that the root cause analysis approach is more structured. The structure of the approach is intended to ensure that a more thorough analysis is performed and assumptions are examined.

SECTION 3 Initiating Investigations

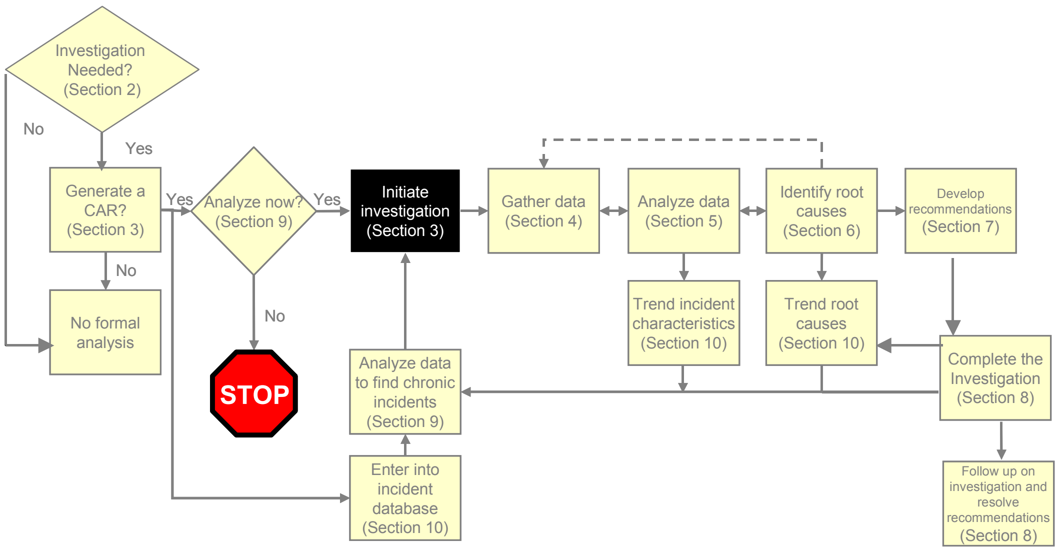
1 Initiating the Investigation

Initiating an investigation or analysis involves many tasks. The following is a list of the typical tasks involved. Each of these issues will be reviewed briefly.

- Notification
- Emergency response activities
- Immediate response
- Beginning the investigation
- Corrective action request (CAR)
- Incident classification
- Investigation management tasks
- Assembling the team
- Restart criteria
- Gathering investigation resources

Section 3, Figure 1 shows where initiating an investigation falls within the context of the overall incident investigation process.

FIGURE 1
Initiating Investigations within the Context of the Overall Incident Investigation Process



2 Notification

A notification process is needed to ensure that all appropriate personnel are notified of the incident. Designated individuals should report incidents to key individuals within an organization and outside of the organization. Statutory requirements and organizational policies usually specify the personnel who need to be notified, as well as the timing and content of such notifications.

A predefined process (often a contingency plan) should be used to perform internal and external notifications. The organization should develop call lists and procedures to ensure that the correct personnel are promptly notified of incidents. Individuals in the organization should know the internal process used to report incidents and the types of incidents they should report. By completing internal notifications promptly, the appropriate external notifications can be performed within the applicable time requirements. Usually notification of these individuals is outside the scope of the investigation team's responsibility. Appendix 7 provides an Initial Call Checklist to illustrate some of the information that should be documented.

3 Emergency Response Activities

Emergency response personnel cause problems for investigators. During performance of their duties, they alter data. This makes it more difficult to recreate the sequence of events that led to the incident. Despite the alteration of data, the primary goal during the emergency response phase must be preventing further injuries, property damage and environmental impact. The investigation activities should not be allowed to interfere with the proper performance of emergency response activities. However, if the investigation can begin concurrently without interfering, hindering or delaying emergency response activities, then preservation and collection of data can be performed in parallel.

The adequacy of the emergency response may or may not be within the scope of the investigation. The instructions provided to the incident investigation team should specify if the team is supposed to assess the adequacy of the emergency response. The loss events/conditions defined by the team will also determine if emergency response will be within the scope of the investigation.

4 Immediate Response Activities

Some thoughts that should be kept in mind by the incident investigation team immediately following an incident include:

- Ensure that actions of investigators do not lead to another incident.
- Follow all directions and limitations issued by the onsite incident commander.
- Follow all directions and limitations with regard to safe work practices for isolating energy sources and controlling hazards.
- Remember that following an incident, there are often unusual hazards with the potential to create dangerous situations.
- A job risk analysis or job safety analysis may have to be performed to determine how the investigation activities can be performed safely.

Access to the incident site (and any associated records) should be controlled to preserve all relevant incident data. Only personnel specifically authorized by investigation team personnel should be permitted entry to the site.

It is important to determine the data that may be useful in investigating the incident – equipment, personnel, paper, photos, position information, electronic data, etc. – and preserve it for analysis. It is prudent to preserve more than may seem necessary. Unneeded items can always be released later; however, once released, the data from the item can often become useless. A timesaving approach is to develop a generic list of data that are typically useful during investigations. A document entitled Data Needs Checklist in Appendix 7 provides some suggestions for the types of data that might be useful to collect. The checklist should be reviewed at the beginning of an investigation, The Data Needs Form, also in Appendix 7, can be used to document data requirements. Data requirement can be based on the Data Needs checklist, with entries added and deleted, as appropriate. During the investigation, reference back to the checklist and entries on the completed Data Needs form is recommended.. Developing a Data Needs list should ensure that the incident investigation team does not forget to obtain key data.

Once access to the incident scene is granted, the Initial Incident Scene Tour checklist and the Post-Tour checklist provided in Appendix 7 can assist with focusing your attention on relevant items to observe and document.

Preliminary photographs should be taken and/or initial sketches made of the incident scene. Having a still camera and a video camera readily available will help in gathering preliminary data. Again, take more photos than may seem necessary. Specific guidance for taking photographs and videos is contained in Section 4, “Gathering and Preserving Data”.

5 Beginning the Investigation

The investigation should begin as soon as possible. Legal and organizational requirements may impose a specific time limit. An investigation can get started even while emergency response activities are still being conducted (as long as it does not interfere with emergency response activities).

The loss events/conditions associated with the incident should be specifically identified. As noted in Section 1, the definition of the loss event/condition determines the scope of the analysis, and the magnitude of the consequences determines the level of effort. Therefore, a precise definition of the loss event is vital to the success of the analysis. What equipment, structures, items, cargo and systems were involved should be identified; as well as who was involved; when it occurred (day, date, time, watch); and how much or how many were involved (how much material was released, how many items were damaged).

Multiple loss events/conditions may need to be identified to address the different types of losses and the different stakeholders affected by the incident. For example, a fire could damage equipment in one area of the vessel. The smoke from the fire could be transported to another vital area of the vessel and affect personnel there. The fire could also damage a portion of the cargo. Separate loss events will be needed to address each of these. By having multiple loss events/conditions, it is ensured that the causes of each are identified as part of the analysis.

Loss events/conditions are the starting point for causal factor charts, 5-Whys and fault trees. Therefore, the issue of specifically defining loss events/conditions will be addressed in Section 5, “Analyzing Data”.

6 Corrective Action Requests

For most organizations, the first step towards performing an investigation is the generation of a Corrective Action Request (CAR). Although CARs can be generated for many reasons, some of the CARs will result in triggering an investigation. (*Note*: Not all companies use the “CAR” acronym, but the meaning is the same.)

6.1 Reasons to Generate a CAR

CARs are often the first form completed when problems arise. CARs can be generated as the result of the following activities:

6.1.1 Audits

Following the completion of an audit, nonconformities that need corrective actions are identified. The CAR is initiated to document the corrective actions and relate the corrective actions to the source (in this case, an audit).

6.1.2 Inspections

During inspections of materials, nonconformities may be identified that require further action to resolve. As an example, a purchase order specifies Model 42XP breakers that are purchased from Company A. During receipt inspection, it is noted that Model 52PX breakers from Company B have been received. A CAR may be generated to determine if the substitute breakers are acceptable for use.

6.1.3 Preventative Actions

CARs may be generated for preventative actions (e.g., near-misses, opportunity for improvement or to alleviate conflicts within the management system).

6.1.4 Meetings

During meetings, corrective actions may be identified. By generating a CAR, the action items can be easily tracked.

6.1.5 Training/Drills

During training and drills, performance problems may be identified that require corrective actions to resolve. Generation of a CAR identifies these corrective actions and allows them to be tracked.

6.1.6 Incident

When a performance problem is observed in the field, a CAR is generated to identify and track any additional actions that are needed to respond to the incident.

6.2 Typical Information Contained in a CAR

CAR formats vary somewhat from one organization to another. However, the forms typically contain information such as the following:

- Source/type: audit, inspection, meeting, training, drill, incident
- Audit, investigation, inspection, meeting, training or drill: date, reference number and initiator
- Title
- Description
- Immediate corrective actions taken (i.e., to stabilize the situation or fix the broken item)
- Remarks/comments
- Category
- Applicable regulations/standards
- Status (pending review, approved, etc.)

- Corrective actions (recommendations)

    Description

    Assigned to

    Date to be completed

    Follow-up actions

    Date verified

A CAR can be generated in response to any of these items. As part of generating the CAR, corrective actions can be developed and assigned to individuals. If a more detailed analysis of the issue is desired, an incident investigation can be performed for any of these issues. For example, an incident investigation could be performed to determine what caused the nonconformities that were identified by an audit. An incident investigation could be used to determine why substitutions occurred during the procurement process. An incident investigation can also be used in the traditional sense, following a typical safety or reliability incident.

As shown on the process flow diagram (Section 3, Figure 1, "Initiating Investigations within the Context of the Overall Incident Investigation Process"), the CAR process is not considered part of the investigation process itself. This is because CARs can be generated from many different processes, as described above. For root cause analyses, the CAR is only used to start the process.

6.3 Using the CAR in the Incident Investigation Process

As can been seen from the information normally contained in a CAR, an entire analysis can be performed with the CAR process. The process is much more simplified than an Apparent Cause Analysis or Root Cause Analysis approach. However, it certainly is appropriate for situations where the organization believes there is not much to learn from a more detailed analysis of the situation.

If more details on the sequence of events, the interactions between personnel, the interactions of the management systems and the underlying causes of the incident are needed to generate effective corrective actions (recommendations), then an Apparent Cause Analysis or Root Cause Analysis) is probably appropriate.

The incident reported by the CAR is then assessed against the incident classification criteria discussed in the next subsection.

7 Incident Classification

Once the loss event/condition and consequences are defined, the incident should be classified. By classifying the incident, the organization can appropriately allocate resources to the investigation, identify a qualified team leader and determine team composition (e.g., organizational personnel, outsiders, contractors as required). Typically, the classification scheme is based on the actual or potential consequences of the incident. Organizations typically define two or three levels of analysis.

For each level, the organization provides guidance on the amount of effort appropriate for the analysis. For example, for the lowest level of analysis, a single individual may spend less than one hour and complete a standard report form. For the highest level of analysis, a team of six personnel may spend weeks determining the deep underlying causes and developing a detailed report of their findings.. Example investigation plans are provided in Appendix 7 that can aid with either Simple or Detailed Investigations.

Setting up classification schemes can convey clear expectations for investigations. Classification schemes can account for all types of losses. For example, thresholds can be identified for safety, reliability, environmental, security and quality incidents. Section 3, Table 1, "Incident Classification Criteria," shows some sample classifications.

TABLE 1
Incident Classification Criteria

Operations Complexity	*Type of Incident*	*Severity*	*Applicable Regulation*
High	*Accident*	*Multiple fatalities/serious injuries*	*IMO*
• Inerting	• Collision		• SOLAS
• Vessel gas freeing	• Spill/Release	*Fatality*	• MARPOL
• Maneuvering	• Grounding	*Injury*	• ISM
- traffic	• Explosion	• Hospitalization	• STCW
- restricted waters	• Fire	• Lost time accident	• COLREGS
- weather	• Sinking	• Recordable	• ISPS
• Tanker operations	• Personnel harm	• Medical treatment only	*ILO*
• Bunkering	*Near miss*	• First aid	*Flag Administration*
• Stability calculations	• Near collision	*Evacuation*	*Port State*
• Cargo operations	• Dragging anchor	*Abandonment*	*Port Authority*
- start up	• Failure of critical safeguard	*Reportable*	*Class Society*
- rate down	• Challenge last line of defense	*Level of business interruption/product of losses*	*None*
• Hazardous materials use/storage	• Serious process excursion		
Moderate	*Other*		
• Navigation at sea	• Machinery upsets	*Levels of equipment damage*	
• Engine operation	• Quality variations		
• Maintenance activities	• Downtime		
Simple			
• Taking on stores			
• Housekeeping			

8 Investigation Management Tasks

From a project management standpoint, incident investigations should be treated like any other project. All of the problems that can be encountered during any other project can also be encountered during an incident investigation. However, because of the short time frame involved, any problem that is encountered during an incident investigation tends to have larger, more immediate effects. Incident investigations should have a project manager and project staff with clearly stated goals from the individual or group commissioning the investigation. This helps keep the investigation on track.

Like any other project, ill-defined goals will often result in the team failing to meet the objectives that were expected of it. Although it may initially appear to be a waste of time, determining a very specific goal generally pays off in the end by eliminating any investigation efforts that are not within the scope of the analysis.

Like any other project, the team leader should establish schedule requirements and commitments and arrange for funding consistent with the objectives, scope and schedule. In addition, the team leader needs to assign roles and responsibilities to the team members and augment the team with outsiders, as required. Communication protocols and logistics arrangements should also be handled by the team leader.

All of these investigation management issues are dealt with on both small and large investigations. However, for the small investigations, only a few moments may be spent on these planning tasks. The Team Leader Responsibilities Checklist, included in the MaRCAT Toolkit in Appendix 7, lists specific tasks the team leader should address. Other forms are provided that can assist with investigation management, such as an Investigator’s Log, Open Issues Log, meeting forms and a Contacts form.

9 Assembling the Team

The composition of the team depends primarily upon the characteristics of the incident (recall the classification scheme discussed above). Teams can range from a single investigator to a large, multidisciplinary group of onboard, shore-based, corporate and/or outside personnel. The largest workable team usually has a core group of about eight. However, two to six is the optimum number. Other people may assist the team, but they usually have very specific tasks assigned to them.

A typical team consists of shipboard personnel, operations personnel, naval architects, marine engineers, safety/reliability/quality department representatives and an individual with investigation expertise. Many others can help with the investigation, even if they are not on the team. Examples include vendor representatives, fire investigators, chemists, company attorneys, instrument designers, reliability engineers/specialists and technicians.

In general, individuals who have one or more of the following characteristics should **NOT** be on the investigation team:

- *People too close to the incident.* They often cannot see what occurred during the event because they were too involved in the event.
- *People with insufficient time to participate in the investigation.* The investigators need to be able to devote adequate time to the investigation in order to obtain acceptable results.
- *People who already* know *the answer.* If someone believes that he or she already "knows" the answer, the investigation becomes just a way to confirm what he or she already believes instead of an investigation that explores all the possibilities. Often by the questioning the assumptions about how the organization and systems operate helps to identify the causes of the incident. Someone who already "knows" the answer never questions these assumptions.
- *People too high up in the management chain.* Individuals too high up in the management chain tend to dominate the investigation and intimidate the individuals involved. This can lead to limited data being uncovered during the analysis. Thorough data are needed in order to understand the underlying causes and develop effective recommendations.

Exceptions may need to be made to these rules as a matter of practicality. There are a limited number of shipboard personnel. As a result, providing the investigator or investigation team with the skills and knowledge needed to perform the investigation may require assigning individuals to the team who have one or more of these undesirable characteristics.

10 Restart Criteria

In some instances, restart criteria may need to be established before the equipment or system or even a voyage can be restarted. For example, if a pump malfunctions and is damaged, criteria should be established for its return to operation to ensure that it does not fail again. In most cases, it is not practical to wait for the root causes of the incident to be identified before the equipment is released for restart. However, at least one of the causal factors needs to be identified and addressed before the pump is restarted. By identifying and correcting at least one of the causal factors, there is some assurance that the pump will operate without failing or that the consequences of its failure will be reduced while the underlying causes of the failure are identified and corrected. As described in Section 7, recommendations may be short-term, medium-term or long-term in nature. Restart criteria usually involve implementation of short-term recommendations to ensure that the incident does not recur before implementation of medium- or long-term recommendations.

Restart criteria may also apply to personnel safety incidents. For example, if someone is injured because of an electrical system malfunction, short-term recommendations will need to be implemented to prevent further injuries to personnel. These short-term recommendations may consist of repair of the equipment (correcting a short-to-ground condition) or involve a lockout of the equipment until the underlying causes of the problem can be identified. Medium- and long-term recommendations will need to be implemented to ensure that malfunctions of other electrical equipment are prevented or their consequences are minimized.

Restart criteria have another purpose. In addition to ensuring that the consequences of future failures are avoided or minimized, restart criteria are also used to ensure that the appropriate data are collected before the equipment is released. For example, photographs of scratches on the surface of a failed shaft may be needed to understand the failure. Restart criteria may involve obtaining these photos before returning the component to service. Another example would be collecting oil samples from various portions of a diesel engine before flushing it.

In some cases, development of specific restart criteria may not be possible. For example, following a loss of propulsion, equipment may have to be restarted as soon as possible without regard to the investigation objectives. Because of the immediate need for the operation of the equipment, investigation objectives are a lower priority during the short-term emergency response efforts. Once normal operation is restored, personnel can then begin the investigation process.

11 Gathering Investigation Resources

The team will need some basic tools to perform its investigation. Most of these tools are commonly available items. Examples include:

- Measuring devices – ruler, tape measure
- Markers – pens, pencils
- Self-stick removable (Post-it®) notes
- Flipchart paper
- Forms
- Office supplies – paper clips, stapler
- Gloves
- Plastic bags
- Plastic tarp
- Camera (preferably digital or with film, batteries, etc.)
- Flashlight with extra batteries
- Clipboard
- Personal protective equipment (PPE)

Most of these items can be put together in a kit so that they can be quickly obtained by investigation team members when they begin their work. Suggestions for materials to be included in such a kit can be found in the document entitled “Investigation Tools Checklist” in Appendix 7.

12 Summary

Preplanning must be performed to ensure that the investigation is initiated quickly. The faster the investigation is started, the easier it will be to complete the investigation.

Classifying the incident will help organizations allocate their resources properly. For larger investigations, an effective team leader is needed to manage the investigation process and the investigation team.

SECTION 4 Gathering and Preserving Data

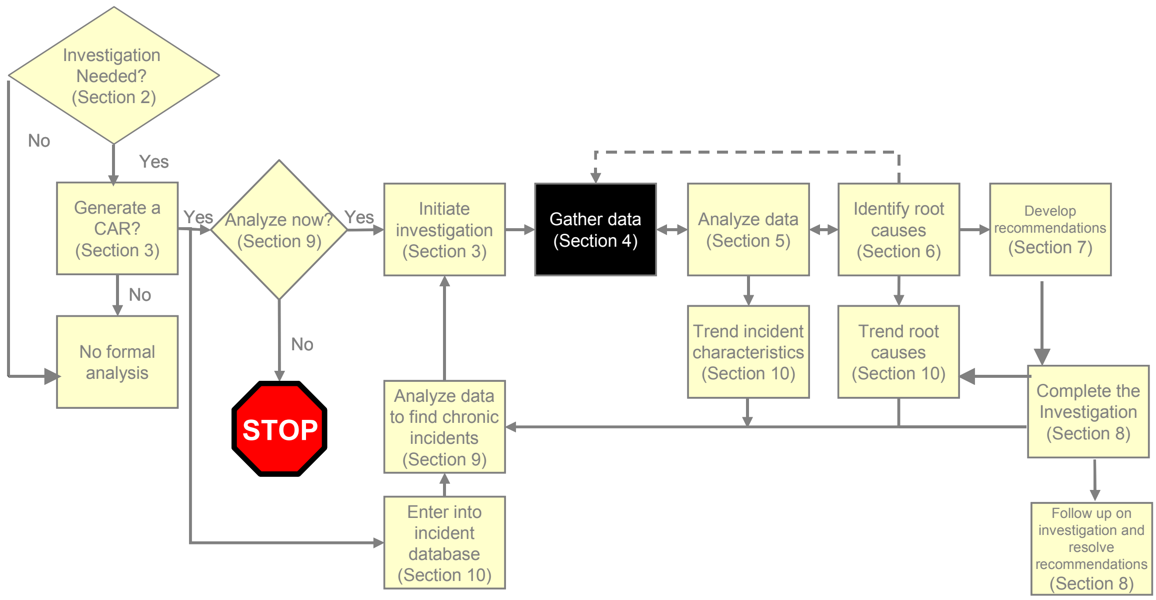
1 Introduction

This Section addresses methods for gathering and preserving data as well as analyzing the data. Section 4, Figure 1 shows this step in the context of the overall incident investigation process.

The topics covered in this Section include:

- Types of data
- Prioritizing data-gathering efforts
- Gathering, preserving and analyzing:
  - People data
  - Physical data
  - Paper data
  - Electronic data
  - Position data
- Overall data collection plan

FIGURE 1
Gathering Data within the Context of the Overall Incident Investigation Process



1.1 Importance of Data Gathering

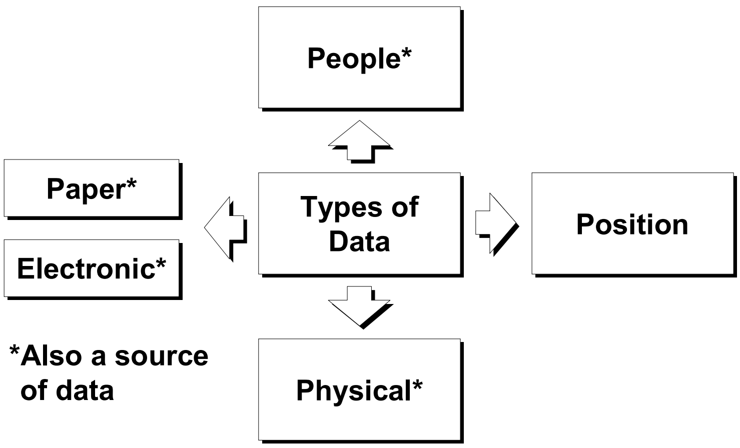
Factual information derived from data-gathering activities serves as the basis for all valid conclusions and recommendations from an investigation. Without effective data gathering, the incident cannot be truly defined and investigated. Gathering data usually takes more time than other investigation steps.

1.2 Overall Types of Data

There are five basic types of data as shown in Section 4, Figure 2, "Overall Types of Data Resources" and listed below.

- *People* – interviews with or written statements from witnesses, participants, etc.
- *Physical* – parts, chemical samples, personal protective equipment (PPE), structures, outfitting items, logs, paper charts, correspondences, etc.
- *Paper* – hard copies of procedures, policies, administrative controls, drawings, sketches, notes, performance and operational data, analysis results, procurement specifications, navigational charts, loading specifications, etc.
- *Electronic* – electronic copies of procedures, policies, administrative controls, drawings, performance and operational data, analysis results, procurement specifications, e-mail, navigational charts, loading specifications, etc.
- *Position* – locations of people and physical data.

FIGURE 2
Overall Types of Data Resources



1.3 Prioritizing Data-gathering Efforts

The fragility of data is the prime criterion used to determine the order in which data should be gathered. Generally, the data types from most fragile to least fragile are:

- People
- Electronic
- Position
- Physical
- Paper

The investigator or investigation team cannot gather all of the data simultaneously. They must set priorities for what to gather first and what can wait until later. The fragility of the data should be the primary guide in setting these priorities. Waiting too long to obtain the data from people, for example, can result in changes to the data that can never be recovered.

Section 4, Table 1, "Forms of Fragility," shows some of the forms of fragility for the various data types. Some examples of the primary issues for each of the data types are discussed below:

TABLE 1
Forms of Fragility

	Form of Fragility		
Data Source	*Loss*	*Distortion*	*Breakage*
1. People/Position	Forgotten Overlooked Unrecorded	Remembered wrong Rationalized Misrepresented Misunderstood	Transferred Influenced Personal conflicts
2. Physical/Position	Taken Misplaced Cleaned up Destroyed	Moved Altered Disfigured Supplanted	Dispersed Taken apart
3. Paper	Overlooked Misplaced Taken	Altered Disfigured Misinterpreted	Incomplete Scattered
4. Electronic	Overlooked Deleted – by design – inadvertently	Altered Diluted Corrupted	Incomplete Scattered

1.4 Types of People Data

1.4.1 Unrecorded

The personnel involved in the event will often not remember the details of the event, including their own actions. The information asked of them to remember is usually not required for the normal performance of their duties. So, there is little reason for them to pay attention to the details typically being asked during an investigation. This is true for all personnel, including those who have a strong motivation to do a good job. Think about the last time you drove to work. Do you remember all of the cars you passed? All the cars that passed you? All of the intersections you went through? Your life depends upon proper performance of this task, yet you cannot remember the details. This is because people normally do not need to remember these details in order to do a good job of driving. Do not be surprised when personnel cannot remember the details of the activities they were performing.

1.4.2 Rationalized

In most cases, the raw data is needed from personnel: what they did, what they saw, what they heard. Investigators are supposed to draw conclusions from the data collected. However, personnel often present conclusions (some valid and others not) as part of the information they provide without realizing they are drawing conclusions. For example, someone might say, “The pump froze up at that point because of overheating.” The fact that the pump stopped is not a conclusion; it was a direct observation they made. The fact that the pump was hotter than normal is also a direct observation. However, the conclusion that the pump stopped because it overheated may not be valid. It may have been hotter than normal, but not hot enough to cause the pump to seize. Investigators must carefully separate the observations from the conclusions. In this case, it would be important to understand the basis for the stated conclusion. Additional data (questions and physical data) will be needed to confirm that the pump seized from overheating.

1.4.3 Personal Conflicts

Personnel will generally not reveal information that has a high potential for causing them personal harm. This is the primary reason for setting up interviews in the most non-threatening environment possible. Many investigations rely heavily upon the data provided by personnel. The personnel have the data and they do not have to give it to the investigation team. Being respectful of the witnesses so that they can relax may be the only way to get the data from them.

1.5 Types of Electronic Data

1.5.1 Deleted

Electronic data can be easily deleted. Deletion may occur on purpose or unintentionally. A few keystrokes can often delete a great deal of data. Policies and processes for backing up data and duplicating are often needed to address this issue.

1.5.2 Diluted

Some electronic systems contain detailed information for the most recent period, but automatically delete some of the details after a set period of time. For example, information on system performance may be available in 5-second intervals for the last 24 hours, but only once per minute for the last 7 days, and once per hour prior to that. Therefore, it may be necessary to capture electronic data quickly after an incident in order to save detailed data.

1.5.3 Scattered

The information that is needed may be scattered among many different computer systems. For example, procurement information may be available in the corporate office, warehouse records in a remote facility and installation records onboard the vessel. Connecting the information from these three different systems can prove difficult and time-consuming.

1.6 Types of Position Data

1.6.1 Cleaned Up

Position data are often altered by our efforts to clean up the incident scene. For example, cleaning up a spill will alter the size and position of the spill. Unless the original size and position of the spill is noted, it will be difficult to recreate. Cleanup efforts should be balanced with the need to obtain data.

1.6.2 Taken Apart

Investigators often destroy and alter data in the process of discovering the causes of the failures. When equipment is taken apart in an effort to understand the causes of the failure, position data are altered and destroyed. For example, if an operational test is performed on a seized pump, the position the shaft was in when it seized is lost when the shaft is rotated. Connections between items can also be lost. For example, it can be difficult to determine how electrical or control cables were connected once they are disconnected.

1.7 Types of Physical Data

Investigators often destroy and alter data in the process of discovering the causes of the failures. When equipment is taken apart in an effort to understand the causes of the failure, physical data are altered and destroyed. Test plans are normally developed to help prevent the inadvertent alteration of the data by the investigator. However, in some cases, the investigation team has no choice but to destroy some data.

To obtain some data requires the alteration of other data. For example, consider a pump that is suspected of seizing from overheating. It might be desirable to rotate the pump shaft to see if the pump is still seized even after it has cooled down. However, even hand rotating the shaft could further scratch the internal parts of the pump, making it harder to determine the original extent of damage to the pump. If the pump is disassembled first, it cannot be reassembled to its original condition to perform a subsequent operational test.

1.8 Types of Paper Data

Paper data are the most stable of the data types. Therefore, there are usually no significant problems with the loss of the data. However, like electronic data, paper data can be scattered throughout an organization or across multiple organizations. As a result, the data may be very difficult to locate.

2 Gathering Data

The next five subsections provide guidance on gathering, preserving and analyzing data from the five data types. In addition to the guidance provided here, numerous data collection forms are included in the MaRCAT Toolkit in Appendix 7. They are referenced at the appropriate location in the text.

3 Gathering Data from People

Data from people is one of the primary sources of information for most investigations. People data tend to be one of the most fragile of the data types, so it needs to be gathered quickly.

Most data from people are gathered during interviews. The primary focus of most interviews should be on the witnesses' direct sensory observations (I saw …, I smelled …, etc.) and their memories of their own actions. The investigator will then use the data collected from the interviews, along with the other data collected, to draw conclusions about what occurred.

Witnesses' conclusions and opinions may prove interesting, but these are generally not as important as the factual data provided. The conclusions and opinions of personnel may not be valid because they often have only part of the data needed to draw a valid conclusion. Nevertheless, it is a good idea to ask for their opinions. Besides showing them that their opinions are valued, personnel sometimes identify rather simple and elegant solutions to the problems.

Many factors affect the information provided by witnesses. What actually happened and what witnesses say may differ significantly. Some examples of typical influences include:

- Location of the witness (downwind versus upwind, on deck versus below deck, etc.)
- Relative location of nearby equipment and structures
- Ambient conditions
- Relative location of the sun
- Number of people nearby
- Common optical illusions
- Relative motion
- Vertigo
- Medication effects
- Absence of shadows
- Night vision limitations
- Refraction of light
- Intensity of lights over a distance
- Age, long-term physical condition and short-term physical condition
- Emotional status
- Individual sensitivity
- Intelligence
- Knowledge/familiarity with the process and overall experience
- Emotions
- Position/job threat
- Exaggeration
- External influences
- Tendency to underestimate long distances or periods of time or overestimate short distances or periods of time

Often what witnesses report does not ultimately prove to be the truth. However, in most cases, it is the truth as best they know it. Try this exercise:

> Draw both sides of a coin you use on a frequent basis (e.g., a penny) on a piece of paper. Then find that coin and compare your drawing to the real thing.

How did you do? Did you get all the details? If it was a penny from the United States, did you remember the word “LIBERTY” on the front, “E·PLURIBUS·UNUM” with the dots on the back? No? Maybe your poor performance has something to do with your poor attitude towards coins. Maybe if you paid more attention you would have done better in the drawing exercise. Maybe a few days off will help you remember how to draw a penny better next time.

On the other hand, maybe you cannot draw a very good picture of the coin because you are an average human. Unless you are a coin collector, you probably cannot do a very good job with the drawing because that skill is not vital to you. During most events, there is no reason for workers to notice everything that is going on during their job until after a loss occurs. So, do not think that a witness is purposely trying to withhold information or is being purposely misleading you when they state something that is incorrect.

3.1 Initial Witness Statements

Investigators rarely are able to start interviewing personnel as quickly as they would like. A quick method to obtain some general information from each of the personnel involved in an incident is to use an Initial Witness Statement form. The form can be distributed by the master, first officer or chief engineer to personnel who are believed to have information related to the incident. Using the form allows a single investigator to collect data from multiple personnel simultaneously. The completed forms can then be reviewed by the investigator to determine the order of the interviews and potential issues or questions to discuss during the interview. An Initial Witness Statement form is included in the MaRCAT Toolkit in Appendix 7.

Some personnel may have difficulty completing the forms because of their reading or writing ability or the language used on the form. Alternative methods may be needed to address this issue, such as translation of the form into other languages.

3.2 The Interview Process

The goal of interviewing is to obtain as much information from the witness as possible. Most individuals will provide more data if they are relaxed. Therefore, most of the guidance in this subsection is designed to relax the witness. Section 4, Figure 3, "Flowchart of Typical Interview Sequence" shows the interviewing process. Each of the items in the figure is discussed. The Interview Preparation Guidelines are included in the MaRCAT Toolkit in Appendix 7. An Interview Documentation form is also provided.

3.2.1 Identifying Witnesses

The first step in the interviewing process is to locate potential witnesses. Many methods can be used to locate potential witnesses. Examples include referrals made by current witnesses, lists of personnel responding to the emergency associated with the vessel and/or operation, crew lists, visitor sign-in sheets, work orders, logs and any other documents that have individuals' names on them. A Contacts form is included in the MaRCAT Toolkit in Appendix 7. This form can be used to record names and contact information for potential interviews.

3.2.2 Selecting the Interviewer

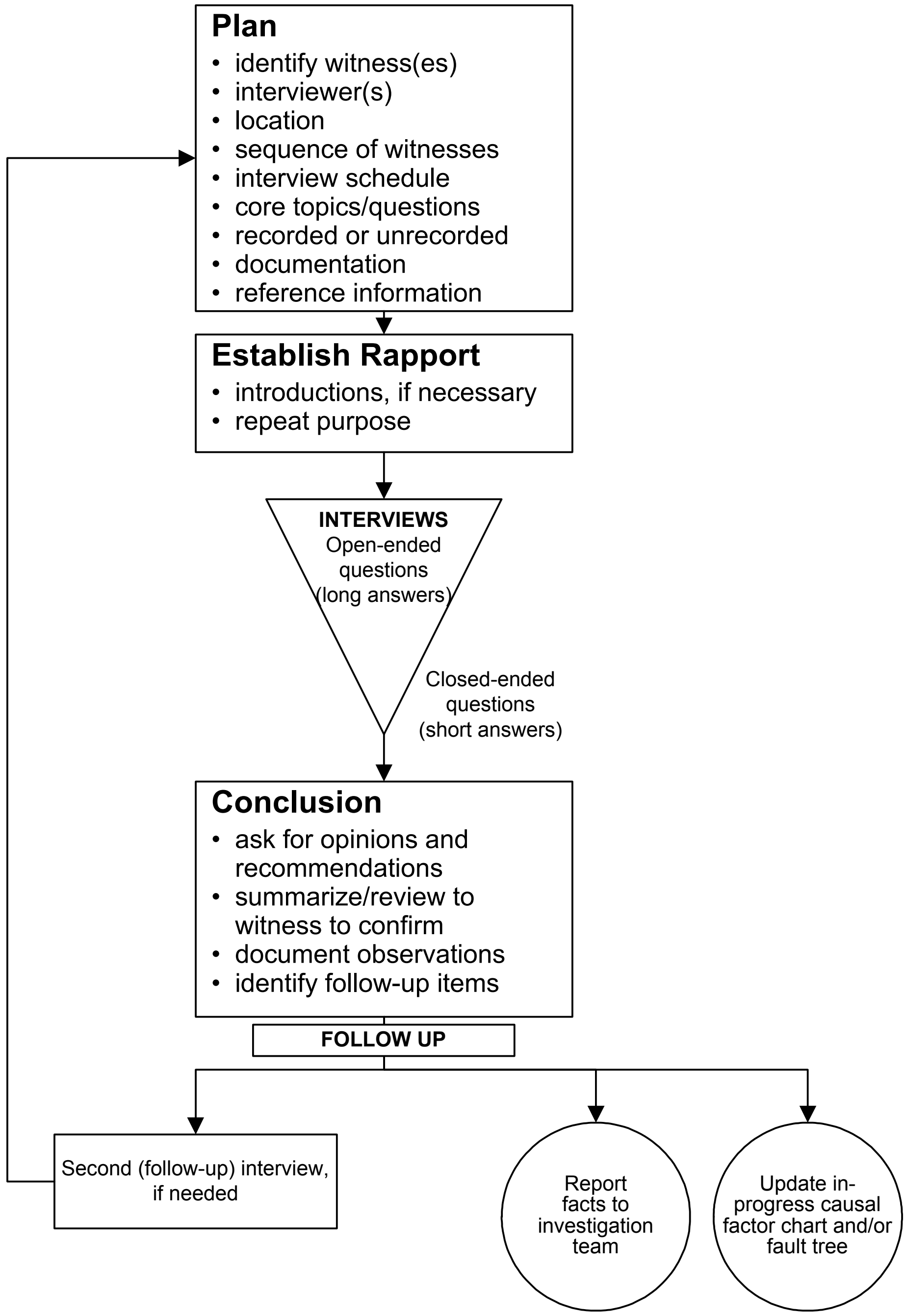
Matching the interviewer to the witness is very important. The interviewer should be someone with whom the witness will feel comfortable. The witness will be more relaxed if he or she is matched with someone who is (1) at a similar level in the organization (not too high up or too low), (2) familiar with the system and its terminology and (3) good at interviewing. By having the individual be more comfortable with the interviewer, it is more likely that the individual will share information with the interviewer.

The best setup for an interview is one-on-one or two-on-one. No more than two people should interview a witness. With a one-on-one interview, the person asking the questions is also responsible for taking notes. This can slow down the interview. A second interviewer can help by taking notes during the interview. This allows the individual asking the questions to concentrate on what the witness is saying and formulate the next question. To keep the witness focused on the interviewer, the person taking the notes should not ask any questions until the end of the interview when the primary interviewer asks the note taker if he or she has any other questions. At this point, the witness can focus on the note taker. By having only one person at a time asking questions, the impression that the investigation team is ganging up on the witness can be avoided.

Group interviews can also work, but the level of trust in the group must be very high before individuals will share sensitive information in a group setting.

Group interviews can also work later in an investigation when a few minor details are being resolved. However, care must be taken not to embarrass individuals during these meetings.

FIGURE 3
Flowchart of Typical Interview Sequence



3.2.3 Selecting the Interview Location

The best location for an interview is one that is familiar to the witness. In general, the incident scene is the most desirable location. It allows the witness to share with the interviewer additional information that might not be shared if the interview took place at another location. Other possible locations include the galley, recreation areas and work stations. The witness may be embarrassed or worried about being seen with the investigator in these public areas. So, the investigator should move the interview to a more private location when necessary. Never perform an interview at a location unfamiliar to the witness, such as the captain's quarters.

3.2.4 The Sequence of Witnesses

In developing a schedule for interviews, consider the fragility of the data and the availability of the data. Interviews should be scheduled promptly. The first witnesses should be those individuals:

- With the most fragile information
- With the most detailed information
- Most likely to want to provide information

3.2.5 Interview Schedule

Adjust the schedule/interview list based on the data as they appear. Select a schedule that minimizes contact between witnesses to reduce the sharing of information. Provide time between the interviews to finish documentation of the prior interview, analyze the data provided and prepare for the next interview. An Interview Scheduling form is included in the MaRCAT Toolkit in Appendix 7. This form can be used when numerous interviews are to be performed.

3.2.6 Core Topics and Issues

Develop a list of core topics and issues that need to be resolved during the interview. This is not a list of questions to ASK, just topics to cover or issues to resolve. Hopefully, these topics and issues will be addressed and resolved by the open-ended questions asked at the beginning of the interview. The list of specific topics/issues can be developed from the questions and data needs identified on a causal factor chart or fault tree (these tools will be covered in Subsection 4 of Section 4, "Physical Data").

3.2.7 Documentation

Interviews should be documented to provide a record of the interview. Try to record as many details as possible. Use the witness's exact wording, if possible, especially when the witness describes what he or she said to other people. Writing notes should be done unobtrusively to avoid distracting the witness. Avoid using taping devices (audio or video). The witness may feel very uncomfortable being taped and, as a result, will probably not speak as freely. Notes are not as accurate as a tape, but more information is usually obtained during an interview when notes are used versus a tape recorder. Interview Guidelines and an Interview Documentation form are included in the MaRCAT Toolkit in Appendix 7.

3.2.8 Establishing Rapport

To open the interview, explain the purpose and objectives. The purpose should be to help the organization understand what happened and how it happened so that it can change the way the organization operates and avoid problems like this in the future. Warm up with non-business issues and routine matters such as the witness's name, position, years at the company/ position, etc. This will get them to relax a bit and start talking.

Be respectful of the witness during the interview. Be friendly, listen attentively and reflectively. Show compassion and avoid attitudes that destroy rapport. Do not be overbearing/commanding, proud/overly confident, overeager or timid. Do not judge, refute or anger the witness. Do not suggest answers to questions or lead the witness. Do not rush the witness, even if little new information is appearing. Relax and let the witness control the pace. It may feel like a waste of time, but this is the quickest way to get to the vital data the witness has.

3.2.9 Conducting the Interview

Promote an uninterrupted narrative by asking open-ended questions (questions that require long answers). Ask the witness for an initial statement. For example, "Tell me what you saw or did when you first knew of the problem."

Avoid the urge to interrupt with questions after asking open-ended questions. Be quiet and let the witness talk. The point of asking these open-ended questions is to let the witness take you wherever he or she wants to go.

Near the end of the interview, ask closed-ended questions (questions that only require short answers). For example, "Do you use a procedure to start the system?" instead of "How do you start up the system?"

Resolve to remain unbiased and to avoid any actions/questions that may lead the witness. For example, ask, "In what order do you open the valves?" instead of "You open valve 21 before valve 31, right?"

Pretending ignorance usually results in obtaining more information than acting too smart. Remember, the point of the interview is to obtain information from the witness, not to show the witness how smart you are.

Avoid accusatory questions. For example, ask "How does the procedure say to do it?" instead of "That's not the way you're supposed to do it, is it?"

Pursue specifics. Do not let general statements stand. For example, if the witness says "At this point, I ran up the speed quite a bit," ask for a clarification. How fast? Faster than normal? To a specific value such as 90%? Try to get the witness to be as specific as possible. Other examples of specific issues that may need to be pursued are items such as the following:

- Timing of events
- Location of personnel
- Environmental conditions
- Anything moved/repositioned during or after the incident
- Emergency response activities
- Indicators of conditions
- Actions of other people
- Training and preparation
- Histories of similar incidents
- Information gaps
- Inconsistencies in data
- Shore-based personnel involvement
- Possible causal areas
- Beliefs, opinions and judgments related to the incident

3.2.10 Concluding the Interview

Conclude the interview by asking the witness for his or her opinions and recommendations. Most witnesses want to give their opinions and they often have good suggestions for resolving the problems that have been identified. However, wait until the end of the interview to ask about this to minimize influencing the witness. If these questions are asked too early in the interview, the witnesses may do much more filtering of their data.

Finally, ask who else may be able to contribute valuable information and invite additional input if the witness has new information or remembers or discovers other relevant data. Express appreciation for the witness's time, information and cooperation. Gain consent to contact the witness later, if necessary, even if you are confident you will not need to. This ensures that some personnel will not feel singled out for follow-up interviews. At the end of the interview, the notes should be reviewed with the witness. There are two primary reasons for this. First, it helps to ensure that the notes are accurate, and secondly, you will probably gain more information from the witness during this review.

3.2.11 Follow-up Activities

Once the interview is complete, the investigator/investigation team should use the data obtained from the interview to update the analysis tool being used (e.g., causal factor chart or fault tree). This will provide the rest of the team with the information obtained from the interview as well as identify additional data that need to be collected.

3.2.12 Follow-up Interviews

When conducting follow-up interviews, follow the same general format as initial interviews, but use a more structured, straight-to-the-point interview style. Follow-up (closed-ended) questions should be asked sooner than they would be asked during the initial interview. Focus on gaps in information and apparent inconsistencies. Ensure that witnesses do not misunderstand and believe that the follow-up interview indicates the interviewer doubts their credibility.

4 Physical Data

4.1 Sources of Data

Physical data consist of a wide variety of different items. Examples include components of systems, tank samples, control systems, safety systems, support systems, auxiliary systems and personal items [including tools and personal protective equipment (PPE)].

The first step in physical data preservation and analysis is the identification of physical data of interest. Typically, the investigator is looking for items used by personnel or the systems in use during the incident. Specific examples include:

- Fractures, distortions, surface defects/marks and other types of damage on equipment/structural items/outfitting items
- Items suspected of internal failure or yielding
- Seized parts
- Misaligned/misassembled parts
- Control/indicating devices in the wrong position
- Chemical samples
- Pools of residues of chemicals/materials

- Stains and oxidization
- Foreign objects
- Hull structure, decks, outfitting
- Machinery, equipment, components
- Loading/unloading equipment (cranes, conveyors, etc.)
- Vessel control systems
- Buildings and structures (for dock facilities)
- Support systems (HVAC, compressed and instrument air, inerting systems, electrical and lighting equipment, piping systems, power generation equipment, ballast and trim systems)
- Temporary equipment
- Safety equipment (PPE, survival craft, etc.)

4.2 Types and Nature of Questions

Before looking at the specific steps involved in analyzing this type of data, it is important to compare and contrast the analysis of physical data with that of collecting data from people. When collecting people data, open-ended questions are asked about what the person did in the past. For example, "Tell me what happened when you first noticed there was a problem." This is a good question for an interview of a person, however, this approach does not work for obtaining information about physical data. Closed-ended questions work best.

It is important to plan the questions that will provide relevant information. Most of the questions to be asked will need to be stated in the past tense to determine the state of performance prior to the accident. While a test can be performed to see if the level sensor is working now, this does not necessarily mean that it worked yesterday. Changes in environmental conditions and testing methods used can result in changes in equipment performance when it is tested. Therefore, the investigator must be careful when interpreting the test results. Some items can provide information about past performance, such as fatigue marks on a broken metal shaft, but most physical data cannot provide much information about its history.

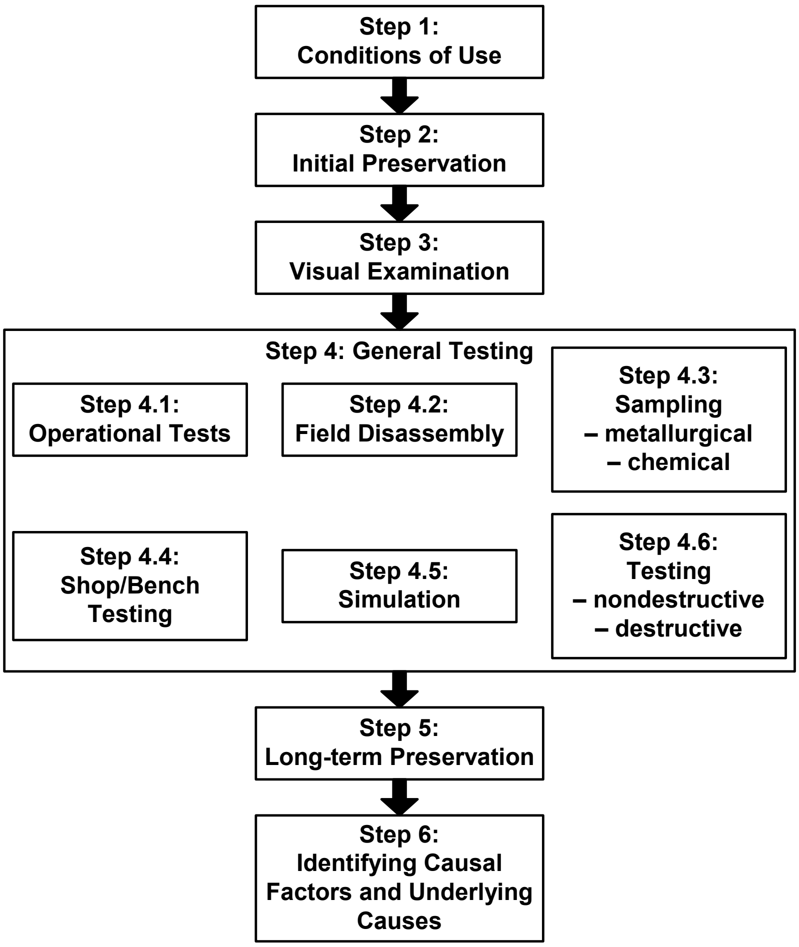
Finally, the order in which the questions are asked is also important. For example, suppose it is desirable to examine the internals of a pump, but it is also important to test the pump to measure its discharge flow. If the test is run to measure pump flow, then more internal damage could be caused by doing the testing. Then, when the pump is taken apart, it might not be possible to determine what damage occurred from the failure and what occurred because of the testing. If the pump is disassembled before the testing run, it might not be possible to put the pump back together in quite the same way, so the operability test results will not really be valid. Therefore, in the planning phase, it must determined which of the two questions are more important to answer.

All of this points to planning the analysis of physical data. Test plans are usually developed to assist in the planning process. Example Test Plan Forms are included in the MaRCAT Toolkit in Appendix 7 and will be discussed further in paragraph 4.4, "Use of Test Plans" in this section.

4.3 Basic Steps in Failure Analysis

Section 4, Figure 4, "Basic Steps in Failure Analysis", shows the overall approach to physical data preservation and analysis. The steps in developing a test plan parallel the steps outlined in the figure and addressed below.

FIGURE 4
Basic Steps in Failure Analysis



4.3.1 Step 1. Conditions of Use

Determine the conditions under which the component operated prior to the failure. How long had the item been in service? What were the environmental conditions? Did the failure occur during startup or normal operations? Was it a rotating piece of equipment? Did it abrade something? Was there any fluid flow past the device? Was the item exposed to the elements, the cargo or dust?

Next, determine the desired conditions of use. How should the item have been operated and maintained? Is it supposed to be used outdoors? Must it have a controlled voltage source? What is its expected lifetime? Is it supposed to be stored in controlled conditions? Should exposure to certain chemicals or materials be prevented? Differences between the desired conditions and the actual conditions can often point to the proper data to collect as part of the analysis. This part of the step may be delayed in order to ensure that the field preservation and examination of the data are not unduly delayed.

Based on this information, candidate failure mechanisms may be identified. For example, if a pump was recently installed, failure mechanisms such as erosion, corrosion, wear and fatigue are unlikely causes of the failure, while overloads caused by manufacturing or installation issues are likely causes.

4.3.2 Step 2. Initial Preservation

This step often involves prevention of further damage to or alteration of the item. Personnel repairing the item and cleaning up the area often destroy or alter data. Preservation of the data at this point requires the identification and segregation of the items. This can include roping off the area or tagging the item to prevent it from being disturbed. The Data Needs Checklist (discussed in subsection 8 of this section) can be used to help identify items of interest.

4.3.3 Step 3. Visual Examination

Avoid disturbing or touching the item until absolutely necessary. Conduct a visual examination without alterations. Take pictures of the item and mark its position in the field if immediate removal is necessary. Remove items in a controlled, careful and methodical manner. Evaluate the importance of coatings/residues/deposits/impurities before scraping them off or cleaning the item. Measure the position of the item and document all observations.

4.3.4 Step 4. General Testing

Many different tests can be used by the team to understand the underlying causes of the failure.

1. *Operational Tests.* Operational tests can be performed on components to determine if they function and to gather further data about the component. For example, attempts can be made to start and run mechanical equipment. Electrical equipment and instruments can be tested by providing simulated inputs and observing the output.
2. *Field Disassembly.* Field disassembly involves removing the equipment from its installed location in the field. Removal is often required to allow for continued preservation of the item (see Step 5) or for additional testing. Removal also allows new items to be installed and the equipment to be returned to service.
3. *Sampling.* Sampling may be needed to allow for continued preservation of the material and/or so that additional testing can be performed.
4. *Shop/Bench Testing*. Shop/bench testing uses additional equipment or equipment that has greater accuracy than that used in field testing. More accurate measurements may be able to be taken in the shop environment at a lower cost.
5. *Simulation*. Testing under simulated conditions can provide additional information about the methods and consequences of failures. It can also provide a confirmation of suspected failure mechanisms. Examples of simulation tests include operational tests, mixing experiments, metallurgical tests and combustion experiments. Some simulations are very simple, such as determining if two materials separate after mixing or observing how fast an area cools down without any heating.

   Ensure that the simulation is as realistic as possible without reproducing the consequences of the failure. Ensure that similar parts and samples are used and that the environmental conditions are recreated as part of the simulation. Assess any differences between the event conditions and the conditions of the simulation to determine the effects of these differences on the simulation results.
6. *Destructive and Nondestructive Testing*. More detailed examination methods may also be used, such as:
   - Mechanical property testing
   - Chemical analysis

     Atomic absorption

     High temperature combustion

Electrochemical

Ion chromotography

Neutron activation analysis.

- Nondestructive examination

    Ultrasonic testing

    Radiography

    Acoustic emission

    Microwave

    Thermal testing

    Holographic

    Visual

    Leak tests

    Liquid penetrant

    Magnetic particle

    Eddy current

Document all results as the tests are performed. Testing can involve substantial costs. Track costs and assess the cost/benefit of these tests to ensure that the testing is worth performing.

4.3.5 Step 5. Long-term Preservation

Provide a safe, secure and controlled storage location for the physical data. Provide special storage conditions (temperature control, humidity control, wrapping, etc.) as required. Prepare the parts or other items for further evaluation, avoiding actions that may destroy/degrade data.

4.3.6 Step 6. Identification of Causal Factors

Use fault trees, causal factor charting data (or other analysis methods) and root cause identification techniques to look beyond the functional cause of the failure and understand the causes of the failure.

4.4 Use of Test Plans

As noted above, test plans help with preparation and performance of the analysis of the item. Developing the test plan is like preparing for an interview, however, unlike the open-ended questions asked during an interview with a person, questions concerning machinery, equipment or parts can only answered very specifically and, generally, answers will be stated in the present tense. Examples of question that could be asked include:

- How does the item work?
- Did the item function as intended?
- How did the item fail?
- Why did the failure occur?

The test plan must be designed to ensure that questions such as these will be answered. Test plans should be developed before the analysis of physical data begins. Test plans help:

- Ensure complete collection of required data
- Ensure complete analysis of the data
- Prevent inadvertent destruction of data by the investigators
- Gain agreement from all parties involved in the process and methods to be used in the analysis
- Ensure that the test is worth doing before it is done
- Identify decision points in the analysis

The test plan should include the following:

- Objective of the test
- Methods to be used for preserving the item and performing the test
- Description of the methods/procedure to be used
- Names and qualifications of the persons who will perform the test
- Scheduled times and locations of the testing
- Serial numbers and calibration information for any equipment used in the testing
- How the test results will be recorded
- Information on multiple tests of the same item
- Disposition of the test specimens after the test

The qualifications of the personnel and the accuracy of the equipment used in the testing should be documented. The qualifications of personnel who perform the testing should be assessed and documented to ensure that the test will be properly and accurately performed. Calibration records for equipment should also be assessed and documented to ensure that the equipment is appropriate for the task.

Test plans should not be lengthy documents and, in some cases, documentation of the plan may not be necessary. The primary purpose of test plans is to think through the test approach and outline the purpose and steps of the plan. During the planning process, it is also important to determine what data will be destroyed in the process of gathering the data. Example Test Plan forms are included in the MaRCAT Toolkit in Appendix 7.

4.5 Chain-of-Custody

Chain-of-custody should be applied to physical data even if legal proceedings are not involved. The primary purpose of the chain-of-custody is to ensure that the data obtained is valid and true. Establish a physical data log to ensure the integrity of the physical data. A Data Log form is included in the MaRCAT Toolkit in Appendix 7. Number or tag each item collected and control access to and use of data to prevent modification of the data and prevent destruction or disposal of the items. A Data Checkout Log form is also included in the MaRCAT Toolkit to help track who has custody of each item.

4.6 Use of Outside Experts

The analysis of parts and materials can be a very complex science. The use of outside experts may be required to adequately perform the required analyses. An assessment of the costs of this outside expertise should be balanced against the expected benefits from the expert analysis.

5 Paper Data

Analysis of paper data can help with understanding not only what happened and how it happened, but also why the incident happened. Paper data can lead to an understanding of the root causes of the incident because they can help identify factors that mold the environment and influence the attitudes of the personnel.

Paper data generally provide objective data and are the least fragile of the data types. The biggest difficulty with paper data is that there tends to be a lot of items to sort through. Paper data resources are not always obvious, and the most difficult aspect of paper data resources is finding them. Much time can be expended in sorting through stacks of paper.

Analysis of paper data often involves comparison of various documents to determine the various methods specified for performing a task. Comparisons can also be made between the descriptions in the document and actual performance in the field. Documents should also be reviewed to determine if they describe the proper methods to be used to perform the task. Questions, notes, inconsistencies and follow-up items can be tagged using self -stick removable (Post-it) notes on the edges of the pages. As the items are resolved, the self-stick removable (Post-it) notes can be moved to the inside of the page. This will make it obvious which items still need resolution and provide a location to document resolution of each issue.

Paper data from instrument charts, such as strip chart recorders and disk recorders, need to be high-priority items for the team. Careful documentation prior to removing the data from the instrument is vital. Documenting the time and speed of the recorder must be determined first. The MaRCAT Toolkit in Appendix 7 contains Paper Chart Data Collection Guidelines for ensuring proper documentation of each item.

Chain of custody should also be applied to paper data. Establish a document log to ensure that the team is examining the same documents that were in use during the event. Number each item collected and inventory the items so that they can be quickly located. Control access to and use of data. Controlling access also involves tracking where data is sent and to whom. A Data Correspondence Log form is provided in Appendix 7 to assist with this task.

Transmittal of documents to outside agencies and organizations should also be tracked. This helps manage the flow of information and assists with dealing with regulators and the press. The same Data Correspondence Log form mentioned above can be used for this purpose.

6 Electronic Data

Electronic data are very similar in content to paper data. Like paper data, electronic data can lead to an understanding of the underlying causes of the incident because they can help identify factors that mold the environment and influence the behavior and attitudes of the personnel.

Because of the ability to easily store large amounts of electronic data, a significant issue with electronic data is sorting through the data to identify the relevant information.

Unlike paper data, electronic data are one of the most fragile data types. Electronic data can be easily modified. Therefore, chain of custody should also be applied to electronic data to ensure their integrity. Controlling access to and the use of data will also help maintain their integrity. As with paper data, tracking where data is sent and to whom is important. A Data Correspondence Log form is provided in Appendix 7 to assist with this task.

A final issue unique to electronic data is the potential loss of the data following an event because the data are not automatically saved or are destroyed as a result of the incident. Inability to recover data from the time of the incident will make understanding the incident very difficult. Special data-collection and backup practices may be needed to ensure that data are available to the investigation team following an incident.

7 Position Data

7.1 Unique Aspects

Position data are a subset of physical and people data. They are called out as a separate data type to ensure that investigators focus on the position of physical items and people early in the investigation. Position data are often lost during the initial stages of the investigation. Emergency response actions often involve movement of people, items and equipment, such as removal of the injured and restoration/stabilization/demolition work. Curious investigators and other personnel often move equipment, switches and indicators in an attempt to quickly collect data. Weather and exposure can change the levels in tanks and the locations and extent of stains and other markings. Like physical data, once the data are altered or disturbed, there may be no way to recover the information.

7.2 Data Collection

The easiest method to collect position data is through direct observation, however, this does not produce a permanent record of the observations. Two common methods for recording position data are the still camera and the video recorder. Cameras and camcorders need to be readily available for the investigator to use during the initial stages of the investigation.

7.3 Documentation of Data Collection

Documentation needs to be generated as photographs are taken to ensure that the contents of what is in each photo is preserved. When using a camcorder, a voiceover can describe the items being viewed, and thus provide similar documentation. Photos can record vast amounts of detail and allow investigators to review the "original" condition of the equipment and site immediately after the incident. A Photographic Record form is included in the MaRCAT Toolkit in Appendix 7.

Reference items should be included in all photos and videos. A reference item can include a ruler or other object of known size. The object can also be oriented to the bow to show the overall orientation of the photo. Self-stick removable (Post-it) notes or other labels can also be used in the photograph to indicate the contents of the photo. Photography Guidelines (for stills and video) is included in the MaRCAT Toolkit in Appendix 7.

Other specialized photography methods can also be used. For example, infrared thermography can be used to record the locations of hot spots in equipment.

Other examples of photographic opportunities include:

- Overview of area
- Site Orientations
- Perspectives of personnel
- Record detail
- Record positions
- Improper use
- Improper assembly
- Environment
- Disassembly stages
- Deterioration
- Failure sequence
- Analysis worksheet
- Training aids

7.4 Alternative Sources of Position Data

Sometimes photos are not practical. In these cases, charts, maps and drawings can be used to capture the required information. Obtaining drawings of machinery or vessels can allow for rapid development of a drawing or sketch of the data.

Examples of applications for maps, diagrams and charts include:

- Location of items: vessels, navigational aids, people, equipment, materials, structures
- Navigational charts
- Hull diagrams
- Machinery and flow diagrams
- Cargo system diagrams
- Fuel system diagrams
- Movement of key actors
- Environmental conditions: noise, temperature, ventilation, illumination, weather
- History of events
- Area sketches
- Process flow sketches
- Equipment/part sketches
- Fragmentation maps

Absolute measurement of the location or dimensions of an item may also be needed. A Position Data form is included in the MaRCAT Toolkit in Appendix 7.

8 Overall Data Collection Plan

Each incident investigation is a unique task and should be accompanied by a specific data collection plan. The initial plan, specific to each incident, must be continuously revised and updated as new priorities and concerns are identified during the course of the investigation. This specific plan builds on the general preplanning that has been previously established as part of initiating the incident investigation. The team leader can use the Data Needs checklist and form to generate a list of data that needs to be collected. The Data Needs checklist and form are included in Appendix 7.

The Data Needs form contains a column for each of the data types. The investigation team should use the form to brainstorm a list of data that could be helpful during the investigation. The Data Needs form is then used as a dynamic checklist. Items should be added to and deleted from the checklist as the investigation progresses.

To save time during an investigation, a generic data needs form can be developed that will cover the majority of the data needs for the majority of investigations. During an investigation, a few items can be deleted or added to the list, as appropriate.

The team leader usually develops an initial plan after he/she has made a brief orientation visit. The team leader should ensure that access to the area is minimized as much as possible. In addition, he/she should verify that the personnel who do enter the incident area are aware of data preservation considerations.

For most small- to medium-sized investigations, the team may only consist of a primary investigator. For these small to medium investigations, all of these field tasks are typically the responsibility of the primary investigator.

The investigator should not only look at what is present, but also note what is **not** damaged. Questioning the obvious and looking at all of the physical data is often the key to discovering important data. The investigation team should make a conscious effort to determine *what is absent that should be expected to be present* during the operations that were being conducted. This determination requires a relatively thorough understanding of the operation, activities and physical systems on the part of the investigation team.

Once the initial plan is developed, it should be periodically reviewed and altered as new data are collected. This planning is more important as the scope of the investigation and the size of the investigation team increase.

Throughout the investigation field activities, the team should always take all the necessary safety precautions, including using appropriate PPE.

As noted elsewhere, data collection is an iterative process within the data analysis process. As a result, data collection occurs throughout the investigation and takes a majority of the investigation effort.

9 Application to Apparent Cause Analyses and Root Cause Analyses

The techniques for data collection, preservation and analysis discussed in this Section apply equally to both apparent cause analyses and root cause analyses. Section 4, Table 2, "Application of Data Collection Methods," outlines some of the typical differences in the extent of the data collection, preservation and analysis activities that may be performed for apparent cause analyses versus root cause analyses. The same techniques are generally used for each of the data types. However, for root cause analyses, more time is spent in looking at the management system issues. This generally alters the people interviewed to include more management personnel, and the paper data reviewed to include more policies and standards in addition to the procedures and proof documents. This table is only a general guide. During an apparent cause analysis, some of the activities covered during root cause analysis may also be performed. In addition, not every root cause analysis requires the use of outside experts to analyze physical data.

10 Summary

Data collection is the activity that typically takes the greatest amount of time during an investigation. Using methods that efficiently collect data without altering or destroying the data is vital to getting to the underlying causes of the event.

TABLE 2
Application of Data Collection Methods

Data Type	*Description*	*Apparent Cause Analyses*	*Root Cause Analyses*
People data	Interviews and initial witness statements	Initial witness statements from a few individuals collected by local management. Interviews of selected personnel, mostly frontline personnel	A few to many initial witness statements. Numerous interviews of both frontline personnel and managers
Physical data	Overview and detailed analyses of physical data	Overview analyses performed by local staff. Usually no detailed analyses of items	Overview analyses performed by local and organizational staff. Some detailed analyses using organizational staff and outside experts
Paper data	Retrieval and analyses of paper records	Detailed analysis of data by team. Policies and standards not reviewed in as much detail as procedures and proof documents	Detailed analysis of data by team. Policies and standards reviewed in detail in addition to procedures and proof documents
Electronic data	Retrieval and analyses of electronic records	Detailed analysis of data by team. Policies and standards not reviewed in as much detail as procedures and proof documents	Detailed analysis of data by team. Policies and standards reviewed in detail in addition to procedures and proof documents. Retrieval of altered or deleted files by experts may be required
Position data	Photographs, mapping and measurements	Photography and mapping performed by local personnel	Photography and mapping performed by local personnel and outside experts. Detailed measurements of components

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SECTION 5 Analyzing Data

1 Introduction

Data analysis is at the heart of the incident investigation process. The goal of data analysis is to identify causal factors and their underlying root causes. For each causal factor, multiple root causes will be identified. Therefore, for every causal factor that is missed, the investigators will miss multiple root causes. The use of the structured tools addressed in this section will help ensure that the investigators identify all of the causal factors.

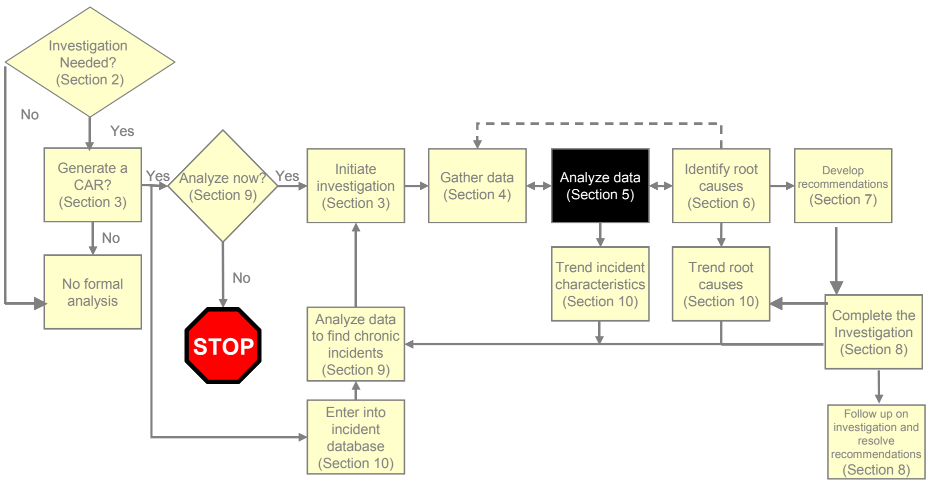
Data analysis usually takes 15 to 25% of the analysis time, but it feels much longer because the data analysis techniques drive the data-collection process. Data analysis focuses on organizing and judging the relevance of data collected and formulating a model of how the problem occurred. The model that is created stimulates and guides additional data-gathering activities by identifying gaps and inconsistencies in known information. This makes the most time-consuming part of the investigation, data gathering, more efficient.

The three basic steps in analyzing data are as follows:

1. Summarizing the relevant facts from data-gathering activities and separating fact from supposition
2. Developing a loss scenario model based on deductive and/or inductive reasoning approaches to identify causal factors, items of note, intermediate causes and possibly root causes for the incident
3. Verifying the completeness and accuracy of the incident model (necessary and sufficient)

Section 5, Figure 1 shows the data analysis step in the context of the overall incident investigation process.

FIGURE 1
Analyzing Data within the Context of the Overall Incident Investigation



2 Overview of Primary Techniques

There are three primary data analysis techniques: simplified fault tree analysis, 5-Whys technique and causal factor charting (although other techniques such as change analysis can also be used).

Fault tree analysis is a structured approach for modeling the combinations of human errors, structural/machinery/equipment/outfitting problems and external factors that can produce the type of incident or problem being evaluated. It is used frequently to resolve gaps in causal factor charts, but can also be used as a stand-alone tool. It is the best tool for analyzing structural/machinery/equipment/outfitting problems as well as chronic problems. It can also be described as a troubleshooting approach or a structured guessing approach. Hypotheses (guesses) are put forward as to what could have caused each event. Then data are systematically gathered and analyzed to determine if the potential cause is an actual cause of the event.

The 5-Whys technique is very similar to fault tree analysis. The primary difference between the two methods is that the fault tree approach uses OR and AND logic gates and the 5-Whys technique does not use any gates. The 5-Whys technique is somewhat simpler than the fault tree technique because no gates are used. Generally, the 5-Whys method is restricted to small or simple incidents.

Causal factor charting arranges building blocks to graphically depict the timing of events and the cause-effect relationships between known events and conditions. It has many of the attributes of a timeline, but also has logic tests built into the process through "necessity" and "sufficiency" testing of data. These two tests are similar to the "and" and "or" logic that fault trees use. It is the best analysis method to use when timing of events is important. It is usually the best tool for incidents with safety and environmental impacts.

Section 5, Table 1, "Applicability of Analysis Techniques," summarizes the characteristics of the three analysis techniques that will be discussed. Other techniques can also be used, but discussion of these supplementary techniques is beyond the scope of this Guidance Note.

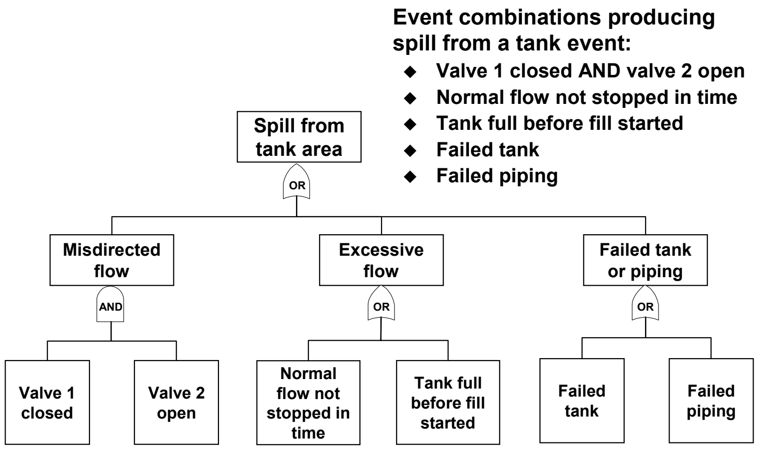
TABLE 1
Applicability of Analysis Techniques

	Causal Factor Charting	*Fault Tree Analysis*	*5-Whys Technique*
Acute Incidents	Good	Good	Good
Chronic Incidents (including most large, acute accidents)	Can only characterize typical event	Good	Good for small incidents
People-oriented problems (large, acute accidents)	Best	Good	Not very useful
Structure, machinery, equipment, outfitting problems (including most chronic problems)	Good	Best	Good for small incidents
Incidents where timing is important	Best	Not very useful	Not very useful

3 Fault Tree Analysis

Fault tree analysis begins with a known event (referred to as the top event) and describes possible combinations of events and conditions that can lead to this event. The top event in the fault tree can be the loss event under investigation or a specific event that is involved in the incident. In Section 5, Figure 2, "Tank Spill Example Fault Tree," the top event is defined as a "Spill from tank area".

FIGURE 2
Tank Spill Example Fault Tree



The fault tree looks backward in time to describe the potential causes of the top event. In the example, three possible causes are shown: (1) misdirected flow, (2) excessive flow and (3) failed tank or piping. Each of these, by itself, was considered to be sufficient to cause the spill from the tank.

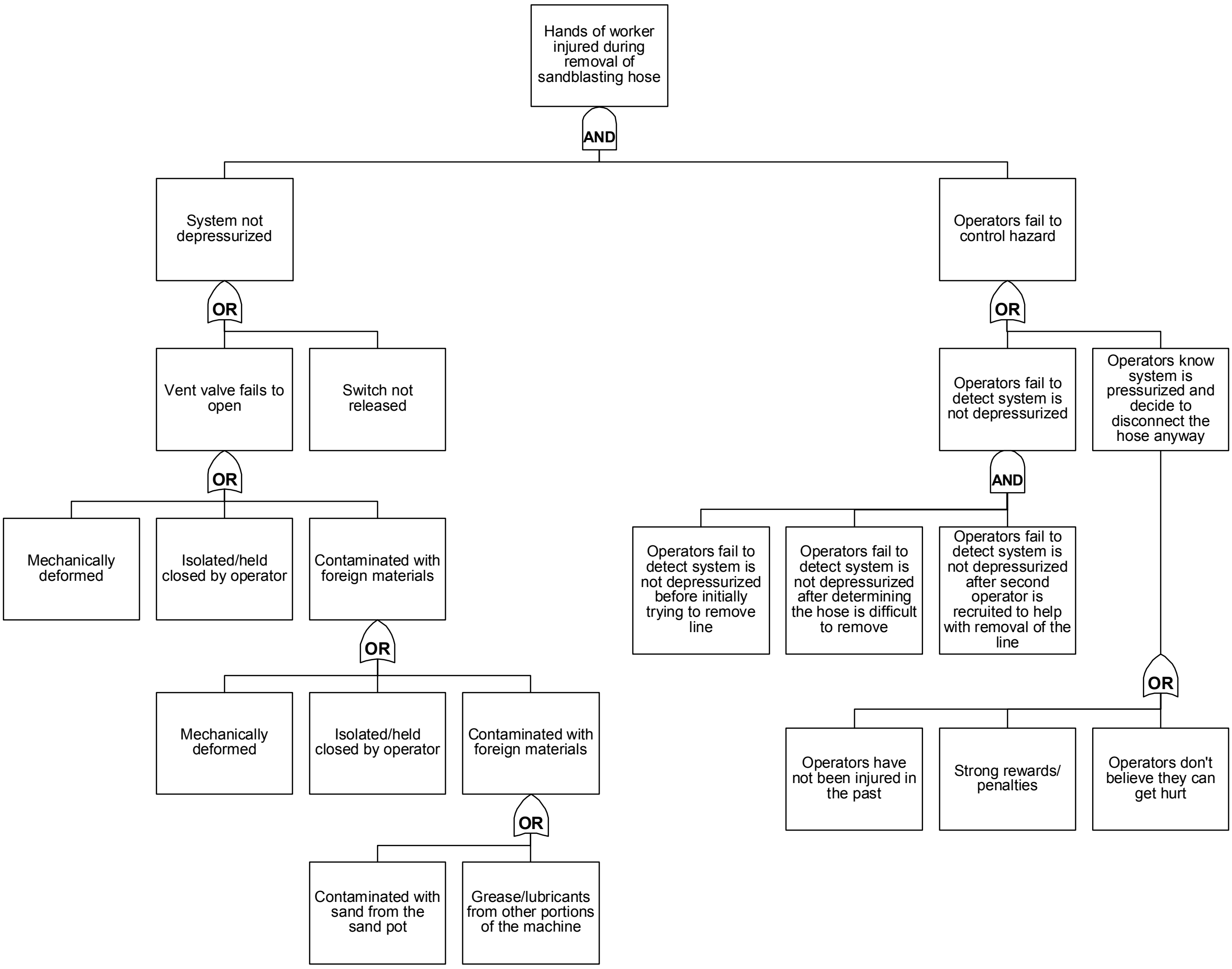
AND and OR logic is used to graphically show potential combinations of events and conditions leading to the top event. This type of logic is commonly used proactively during risk assessments to identify dominant potential contributors. For incident investigation applications, however, the smallest possible tree is developed. As soon as a branch is shown not to be credible, development of that branch is stopped.

Most reactive and proactive analysis techniques only identify single-event failures. One significant advantage of the fault tree technique is that it can help identify multiple-event failures. Multiple-event failures are those that require more than one event for a failure to occur. For example, for a fire, three conditions must exist simultaneously: fuel, oxygen and an ignition source. Most incidents involve multiple-event failures. Therefore, the ability to model multiple-event failures is an essential element for any incident modeling methodology.

A fault tree can also show design and operational errors. In some cases, equipment performs to its capabilities, but its capabilities are insufficient for the task. For example, a generator fails when it is overloaded or a diesel fails following a loss of its fuel. Examples of fault trees are provided below as well as an explanation about the building blocks of such trees and a procedure for constructing a tree.

A more complex example of a Fault Tree is provided in Section 5, Figure 3, "Sandblasting Fault Tree Example". This example can be contrasted with an analysis of the same event using causal factor charting. Appendix 2, "Fault Tree Details", provides information on how to use and construct fault trees. It provides a detailed procedure for conducting fault tree analysis and examples of fault trees are provided.

FIGURE 3
Sandblasting Fault Tree Example



4 The 5-Whys Technique

The 5-Whys technique is a data analysis technique that is similar to the simplified fault tree approach. The primary difference between the two methods is that the fault tree approach uses OR and AND logic gates and the 5-Whys technique does not use any gates. The 5-Whys technique is somewhat simpler than the fault tree technique because no gates are used. There are a variety of advantages and disadvantages related to the 5-Whys technique. Some of the advantages include:

- This technique can be quicker for small, simpler analyses. However, it can take longer with larger, more complicated analyses because there is less guidance on how to perform the analysis and identification of root causes.
- The technique can also be used as a root cause identification technique or used in conjunction with the ABS *Marine Root Cause Analysis Map*™.

Some of the disadvantages of the 5-Whys Technique include:

- Because the 5-Whys method does not use gates, it is sometimes difficult to ensure that the logic of the analysis is correct. Fault tree development includes tests to ensure that the AND and OR logic is appropriate. This is not part of the 5-Whys technique.
- The results of the analysis are inconsistent. Sometimes the analysis may go to the causal factor level, intermediate cause level or root cause level. Note that this is also true of fault tree analysis. This issue can be addressed with both methods by using the ABS *Marine Root Cause Analysis Map* to perform root cause identification.
- Judgment and experience are key factors in selecting the right level of detail.
- "Why" may have to be asked more or less than five times to get to root causes.
- Although the result is auditable (can be reviewed by others), the results are not reproducible (the same from person to person).

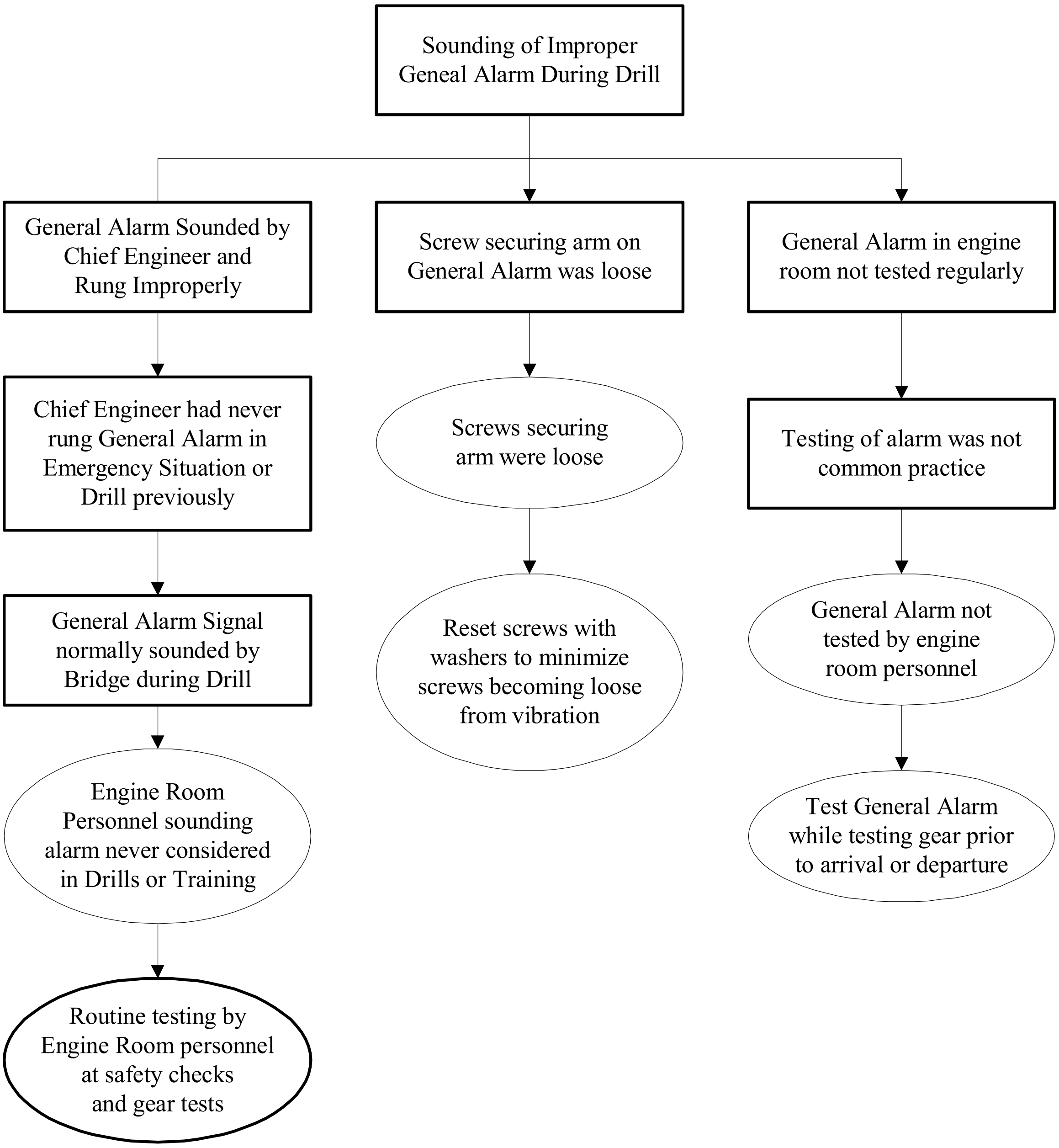
The process for developing a 5-Whys tree is essentially the same as that used for fault tree development, except that the use and testing of logic gates are not part of the process. The primary difference between the two methods is that the fault tree approach uses OR and AND logic gates and the 5-Whys technique does not use any gates. Section 5, Figure 4, "5-Whys Technique Example," provides an illustration of a sample tree and highlights to the reader the absence of OR and AND gates. The 5-Whys technique is somewhat simpler than the fault tree technique because no gates are used. A simplified process for the 5-Whys techniques is as follows:

1. Select an item for analysis. The item could be a loss event, a causal factor or any other item. This is similar to the top event of a fault tree.
2. Ask why this event occurred (i.e., the most direct cause of the top event).
3. Find answer(s) to this question. The answer may identify more than one sub-event or condition as the cause. In other words, more than one branch may be identified.
4. For each of the items, ask why it occurred.
5. Identify questions or develop tests to determine if each item is true or false.
6. Use the answers to the questions or results of the tests to determine if each item is true or false.
7. Cross out the false items and stop development of these branches.
8. Repeat this process at least four more times (a total of at least five times) for all true branches.
9. Identify causal factors and root causes.
10. Develop recommendations for each causal factor and root cause.

It is recommended that the fault tree approach be used for all formal analyses because of the added structure provided by the fault tree analysis technique and the minimal extra effort to develop the fault tree (compared to the 5-Whys tree). Informal analyses, such as troubleshooting, that do not require the rigor of the fault tree approach may benefit from the added structure of the 5-Whys techniques.

A 5-Whys Worksheet is provided in Appendix 7 to aid in the documentation of 5-Whys Analyses. Appendix 2, "Fault Tree Details," provides information that could prove useful for constructing 5-Whys Trees since the approach is similar to fault trees.

FIGURE 4
5-Whys Technique Example



5 Causal Factor Charts

Fault tree analysis (and the 5-Whys technique) is a good analysis technique for equipment and machinery-oriented problems. Its structure works very well when dealing with the structured behavior of the equipment. However, fault trees and 5-Whys trees have one major drawback. They do not show the relative timing of events.

Timing is usually important when people are involved in incidents. It is also important in most safety and environmental incidents. Causal factor charting specifically addresses the timing of events. It also tries to incorporate some of the logic that is seen in the fault and 5-Whys trees. In other words, it tries to combine timing and logic into one technique.

Causal factor charting establishes the relative timing of events and sets the time frame of interest for the incident. It sorts the data (events and conditions) into the following:

i) The loss event(s),

ii) Main events and conditions,

iii) Reasons why the main events and conditions occurred or exist,

iv) Other significant events, and

v) Unimportant, insignificant events that do not affect our analysis.

Like fault tree analysis and the 5-Whys technique, it helps ensure that all data are gathered and analyzed for causal factors.

Causal factor charts are constructed by working backwards. The loss event/condition is the starting point and the chart is constructed by working backwards in time. This is essentially the same approach used to construct fault or 5-Whys trees. The top event in either is equivalent to the loss event in the causal factor chart. As we work backwards, building blocks (events and conditions) are added to the chart based on time and logic.

Section 5, Figure 5, “Sandblasting Causal Factor Chart Example,” illustrates the form and content that such a chart takes. Note that the chart has four major elements:

i) *The Main Event Line* contains the most important events. Reading the events on the main event line provides an overview of the events leading up to and causing the loss event/condition

ii) *Events and conditions* explains why the events on the main event line occurred. The events above the main event line explain why the events on the main event line occurred. These answer the question “Why did this happen?”

iii) *Less significant events and conditions* that help explain the loss event are located below the main event line and help put the loss event/condition in perspective. These events provide the details of the event.

iv) *The loss event(s)/condition(s)* provides the reason why the analysis is being performed. The loss event(s)/condition(s) provides a scope for the analysis.

For further information on causal factor charts, Appendix 2, “Causal Factor Charting Details,” provides information of the how to use and construct causal factor charts. It provides a detailed procedure for conducting this type of analysis, and examples of causal factor charts are provided.

FIGURE 5
Sandblasting Causal Factor Chart Example

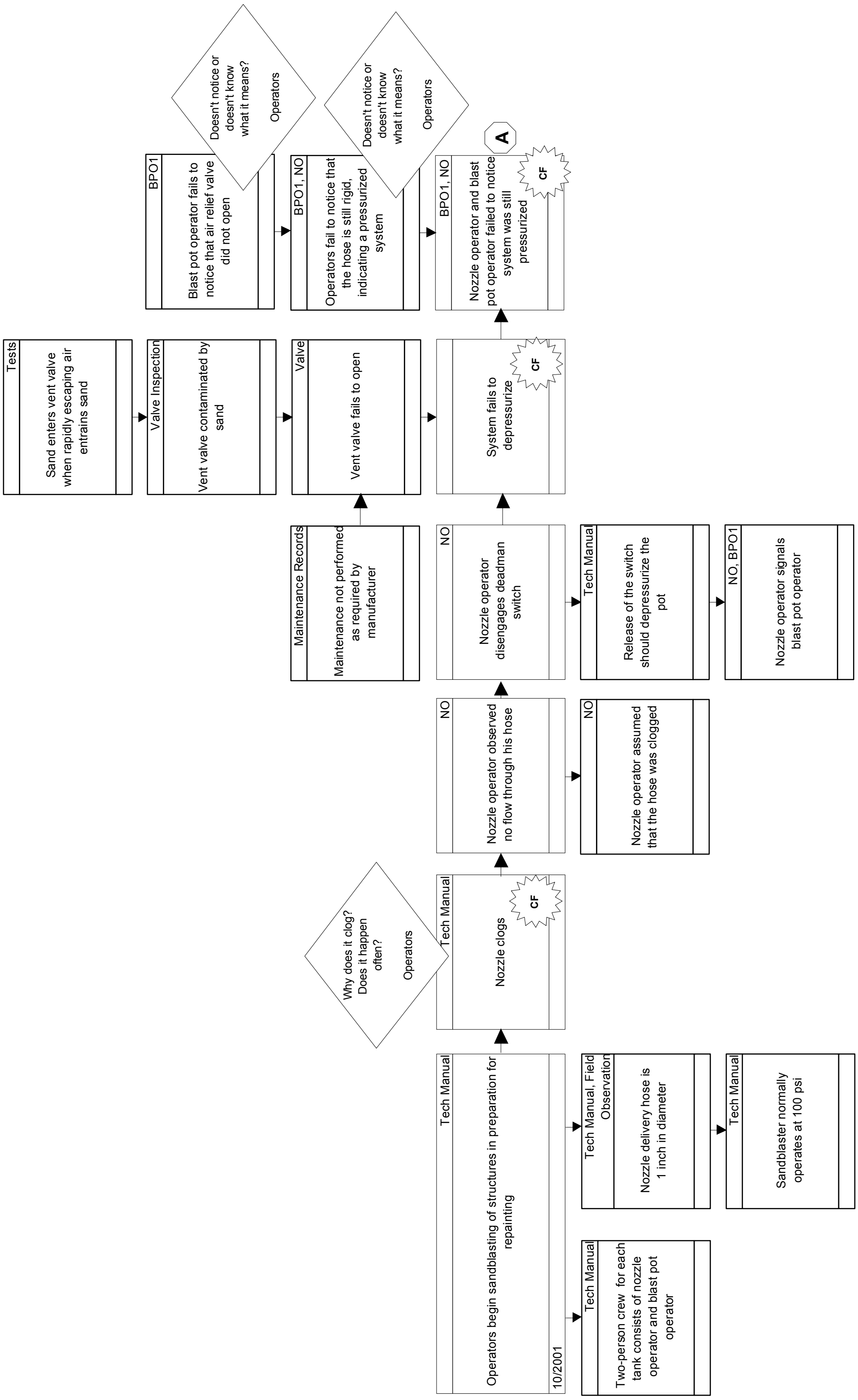
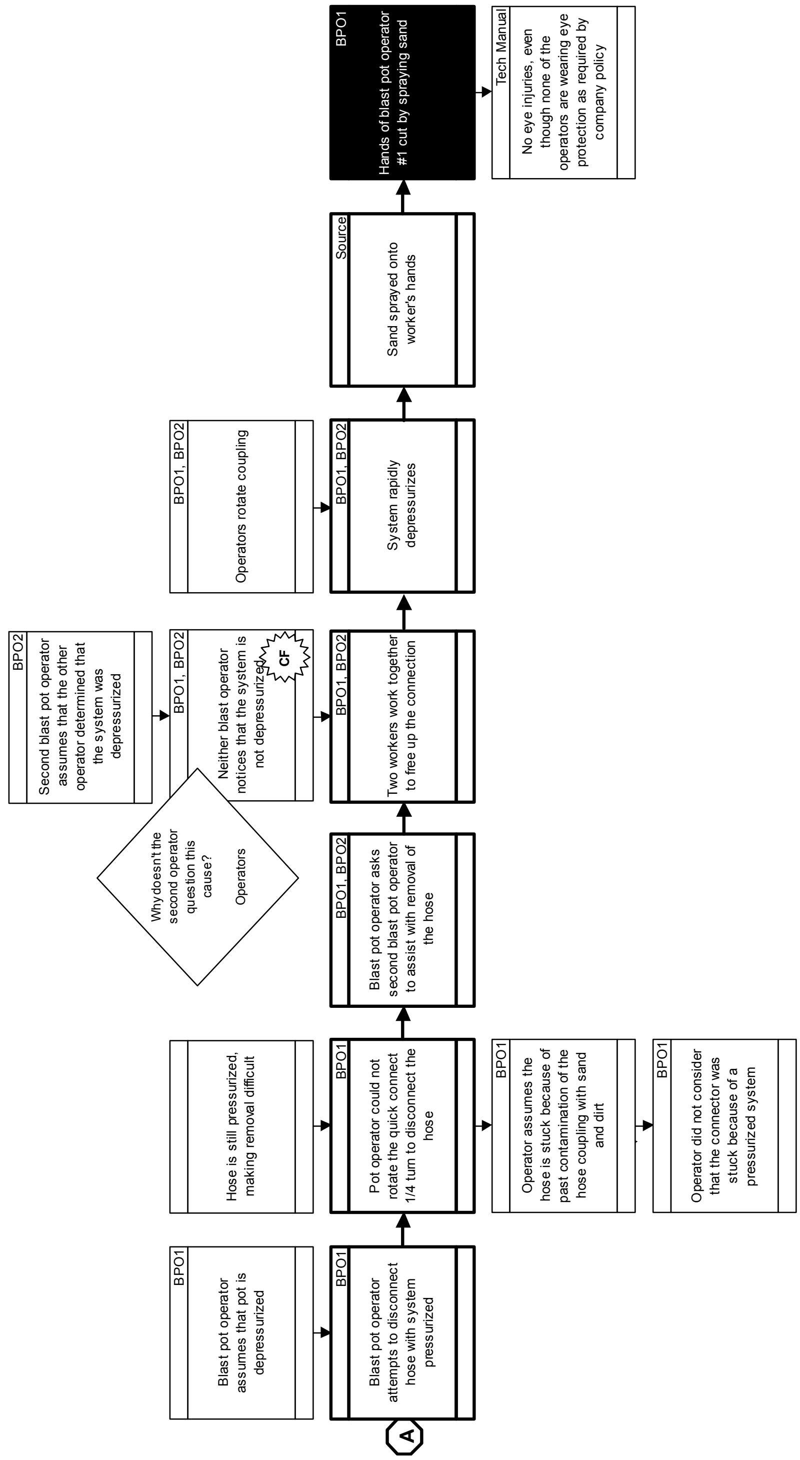


FIGURE 5 (continued)
Sandblasting Causal Factor Chart Example



6 Using Causal Factor Charts and Fault (or 5-Whys) Trees Together during an Investigation

For example, for a typical safety event, the data analysis would begin by using causal factor charting to show the sequence of events and some of the underlying causes. When structural/machinery/equipment/outfitting problems are encountered that cannot be explained with the available data, a fault or 5-Whys tree is begun with the problem at the top of the tree. The investigator then uses these to explore potential causes of the problem. Multiple fault or 5-Whys trees may be developed as each unexplained event/condition is analyzed.

7 Application to Apparent Cause Analyses and Root Cause Analyses

Fault trees (or 5-Whys trees) and causal factor charts are generally used for all analyses, regardless of the effort expended. However, the level of the analysis will determine the extent of the tree or chart development and the level of documentation performed.

For even the simplest of analyses, a tree or chart should be developed, even if it is not formally documented. Even an investigation that takes 10 to 15 minutes should involve identification of the loss event and identification of the sequence of events that led to the loss event (a causal factor chart) or the possible causes of the incident (a fault tree).

At the other extreme, on very large investigations a causal factor chart and numerous fault or 5-Whys trees may be developed. The causal factor chart is used to explain the sequence of events and the fault or 5-Whys trees are used to help explain the underlying causes of the human errors and structural/machinery/equipment/outfitting problems. The trees can show not only the paths that proved to be valid, but also the other possibilities considered and rejected. For complex analyses, fault trees would be favored, especially for situations where quantification is desired.

Section 5, Table 2, "Guidance on Using Causal Factor Charts and Fault Trees," provides guidance on using causal factor charts and fault trees during different levels of the investigation.

8 Summary

The goal of data analysis is to identify causal factors, items of note and underlying causes. The three tools that are used to perform this task are fault trees, 5-Whys trees and causal factor charting. Using these techniques should help guide the data-collection process and make the overall investigation more efficient.

Some investigations will only require the use of one of the data analysis tools. However, some investigations will require using two or three tools together. Often, the analysis is begun using one of the tools. Then, as the analysis progresses, other tools are used.

TABLE 2
Guidance on Using Causal Factor Charts and Fault Trees

Item	*Levels of Investigation*		
	Simple, Informal Troubleshooting	*Apparent Cause Analyses*	*Root Cause Analyses*
Fault or 5-Whys tree development	The tree is developed until at least one of the causal factors is identified	The tree is developed until all of the causal factors and some underlying causes are identified	The tree is developed until the causal factors and all of the underlying causes are identified. Fault trees are favored for more complex analyses.
Fault or 5-Whys tree documentation	The tree is not drawn, but a description of the general possibilities considered may be listed on the work request or other document	The tree is typically documented as part of the report	The tree is documented as part of the report. Fault trees would be favored for more complex situations or for where quantification is desired.
Causal factor chart development	The basic sequence is developed until at least one of the causal factors of the failure is identified	The sequence of events is developed until all the causal factors and some underlying causes are identified	The chart is developed until the causal factors and all of the underlying causes are identified
Causal factor chart documentation	The chart is not drawn, but a description of the general sequence of events may be included on the work request or other document	The causal factor chart is typically documented as part of the report	The causal factor chart is documented as part of the report
Use of trees and causal factor charts together	Usually only one of the tools is used	Usually only one of the tools is used, but occasionally both will be used	Both tools are often used together

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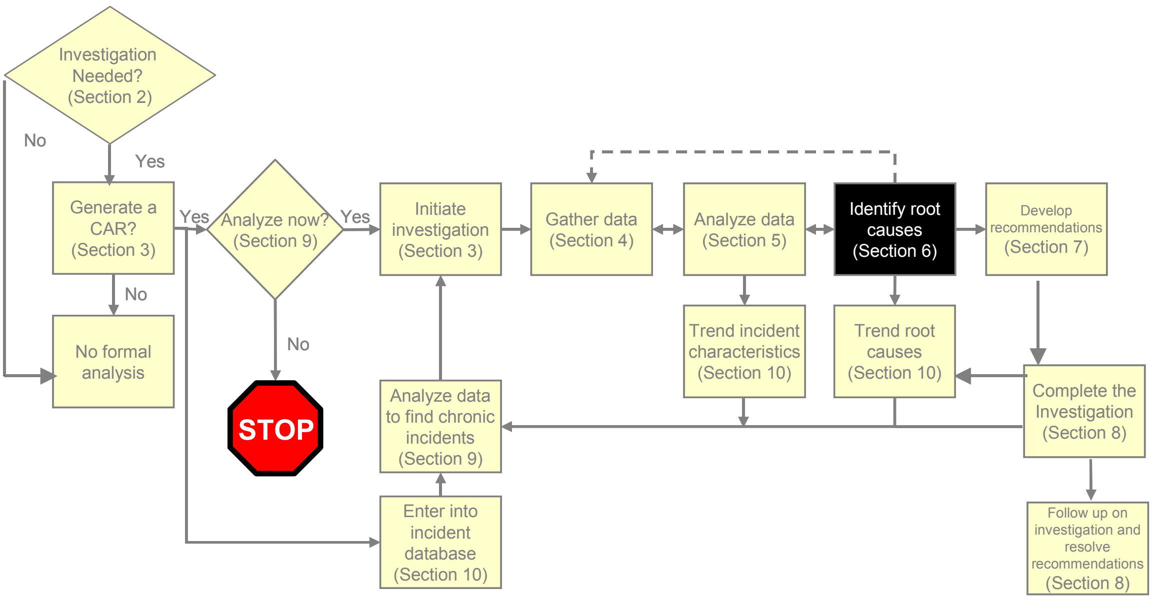
SECTION 6 Identifying Root Causes

1 Introduction

Identifying root causes is one of the main goals of the incident investigation process, but it is heavily dependent on finding the causal factors. Root cause identification should not be started until the causal factors have been identified. Starting this step too early will lead to the identification of invalid underlying causes and, therefore, invalid recommendations. Section 6, Figure 1 shows this step within the context of the overall incident investigation process. This step generally requires less time than most of the other steps.

FIGURE 1
Identifying Root Causes with the Context of the Overall Incident Investigation Process



For virtually every incident, some improvement(s) in management systems could have prevented most (or all) of the contributing events from occurring. Even in instances where individual personal performance is the cause of an incident, the management systems that are used to select, train and supervise personnel should be reviewed to determine if improvements are necessary. Therefore, the absence, neglect or deficiencies of management system features are fundamentally the root causes of most incidents.

A root cause indicates a management system weakness and addresses something over which management has control. This allows recommendations to be developed that address the issue. Identifying root causes that are outside the control of management does not help resolve the issue and can often lead to a sense of helplessness. While there are many environmental and organizational issues that cannot be prevented or directly controlled, how the organization responds to the issue can be controlled. For example, it may not be possible to control the condition of dock facilities in a particular port. Preparation for these conditions can be made by having equipment and personnel available to ensure the timely and safe unloading and loading of vessels. While the weather cannot be controlled, how preparation occurs for operations in different climates can be.

Root causes are deep enough that identification of deeper underlying causes would be unproductive. As described in Section 2, deeper underlying causes can be determined; however, at some depth in the analysis, developing effective recommendations that can be reasonably implemented becomes very difficult if not impossible. Therefore, root causes, such as those on the ABS *Marine Root Cause Analysis Map,* are intended to be as deep as can reasonably be addressed with recommendations.

Finally, there is very rarely one cause for an incident. When investigators try to find the single cause of the incident or the primary cause of the incident, they usually end up missing significant contributors. Multiple safeguards exist to prevent or mitigate almost any incident worth investigating. Therefore, numerous failures of these safeguards have to occur to generate an incident.

2 Root Cause Analysis Traps

There are several traps that investigators often fall into when thinking about root causes. Some of these traps include the following:

2.1 Trap 1 – Hardware Problems

One common trap that prevents organizations from searching for root causes in the belief that "*It just wore out; nothing lasts forever*" or "*It was just a bad part*". Rather than adopt such a thought process, such problems should be viewed as follows:

- Structural/machinery/equipment/outfitting inspections, testing and maintenance can prevent most failures.
- Bad parts could be identified as part of the quality assurance process.
- Something can always be done to prevent failures. It must be decided whether to take action to prevent the failures.

2.2 Trap 2 – Personnel Problems

Another common set of traps that prevents organizations from searching for root causes in the belief that "Nobody else would have made that mistake; he has never been one of our best personnel" or "The procedures are right and she received our standard training; she just goofed up". Rather than adopt such a thought process, such problems should be viewed as follows:

- How did this person come to be hired?
- Are the procedures that the person used accurate?
- Is the training correct and sufficient?
- Has this person committed this error before?
- Was the error detected before with someone else and were effective actions taken to prevent its recurrence?

Often it is not the individual who needs correcting, it is the environment in which they work that needs changing.

2.3 Trap 3 – External Event Problems

Another common trap that prevents organizations from searching for root causes is the belief that "*It was a natural phenomena event beyond our control*". It is true that an organization cannot prevent weather from occurring or individuals from choosing to attempt to harm a vessel or its personnel, however, plans need to be in place for natural phenomena events and other external factors to minimize the consequences of these events when they do occur.

3 Procedure for Identifying Root Causes

For each causal factor, it must be determined why the causal factor existed or occurred. This usually leads to identification of missing, failed or inadequate management systems. These are root causes. The ABS *Marine Root Cause Analysis Map* can be used to help stimulate the thinking of the investigators. In the next Section, information will be provided about how to develop recommendations for these root causes.

Root cause identification should not begin until all of the causal factors are determined. Jumping to root cause identification before the incident is understood and causal factors are identified may result in:

- Developing the wrong recommendations
- Developing ineffective recommendations
- Recurrence of the incident

It is important to verify that the root causes meet the criteria for a root cause by using the Causal Factor, Root Cause and Recommendation Checklist that is included in the MaRCAT Toolkit in Appendix 7.

4 Using the ABS Marine Root Cause Analysis Map

There are many methods for root cause identification. They all have the same objective: to understand the underlying causes of the incident. Some methods use a predefined list, like ABS's *Marine Root Cause Analysis Map*, while others do not. There are advantages and disadvantages to using the predefined list approach. These will be discussed after information is presented about how to use the map.

Using ABS's *Marine Root Cause Analysis Map* structures the reasoning process for identifying root causes. It identifies detailed root causes (management system weaknesses and deficiencies) for each major root cause category.

One of its primary advantages is that it facilitates consistency across all root cause investigations. By using a consistent coding scheme, it supports trending of "root causes" and "categories" by using root cause codes.

5 Observations About the Structure of ABS's Marine Root Cause Analysis Map

The top portion of ABS's *Marine Root Cause Analysis Map* parallels the types of causal factors. Items generally associated with structural/machinery/equipment/outfitting problems appear toward the left side of the map while items associated with human errors appear toward the right side of the map. However, the root causes associated with structural/machinery/equipment/outfitting problems may appear on the right side of the map and the root causes associated with human errors may appear on the left side of the map. For example, the underlying reason for a failure of a drive shaft can be that the shaft was not installed properly. One of the underlying reasons the shaft was improperly installed was that the proper tools were not available at the time the installation was performed. Another factor associated with the failure could be that personnel may not have recorded maintenance that was performed because the normal computer system was not available due to the fact that maintenance of the system was not performed.

A different arrangement of the map would not change the fundamental use of the map as a graphical checklist to help provide a comprehensive search for root causes. The ABS *Marine Root Cause Analysis Map* is simply a checklist, arranged in the form of a tree, to help investigators identify root causes. It could also be arranged as an outline with a different order of items. The ABS *Marine Root Cause Analysis Map* structure/terminology can be modified to mesh with the culture and management systems of specific organizations.

The ABS *Marine Root Cause Analysis Map* terminology is purposely written generically so that it will apply to many different types of organizations. The terminology can, and should be, modified to address the specific terminology used by each organization. This will help personnel interpret the items that are on the map and make it a more effective tool.

6 The ABS Marine Root Cause Analysis Map

To use the ABS *Marine Root Cause Analysis Map*, a person would start by selecting a causal factor from a fault tree (5-Whys tree or causal factor chart). At this point, one would work through the map for each causal factor and step down each path, noting the following:

- Problem
- Problem category
- Cause category
- Cause type
- Intermediate cause
- Root cause type
- Root cause

The results would be recorded on the three-column form at each step (see Section 6, Table 1, “First Example of a Root Cause Summary Table” and Section 6, Table 2, “Second Example of a Root Cause Summary Table,” and Section 6, Table 3, “Third Example of a Root Cause Summary Table,”provided later in this section for examples).

6.1 Multiple Coding

Most causal factors have more than one associated root cause. For example, a deckhand fails to follow a procedure. In investigating the incident, it is found that deckhands are taught to always follow procedures. There is even a policy that requires deckhands to always follow procedures, but the deckhands routinely take shortcuts in procedures to get the job done faster. In other words, this particular policy has never been enforced. In addition, many of the procedures are out of date. As a result, many of the procedures cannot be performed as written because of changes that have occurred since the procedures were written.

In this case, there are two root causes. The first is that the standard, policy or administrative control (SPAC) that requires procedures to be used is not enforced. The second is that the SPACs for procedure updates do not address the procedures the deckhands use.

6.2 Using the ABS Guidance Notes on the Investigation of Marine Incidents

Using the ABS *Marine Root Cause Analysis Map* without the ABS *Guidance Notes on the Investigation of Marine Incidents* is usually sufficient for identifying root causes. In order to achieve consistency across investigations, organizations should use these Guidance Notes in conjunction with the map. Appendix 1, "Marine Root Cause Analysis Guidance," to these Guidance Notes provides information on when to use a node (an item on the map) and provides examples of the types of causal factors that should be coded under each node. To achieve the highest level of consistency, an organization should customize the information in the Guidance Notes to make the information and examples specific to their organization.

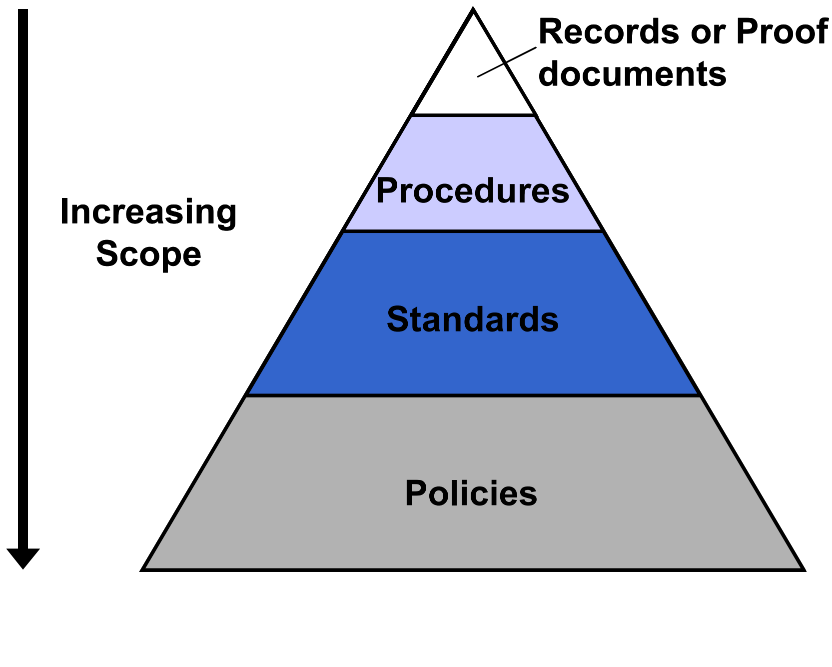
6.3 Typical Problems Encountered When Using the ABS Marine Root Cause Analysis Map

This subsection addresses some of the typical problems encountered when using the ABS *Marine Root Cause Analysis Map*. Many of these problems stem from differences in the use of certain terms.

6.3.1 Policies versus Procedures

Section 6, Figure 2, "Document Hierarchy," shows a typical document hierarchy. Policies are the base of the hierarchy and are the most general types of documents. Standards describe the methods used to measure acceptable performance to the policy. Procedures are step-by-step documents that describe how a task will be accomplished. Finally, records or proof documents provide evidence that the policies and procedures are implemented and the standards are being met.

FIGURE 2
Document Hierarchy



Policies are at a lower, more basic level than procedures. Policies are statements about how different types of activities will be performed. For example, there may be policies concerning design considerations, training, procedures and worker scheduling. The policy on training may specify that there will be initial and continuing training, and that workers will be qualified to perform their duties before they begin work on a task. It may also assign general responsibility for training activities. In some cases, policies are not written. Policies sometimes evolve over time without being formally documented. Often they are described as "the way we do things around here."

Standards are developed to specify the level of acceptable performance. Standards can be written to address policy or procedure requirements. When an audit is performed, performance is compared against the standard to determine if the performance is acceptable. As with policies, not all standards are written.

Procedures describe step-by-step actions that are needed to accomplish a task. For example, the policy on training requires training for all workers. Standards can be developed to assess the implementation of the training program. The training group would then write a set of procedures that describe how it will determine training needs, how training will be conducted, how competency tests will be administered, etc. These procedures implement the policy. The Procedure subsection of the ABS *Marine Root Cause Analysis Map* is reserved for step-by-step instructions. As with policies and standards, procedures may not be written down.

Records and proof documents result from the use of the procedures. Examples include training attendance forms and tests, maintenance records, logs, work orders and procurement records.

6.3.2 Human Factors Versus Design

Human factors issues deal with human-machine interface issues and workload issues. Human-machine interface issues are related to the ability of a human to operate and maintain the system. Will the human have difficulty interfacing with the system because of basic human limitations that were not considered in the design of the system? Often problems related to human factors can also indicate a problem in the design process.

Workload issues can be related to the hardware in the system or to the method used to operate it. The hardware may impose an excessive burden on the human using the system. Often problems related to human factors can also indicate a problem in the design process. Or, the way the system is operated may also place an excessive workload on the human. For example, vessel operation, watch rotations and work assignment practices can cause workload problems.

Design input/output issues are related to the process used to design structures, machinery, equipment or outfitting. How are the design requirements determined? How is it ensured that the design requirements are met? How is it ensured that the design is complete?

6.3.3 Communications

Communications issues are restricted to verbal and other types of informal communication. Examples include orders, notes, e-mails and pages. Procedures, standards and policies are methods of communication, but these are NOT addressed by the Communications subsection of the ABS *Marine Root Cause Analysis Map*. They are addressed by the Procedures or SPAC subsections of the map.

6.3.4 Personnel Performance (Individual Issue)

The only time the Individual Issue portion of Personnel Performance should be used is when the causal factor relates to a characteristic that is specific to the individual. In practice, the Individual Issue portion of the Personnel Performance subsection is very rarely a root cause. Although color blindness, physical impairments, etc., can contribute to an incident, there should be management systems in place to ensure that these will not affect job performance.

Personnel Performance, Individual Issue root causes occur when it is determined that management systems cannot be significantly improved and the human errors are limited to one individual. They may also occur when individuals choose not to try to succeed at their jobs.

Personnel Performance, Individual Issue should only be used when punishing or replacing the individual will actually improve performance and decrease the potential for recurrence of the human error. Again, Personnel Performance, Individual Issue is very rarely a root cause.

6.4 Advantages and Disadvantage of Using the ABS Marine Root Cause Analysis Map

The ABS *Marine Root Cause Analysis Map* uses a predefined list of items to assist in the identification of root causes. Using a predefined list has both advantages and a disadvantage.

6.4.1 Advantages

- Using a predefined list with numerous categories ensures that the investigator will consider a minimum set of issues when identifying underlying causes.
- Using a predefined list can speed up the root cause identification process by providing a starting point for the investigator.
- Using a predefined list can encourage consistency in the identification and coding of root causes. This increases the validity of trending across investigations.
- Using a predefined list can provide a uniform terminology for the organization to use when discussing underlying causes.

6.4.2 Disadvantage

Using a predefined list of categories can limit the brainstorming performed by the individual or team. If the team believes that the list is all-inclusive and that they do not have to think, then this can be a significant limitation. If there are underlying causes that the team does not identify because the predefined list does not trigger them to think of the issue, then it can affect the effectiveness of the recommendations that are identified.

Some organizations and root cause identification methods do not use a predefined list of root causes, such as the ABS *Marine Root Cause Analysis Map*, because it can limit the thinking of the investigator. If the map is treated as an all-inclusive list, then this can be a more significant issue. However, if the map is used properly (as a trigger to get the investigator to think about the different possible underlying causes of the event), this limitation is usually not significant and is balanced by the advantages cited above. As a result, the MaRCAT methodology uses the ABS *Marine Root Cause Analysis Map* for root cause identification.

7 Documenting the Root Cause Analysis Process

Documentation of the investigation process is straightforward. The root cause paths from the ABS *Marine Root Cause Analysis Map* are entered into a table with columns for Causal Factors, Root Causes and Recommendation. By including all three items on the same form, it is easier to ensure that each causal factor has root causes and recommendations associated with it and vice versa.

1. For each causal factor, document the paths through the ABS *Marine Root Cause Analysis Map* and the associated recommendations.
2. Use a three-column format as shown in Section 6, Tables 1 and 2. A blank form is included in Appendix 7, the MaRCAT Toolkit under the title, “Root Cause Summary Table form”.

3. The background information in the causal factor column provides enough information to understand why correcting this causal factor is important. This information can be obtained from the causal factor chart, 5-Whys or fault tree.
4. Verify that the causal factors, root causes and recommendation meet the criteria in the Causal Factor, Root Cause and Recommendation Checklist that is included in the MaRCAT Toolkit in Appendix 7.
5. Paths through the ABS *Marine Root Cause Analysis Map* may be shown using map item number or numeric node codes from the ABS *Marine Root Cause Analysis Map* in the back of the these Guidance Notes.
6. The entries in the second column describe why the *Marine Root Cause Analysis Map* path is appropriate for this causal factor.
7. The entries in the third column are the recommendations associated with each root cause. Section 7, "Developing Recommendations", provides further guidance on the development of recommendations.

8 Application to Apparent Cause Analyses and Root Cause Analyses

Root cause identification is typically not performed for apparent cause analyses (ACAs). If information has been uncovered during the apparent cause analysis (ACA) that indicates one of the underlying management system problems, these root causes can be identified and documented. However, a real danger is that the wrong underlying and root causes are identified because the apparent cause analysis does not require an understanding of these issues. Underlying causes that are identified using an informal and unstructured process can result in developing inappropriate and ineffective recommendations.

It is certainly not wrong to identify some of the incident's underlying causes as part of an apparent cause analysis but, if they are to be identified, the same level of rigor should be applied during the apparent cause analysis .

Root cause analyses attempt to address all of the underlying causes of the incident. While an apparent cause analysis may not identify any of the underlying causes or one or two that are easy to investigate, a root cause analysis seeks to ensure that all of the underlying causes are identified. So while an apparent cause analysis attempts to learn the most it can from the limited time applied to the analysis, a root cause analysis attempts to learn the most it can from the incident that occurred.

9 Summary

The root cause identification process involves identification of underlying causes. The ABS *Marine Root Cause Analysis Map* provides guidance to help the investigator identify underlying causes. The ABS *Marine Root Cause Analysis Map* does not provide every possibility, but should provide sufficient triggers to ensure that the investigator considers a broad range of possibilities. Root cause identification is always performed for root cause analyses, but some root causes may also be identified during an apparent cause analysis.

TABLE 1
First Example of a Root Cause Summary Table

<table>
<tr><th colspan="3">Root Cause Summary Table</th></tr>
<tr><th>Example
Causal Factor #1</th><th>Paths Through Maritime Root Cause Map™</th><th>Recommendations</th></tr>
<tr>
<td rowspan="3">An able-bodied seaman opened valve D-2 instead of valve B-2.

Background

An able-bodied seaman was given instruction by "walkie-talkie" to open a valve. The instruction was to open Valve B-2. The seaman understood the instruction as D-2.
No repeat-back or other verification was used. No company policy existed on this issue. The walkie-talkies used routinely had a great deal of static and white noise. This frequently led to misunderstandings or requiring personnel to go to "good zones" in the vessel to get them to work. The vessel had specified the appropriate model, but it was changed during the procurement process by purchasing. The company has a policy that requires that all changes to purchase requisitions be approve by the requisitioners to ensure that the change is acceptable. However, this policy is rarely used and not enforced.</td>
<td>• Human (4)
• Permanent/Returning Officers/Crew (10)
• Communications (220)
• Communication Mis-understood or Incorrect (228)
• Verification or Repeat-back Not Used (231)
• Company Standards, Policies, or Administrative Controls (SPACs) Issue (256)
• No SPACs/Issue Not Addressed (257)
Conclusion: No repeat-back was used.</td>
<td rowspan="3">Recommendations:
Develop a policy to require the use of repeat-backs when using walkie-talkies.
• Timing-long-term
• Level-4
• Type-prevention
• Responsibility-operations

Recommendations:
Assess the problems associated with the walkie-talkies to reduce the static and remove dead-zones.
• Timing-long-term
• Level-4
• Type-improve inherent reliability
• Responsibility-maintenance

Recommendations:
Develop a policy to require purchasing to discuss changes to procurement specifications with the purchaser.
• Timing-long-term
• Level-4
• Type-improve inherent reliability
• Responsibility-purchasing</td>
</tr>
<tr>
<td>• Human (4)
• Permanent/Returning Officers/Crew (10)
• Human Factors (143)
• Work Environment (158)
• Tool Issue (163)
• See Purchasing Issue root cause below
Conclusion: The appropriate walkie-talkies were not purchased.</td>
</tr>
<tr>
<td>• Human (4)
• Permanent/Returning Officers/Crew (10)
• Management Systems (72)
• Purchasing Issue (112)
• Changes to Purchasing Specifications (114)
• Company Standards, Policies, or Administrative Controls (SPACs) Not Used (261)
• Enforcement Issue (265)
Conclusion: Purchasing changed the walkie-talkie requisition without checking with the requisitioner.</td>
</tr>
</table>

TABLE 2
Second Example of a Root Cause Summary Table

<table>
<tr><th colspan="3">Root Cause Summary Table</th></tr>
<tr><th>Example
Causal Factor #1</th><th>Paths Through Maritime Root Cause Map</th><th>Recommendations</th></tr>
<tr>
<td rowspan="2">Description:
Someone incorrectly closed a cooling water line to a diesel engine.

Background:
Someone incorrectly closed a cooling water valve on a color-coded control system because he was color-blind. Although a screening program existed for the job, it did not specify the ability to differentiate colors as a requirement. As a result, this individual was not screened for color blindness.</td>
<td>• Human (4)
• Company Employee (12)
• Management Systems (72)
• Human Resource Issue (81)
• Employee Screening/Hiring Issue (82)
• Company SPACs Issue (256)
• No SPACs/Issue Not Addressed (257)

The issue of screening for color blindness was not addressed in the company SPACs.</td>
<td rowspan="2">Recommendation:
Determine the positions where recognition of coloring is required to perform the job.
• Timing – medium-term
• Level – 4
• Type – prevention
• Responsibility – human resources

Recommendation:
Screen current employees in positions requiring recognition of color-coding to ensure that they can sufficiently distinguish the color-coding schemes used.
• Timing – medium-term
• Level – 3
• Type – prevention
• Responsibility – human resources

Recommendation:
Examine systems that currently rely on color-coding to determine if an additional recognition method can be used. The objective is to remove the reliance on color-coding.
• Timing – long-term
• Level – 3
• Type – prevention
• Responsibility – engineering

Recommendation:
Modify the design standards to ensure that color-coding is not the only method available to identify equipment/items.
• Timing – long-term
• Level – 4
• Type – prevention
• Responsibility – engineering</td>
</tr>
<tr>
<td>• Human (4)
• Company Employee (12)
• Personnel Performance (245)
• Company Issue (246)
• Inadequate Problem Detection/Situational Awareness (247)
• Company SPACs Issue (256)
• No SPACs/Issue Not Addressed (257)

A color-blind employee was hired to perform a task that required the recognition of color-coding. The employees' color blindness was not detected until the incident occurred. No recommendations were issued to address this root cause.</td>
</tr>
</table>

TABLE 3
Third Example of a Root Cause Summary Table

Root Cause Summary Table		
Example Causal Factor #2	**Paths Through Maritime Root Cause Map**	**Recommendations**
Description: A man entered cofferdam space P7 without properly testing the atmosphere before entering. **Background**: A man entered cofferdam space P7 without properly testing the atmosphere before entering. Though the procedure for confined space entry required that the atmosphere be tested, it did not: • state what tests should be used and the required limits • require a department head to certify the space before allowing anyone to enter As a result, the man entered the space thinking it to be safe and passed out within several feet of the entrance.	• Human (4) • Newly Assigned/Contract/ Temporary Officers/Crew (11) • Procedures (120) • Misleading/Confusing (125) • Too Much/Little Detail (133) • Company Standards, Policies, or Administrative Controls (SPACs) Issue (256) • Not Strict Enough (258) The SPAC was not strict enough in that it did not address the specific testing and approvals that should be implemented in the procedure.	**Recommendation:** Revise the standards for confined space entry to: • specify the tests required before entry • specify the acceptable test results prior to entry • specify the approvals required before entry • **Timing –** long-term • **Level –** 4 • **Type –** prevention • **Responsibility –** safety group **Recommendation:** Provide training to individuals who may perform confined space entries to ensure that they are aware of appropriate requirements. • **Timing** – medium-term • **Level –** 4 • **Type –** prevention, mitigation • **Responsibility –** training group **Recommendation:** Revise the training requirements to ensure that new personnel who may perform confined space entries are aware of appropriate requirements. • **Timing –** long-term • **Level –** 4 • **Type –** prevention, mitigation • **Responsibility –** training group

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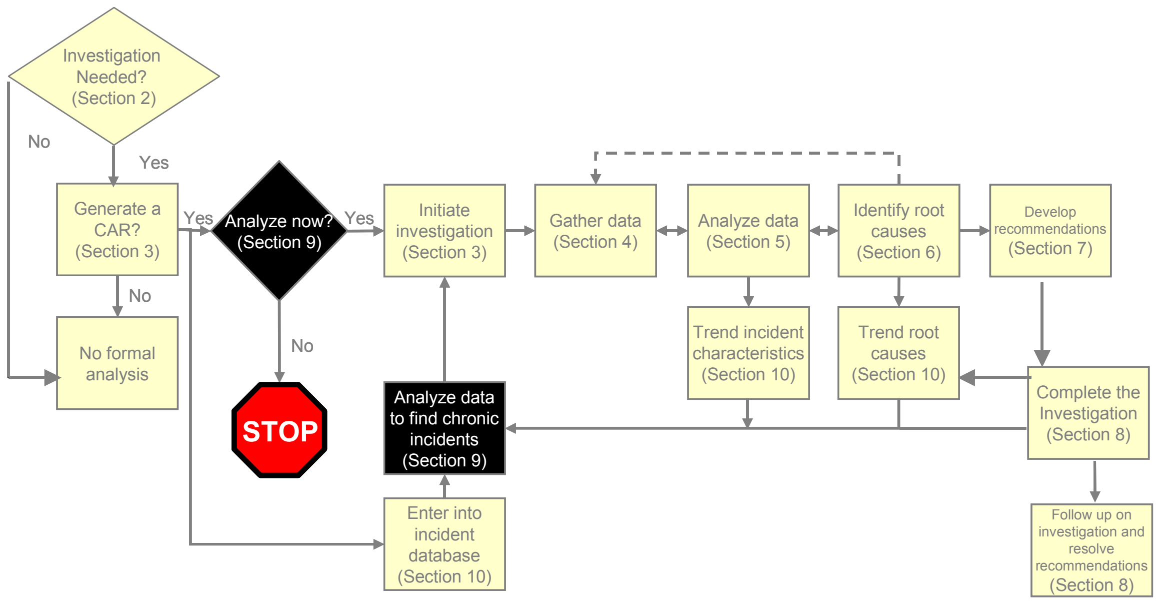
SECTION 7 Developing Recommendations

1 Introduction

Recommendations are the most important products of the investigation. In addition to addressing the higher-level causes of an incident, recommendations should also address system improvements aimed at a problem's root causes.

Recommendations are developed after the data analysis and identification of underlying causes (if performed as part of a root cause analysis) are completed. Section 7, Figure 1 shows this step within the context of the overall incident investigation process.

FIGURE 1
Developing Recommendations within the Context of Overall Incident Investigation Process



Recommendations should be directly tied to causal factors and their underlying causes. Implementing a recommendation should eliminate the causal factor and the underlying root causes. Therefore, it should inhibit and disrupt the sequence of events that led to the loss event.

The only acceptable recommendations are those that are actually implemented and later proven to be effective. Therefore, recommendations must be practical, feasible and achievable and should be assigned to someone along with a completion date. What is practical, feasible and achievable varies significantly from organization to organization and from industry to industry. Different organizations and industries have different levels of risk acceptance and risk tolerance. As a result, a recommendation that would be implemented in one industry would be considered impractical in another. A valid recommendation can be written, but if it is not practical to accomplish, it will not solve any problems because it will not be implemented.

Most recommendations do not have to be implemented in the short term to continue with operations. For example, a recommendation suggests making improvements to the design development process or a change in the way that purchasing is performed to ensure that the equipment and parts used by the organization meet appropriate safety, environmental or quality standards. These are good ideas for the long-term operation of the equipment, but they usually do not have to be implemented to ensure proper operation today. As a result, recommendations need to be assigned to someone along with a specific date for completion. The organization will also need someone to periodically review the list of unresolved recommendations to keep their implementation on schedule.

In most cases, the person who will implement the recommendation is not the person who wrote it. Therefore, the recommendation must clearly state what should be accomplished so that it is carried out as intended.

Recommendations need to be reviewed as part of a management of change process to ensure that they solve more problems than they create. Each recommendation introduces new problems into the organization. The objective is to implement recommendations that have large benefits and minimal negative impacts or costs. Proactive risk assessment techniques should be used to assess the potential impacts of recommendations.

Recommendations should be based on conclusions from analysis of the data collected during the investigation. By ensuring that the recommendations are based on the analysis data, they should be effective in eliminating the incidents or minimizing the effects of the incidents. Getting management support for implementing recommendations is also easier when they can be directly connected to the analysis data.

Finally, recommendations should be written to provide measurable completion criteria. In other words, it should be possible to definitively determine if the recommendation is complete or not. It is difficult to determine if the recommendation "improve procedures to reduce errors" has been completed. However, it is easy to determine if the recommendation "revise procedures to specify how rigging of bulk cargo should be performed" is complete or not. State specifically what needs to be done. If it cannot be stated specifically what needs to done, then the issue to be solved is probably not understood well enough.

A Causal Factor, Root Cause and Recommendation Checklist is provided to ensure that the various items, including the recommendations, are defined appropriately (see the MaRCAT Toolkit in Appendix 7).

2 Timing of Recommendations

Recommendations can be categorized in many different ways. The *first* type of categorization is related to the time frame of implementation. Recommendations are generally put into one of three time-based categories:

i) *Short-term.* These recommendations are usually implemented within a few minutes, hours or days of the loss event. Sometimes these are referred to as broke-fix or quick-fix recommendations.

ii) *Medium-term.* Medium-term recommendations are interim recommendations. They are put into place to address problems while the long-term recommendations are being implemented. Sometimes these medium-term solutions are very undesirable from a long-term perspective because of the negative impacts on the organization, but they bridge the gap until the long-term recommendations are implemented.

iii) *Long-term.* Long-term recommendations are the permanent fixes that are put in place to ensure that the organization functions properly months and years from now. However, because they can take months, or in some cases, years to implement, medium-term recommendations are implemented until these long-term recommendations are completed.

It should be noted that suggested changes should not conflict with other existing processes, procedures or policies within the management system, even for a short time. Also, timetables should be established to audit the effectiveness of implemented recommendations, regardless of whether the recommendation is short-, medium- or long-term.

3 Levels of Recommendations

The *second* type of categorization is related to the depth of the recommendation. There are four levels of recommendations/actions.

3.1 Level 1 – Address the Causal Factor

This corrects the human error or other problem that has occurred. Correcting these allows a return to operation but will not prevent the problem from recurring. These are generally short-term recommendations.

3.2 Level 2 – Address the Intermediate Causes of the Specific Problem

These recommendations seek to eliminate the gaps in the performance of the person, machinery, equipment, process, etc. This will increase the level of confidence in preventing the specific problem from recurring (higher confidence than addressing only the causal factor). Examples of these types of recommendations are changes to the type of seal installed in a pump, changes to a procedure and changes in a supplier. Most of these recommendations are short-term or medium-term recommendations. These recommendations are effective in addressing the specific failure but do not prevent other similar types of loss events from occurring.

3.3 Level 3 – Fix Similar Problems

Fixing similar problems that currently exist is more proactive and will help prevent identical failures in this area of the process or organization. These types of recommendations examine the potential extent of the condition. Are there other vessels that should be implementing changes because of what has been learned during the investigation? Examples of this type of recommendation are:

i) Changes to procedures on all vessels, not just the one that experienced the accident or near miss,

ii) Determining if other vessels have the same type of relays that caused a fire on one vessel, and

iii) Examining the pilot boarding process at other ports in addition to the one where the injury occurred.

Most of these are medium-term to long-term recommendations.

3.4 Level 4 – Correct the Process that Creates These Problems

Level 4 recommendations address the root causes. These recommendations prevent similar causal factors from occurring and, therefore, prevent seemingly unrelated incidents from occurring (the highest value-added type of recommendation). These are the recommendations that truly prevent loss incidents from occurring over a broad range of organizational activities. These recommendations are very proactive. They prevent future losses and keep organizations from having to fix each problem as it arises (being totally reactive). If Level 4 recommendations are not implemented, the organization usually has to implement many more Level 1, 2 and 3 recommendations. Level 4 recommendations are almost always long-term recommendations.

4 Types of Recommendations

A *third* recommendation categorization is related to how the recommendation attempts to eliminate or control the hazard. The most desirable recommendations are generally those that eliminate the hazard, while the least desirable are those that perform emergency response after the consequences of the incident have occurred.

4.1 Eliminate the Hazard

If the hazard can be eliminated, then it will not be necessary to be concerned with safeguards to protect personnel from the hazard. For example, if dust generation during loading can be eliminated, then it will not be necessary to worry about trying to control it or plan responses to dust explosions. If the storage of flammable materials in the galley can be eliminated, then there will be less concern about fires. This is an example of engineering the hazard out of the workplace.

In some cases, it is impractical to eliminate the hazards. For example, it is impractical to eliminate all heat sources from the galley to prevent fires. It is impractical to eliminate flammable materials on an LNG carrier. In these cases, it will be necessary to move to the next level of dealing with hazards.

4.2 Make the System Inherently Safer/More Reliable

Assuming the hazard is present, it is necessary to take actions to make the system inherently safer and/or more reliable. This could include minimizing inventories of a material, moving from single-hull to double-hull designs, widening and deepening waterways, using lower speeds in close maneuvering areas and installing equipment with greater design margins.

4.3 Prevent the Occurrence of the Incident

Preventing the occurrence of the incident can involve designing interlocks that largely prevent errors, installing cargo hold tops with greater strength, installing better navigational equipment and navigational aids, using maintenance procedures, supervision of personnel, management systems to control work processes and developing error-proofing methods for equipment.

4.4 Detect and Mitigate the Loss

Here, actions are recommended to do a better job of responding to the loss once it happens. For example, fire detection and firefighting equipment help detect and then mitigate the loss. Trouble alarms, failure finding maintenance and routine rounds are methods used to detect problems with the machinery and equipment. Audits, record reviews and supervision are used to detect issues with the behavior of individuals. Emergency response activities are included in this category.

Depending upon the situation, the organization may choose to implement a number of different types of recommendations. For example, they may reduce the amount of flammable raw materials stored onboard (make the system inherently safer), improve general housekeeping in the area (prevent the occurrence) and improve the training drills for the fire team (mitigate the loss). In most cases, the potential for an incident cannot be eliminated, but its probability of occurring can be minimized. If it does happen, then the consequences of the incident should be minimized. To do this, multiple levels of recommendations may be required.

5 Suggested Format for Recommendations

For each recommendation, provide a general objective to be accomplished. This should be followed by a specific example of how it could be successfully completed. This ensures that the recommendation is clearly described, yet allows flexibility in meeting the general objective. For example, a recommendation could be written as "Provide a means for engineers to detect slow changes in tank levels. For example, provide a strip chart recorder that shows trends over eight hours." Most organizations will not want to install a strip chart recorder because of the associated maintenance costs. They may choose to install a computerized recording device instead. By phrasing the recommendation in the suggested format, it allows both alternatives to be used. If only one of the alternatives will address the causes of the issue, then the recommendation should be specifically written to only allow that option.

6 Special Recommendation Areas

Restart/resumption/voyage continuation criteria may be important methods for controlling risks. Disciplinary actions or commendations should generally be avoided unless specifically included within the scope of the investigation. The stated objective of the investigation process is to improve the process. Unless there is clear-cut criminal behavior, disciplinary actions are best handled separately from the incident investigation process. A heavy emphasis on disciplinary actions will result in the perception that the process is used to punish personnel rather than change the management systems. This has the potential to strongly discourage disclosure of information.

"No action" may be an appropriate recommendation for certain instances in which the risk of recurrence is very low (an acceptable risk) or the cause is beyond the control/influence of the organization.

7 Management Responsibilities

After the recommendations have been developed by the investigator/investigation team, the organization must ensure that the recommendations are properly resolved. Resolution of the recommendations is usually not the responsibility of the investigator/investigation team, so the organization needs to have a management system to ensure that the recommendations are resolved.

Management has a number of responsibilities to ensure that recommendations are properly resolved. Their responsibilities include the following:

- *Review recommendations to evaluate feasibility, practicality and effectiveness.* Management should review the recommendations from an overall vessel and organizational perspective to ensure that each recommendation will have a high benefit/cost ratio across the organization.
- *Establish schedules for implementing accepted recommendations.* Management should ensure that the recommendations are implemented in a timely manner by establishing a schedule and assigning resources to complete them.
- *Assign individuals responsibility for implementing accepted recommendations.* In order to ensure that the recommendations are implemented, clear responsibility for each recommendation must be established. Management must allocate sufficient resources, personnel and capital for timely implementation of recommendations.
- *Evaluate recommendations as management of change items.* The changes recommended by the investigator/investigation team should be evaluated and processed as part of the management of change process. This will ensure that a proper risk/safety/quality/security assessment is performed before the change is implemented. In addition, it will ensure that all documentation and configuration changes are appropriately made.

- *Ensure that affected personnel receive necessary information/training about the recommendations.* Individuals affected by implementing recommendations need to be properly trained regarding the changes and effects resulting from implementation of the recommendations.
- *Ensure that resolutions are documented.* Management must ensure that proper documentation of the resolution of each recommendation is performed. Resolution can include accepting the recommendation, accepting a modification or similar alternative recommendation, deferring the implementation until after further evaluation or rejecting the recommendation for cause.
- *Track recommendations to completion.* Track the status of the accepted recommendations to ensure timely completion.
- *Look for opportunities to reduce risks in other systems by applying recommendations from the current investigation.*

8 Examples of Reasons to Reject Recommendations

Not all of the recommendations made by the investigation team should be implemented. As management reviews the recommendations, they should consider the following reasons to reject or modify the recommendation:

- A detailed analysis following the investigation indicated that the suggestion was not a good idea because... As management reviewed the recommendation, they found the team did not identify some of the potential risks of implementing the recommendation.
- A detailed review of the recommendation found that the recommendation is not as beneficial as originally thought. As management reviewed the recommendation, they found that the benefits of the recommendation were overestimated by the investigation team.
- Other information, which was not available to the investigator/investigation team, indicates that the potential problem is not as significant as the analysis results indicate. As a result, the recommendation is not needed or can be modified.
- The situation has changed; the recommendation is no longer valid because... Typically, this occurs when the organization has already made some changes following the incident, the operation of the facility has changed or there is an extended period between the incident and the analysis.
- The recommendation is no longer necessary because other recommendations have already been implemented or are planned for implementation. For example, a recommendation was made to have more data collected during routine rounds and tours. However, implementation of new computer sensors and collection of the data by the computer makes the need for additional manual data collection unnecessary.
- The recommendation, although somewhat beneficial, does not provide as much benefit as... There is a better way to correct and address the issue. Therefore, the alternative recommendation will replace the one under consideration.

Therefore, as management takes an overall view of the recommendation, they need to consider the potential risk reduction provided by implementing each recommendation. In addition, they need to consider the other implications of implementing the recommendation. Every time a change is made, additional hazards and risks are introduced. An assessment (often called a management of change assessment) needs to be made to ensure that the recommendations truly reduce the overall risk for the facility and the organization.

9 Benefit-Cost Ratios

A common method for prioritizing recommendations is to assess the benefit-cost ratio for each recommendation. To estimate this ratio, both the benefits and the costs of implementing the recommendation need to be assessed.

9.1 Estimating the Benefit of a Recommendation

One means for estimating the benefit of a recommendation is as follows:

Current expected costs of potential losses

minus

Expected costs of losses that could occur while implementing the recommendation

minus

Expected costs of potential losses after implementing the recommendation

equals

Expected benefits

In detailed assessments of recommendations with high benefits, the time when benefits are realized (e.g., only after five years) may be important because of the time value of money.

9.2 Estimate the Costs of Implementing a Recommendation by Considering the Total Life-cycle Costs of the Change

Estimating the cost of implementing a recommendation should consider the total life cycle cost of the change. This can be computed as follows:

*Initial implementation costs (*design, equipment, installation, procedures, etc.*)*

plus

Annual costs for ongoing implementation (utilities, maintenance, testing, training, etc.)

plus

Any special cost items in the future (rebuilds/replacements, retraining, etc.)

equals

Expected costs.

In detailed assessments with significant costs, the time when costs are realized may be important because of the time value of money.

9.3 Cost-Benefit Ratio

Recommendations with the largest cost-benefit ratios should be implemented first, unless the cumulative benefit of implementing several lower-cost items provides a more attractive return-on-investment or the resources are simply not available to implement relatively expensive items.

For relatively inexpensive items that seem reasonable, management will often decide to implement the recommendations without detailed cost-benefit analysis because detailed analysis costs may be comparable to, or cost more than, the cost of implementation.

10 Assessing Recommendation Effectiveness

To determine the effectiveness of a recommendation, an assessment of its effects needs to be performed. Trending of general incident data (Section 10) indicates the overall effectiveness of the investigation program. Assessing recommendation effectiveness examines the effectiveness of individual recommendations. For each recommendation, an assessment strategy is developed and implemented to determine if the recommendation is correcting the problem it is supposed to address.

The recommendation assessment strategy should look for indications that the recommendation is changing some measurable behavior. Typical issues to consider during the development of a strategy include the following:

- Identify a measurable parameter that should change if the recommendation is working. It should be tied directly to the recommendation.

  Example: During an investigation, it was noted that surveillance activities were not being performed for some of the cargo unloading conveyors. This has led to some failures during loading/unloading operations and delayed departure for the vessel. Certainly, the number of voyages delayed could be tracked. The number of failures of the conveyors could be tracked. Alternatively, the number of missed surveillances could be tracked. All three of these parameters should change if the recommendations are successfully implemented.

- The parameter should be proactive or a leading indicator of recommendation effectiveness. Proactive measures predict when problems occur. Reactive measures determine the number of problems that have already occurred. One lagging indicator is a repeat of the same types of incidents. However, it would be better to be able to predict when the incidents are going to occur rather than wait for them to occur. However, proactive measures are more costly to implement because they involve actively monitoring the system, can be intrusive and require that time be invested even on successes.

  Example 1: Incidents have occurred because of procedures with missing steps. Changes were made in the way procedures were validated to ensure that all the appropriate steps were in the procedure. A proactive assessment strategy is to verify that validation is performed for all appropriate procedures. A reactive strategy is to examine incident reports to determine the number involving procedures with missing steps. A compromise approach would be to periodically review a sampling of procedures to determine how many of them have missing steps or spot-check a few procedures to ensure validation was performed. The compromise approach may cost less and be more practical to implement.

  Example 2: Problems were encountered with purchasing vessel spares that were inappropriate for the type of equipment used on the vessel. A recommendation was made to inspect certain incoming parts to ensure that they meet the purchasing specifications. A proactive approach to assess the effectiveness of this recommendation would be to verify that the inspections are being performed. Another would be to track failures of these parts that are discovered through routine maintenance. A reactive approach is to look at the number of accidents that have occurred because of inappropriate spares.

- The measurement of the parameter must be reasonable to implement. If the measurement of the parameter is not practical from a cost and effort perspective, the measurement will not be performed. Therefore, the recommendation should be examined from a practicality standpoint to ensure that it can be reasonably performed.

  Example: A problem has been noted with communications during turnovers from watch to watch. The company specified that 10 minutes should be allocated to perform a turnover. How could the effectiveness of this recommendation be assessed? Section 7, Table 1, "Effectiveness of Various Shift Turnover Alternatives," outlines different approaches and an assessment of each.

TABLE 1
Effectiveness of Various Shift Turnover Alternatives

Alternative	*Assessment*
Monitor all turnovers	Probably not practical
Document all turnovers	The extra paperwork might be beneficial for a while, but probably would not last.
Periodically audit turnovers	This seems more reasonable to implement. It is not the most proactive measurement strategy, but it is probably one that is practical to implement.
Monitor the number of incidents caused by poor turnover	A reactive strategy. Less expensive to implement than any other method, but purely reactive in nature.

By measuring the effectiveness of recommendations, it can be determined that the actions taken are really correcting the underlying causes that have been identified. Tracking the effectiveness of every recommendation is probably not practical. For recommendations that are not associated with incidents that had large actual or potential consequences, assessing the effectiveness of recommendations is probably not practical. Selected application of this tool will provide the organization with the most learning value with a minimal investment.

11 Application to Apparent Cause Analyses and Root Cause Analyses

Recommendations are developed for both apparent cause analyses and root cause analyses. The nature of the recommendations will be different between the two levels of analysis. Section 7, Table 2, "Recommendations for Apparent Cause Analyses and Root Cause Analyses," outlines the basic differences between the recommendations developed for the two analysis levels. This table should be used for guidance only. The recommendations for any particular analysis will depend upon the extent of root cause identification performed in the previous step.

12 Summary

Developing recommendations is one of the last steps in the investigation process. Recommendations can be categorized in many different ways, including:

i) The time frame of the recommendation,

ii) The level of the recommendation, and

iii) The methods it uses to control the hazard.

Disciplinary actions should generally be avoided as part of the investigation process. Management has numerous responsibilities to resolve and implement the recommendations. Recommendations can be prioritized by using cost-benefit ratios as a guide. Finally, recommendation effectiveness can be assessed by using a recommendation assessment strategy.

TABLE 2
Recommendations for Apparent Cause Analyses and Root Cause Analyses

Activity	*Description*	*Apparent Cause Analyses*	*Root Cause Analyses*
Time frame of recommendations	Short-term, medium-term and long-term recommendations	Most are short-term and medium-term recommendations	Recommendations span the realm from short-term to long-term
Recommendation levels	Levels 1, 2, 3 and 4 recommendations	Level 1 and Level 2 recommendations are more common. However, some Level 3 and Level 4 recommendations can also be generated	Recommendations include all levels. Typically, more Level 3 and Level 4 recommendations are generated for a root cause analysis than for an apparent cause analysis
Types of recommendations	How the recommendation addresses the hazards	Usually the recommendations are less desirable in that they often are more responsive and less proactive	Recommendations can be more proactive in nature
Benefit-cost ratios	Calculating the return on the investment	Usually benefit-cost ratios are performed informally and qualitatively or not at all	Because of the potentially higher cost of implementing the recommendations, more formal methods of calculating benefit-cost ratios are often used
Assessing recommendation effectiveness	Tracking the effectiveness of the recommendation	Recommendation effectiveness is usually not performed as part of an apparent cause analysis	Some recommendations are usually selected for assessment

SECTION 8 Completing the Investigation

1 Introduction

This Section presents four major issues that need to be addressed following the completion of an investigation. These four issues are:

i) Writing investigation reports

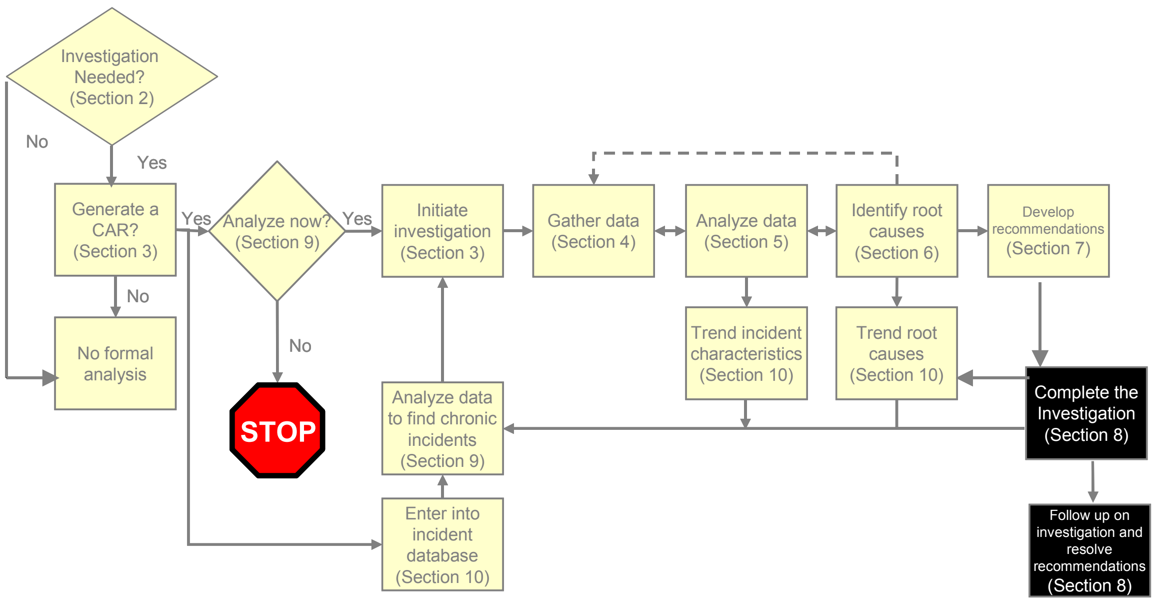
ii) Communicating investigation results

iii) Resolving recommendations and communicating resolutions

iv) Evaluating the investigation process

Section 8, Figure 1 shows this step within the context of the overall incident investigation process.

FIGURE 1
Completing the Investigation within the Context of Overall Incident Investigation Process



2 Writing Investigation Reports

The report is one of the primary tools used by the team to communicate the results of the investigation. It is the permanent record of what was done during the investigation, including the team's conclusions and recommendations. It also provides input into the trending process. Finally, it fulfills regulatory and company requirements.

2.1 Typical Items to Be Included in an Investigation Report

Section 8, Table 1, "Typical Items to Include in Reports," provides a list of items to be included in investigation reports.

A predefined report should be completed for all investigations. The predefined report addresses the basic information needed for all investigations. A Report Checklist and Investigation Checklist is provided in Appendix 7 to assist with determining that all necessary information is formatted properly and included in various types of reports.

Causal factors should be identified for all analyses. Root causes, on the other hand, may not be identified for some of the apparent cause analyses that are performed. Sufficient time and resources may not be allocated to the apparent cause analyses to identify all of the root causes. Instead, causal factors and potentially some intermediate and root causes will be identified.

Recommendations should be captured for all analyses. Even if the recommendations are completed by the time the investigation is started (for example, very short-term items such as broke-fix or quick fix recommendations), documenting the basic steps taken to fix the problem will help with later investigations and reviews.

TABLE 1
Typical Items to Include in Reports

Item	*Scale of Investigation*		
	Small	*Medium*	*Large*
Level of the analysis	ACAs	RCAs	
Predefined report form	Yes	Yes	Yes
Causal factors	Yes	Yes	Yes
Root causes	If identified	Generally yes	Yes
Recommendations	Yes	Yes	Yes
Fault/5-Whys tree and/or causal factor chart	If developed	Generally yes	Yes
Photographs and diagrams	As required	As required	As required
Formal report developed	No	Yes	Yes
Detailed review of rejected hypotheses	No	No	Yes
List of data collected and reviewed	No	Generally yes	Yes
Executive summary	No	Generally yes	Yes

Causal factors, root causes and recommendations should be presented in a manner that clearly shows the connection between each of these levels of the investigation. A standard method for presenting this relationship is a table with the causal factors in the first column, the root causes in the second column and the recommendations in the third column. For some apparent cause analyses, the root cause column may be left blank.

Fault trees or 5-Whys trees and causal factor charts may not be formally developed for some apparent cause analyses. If they are formally developed, they should be included in the report or attached to the report. Fault trees or 5-Whys trees and causal factor charts can often save the investigator additional writing by providing a summary of the incident, including what happened, when it happened, who was involved and how it happened

Photos may be included in the simplest of reports especially if a digital camera is readily available. Photos of the scene and equipment can often be great time savers because photos save the writer from generating lengthy descriptions in the report.

A formal report is anything that goes beyond completion of the standard report form. Most incident investigations (medium-scale and large-scale analyses) should have a formal report. The amount of information gathered is usually well beyond that which a standard form can capture. However, even for these analyses, a standard report form should be completed. Formal reports should attempt to use the documentation and information used for the data analysis (e.g., the causal factor chart, fault tree and/or 5-Whys tree) to the greatest advantage. In some cases, it is not appropriate to include this level of detail. However, in most cases, these tools, along with the three-column forms (as discussed in Sections 5 and 9) showing causal factors, root causes and recommendations, should provide the vast majority of the information needed in the report.

Detailed reviews of rejected hypotheses are usually documented only for large-scale incident investigations. Often this is done to refute theories put forth by various groups within or outside the organization. Often, when an investigation is launched, many preconceived ideas exist concerning the causes of the incident. In some cases, it is prudent to address each of these theories and describe why the investigation team believes it is not a valid cause of the incident. Left unaddressed, the validity of the report may be called into question by individuals or groups, and the effectiveness of the investigation process can be greatly diminished.

Knowing what data were examined can often add credibility to the investigation process and show the depth of the investigation. For smaller-scale investigations, a list of the data reviewed is often not included in the report. As the scale of the investigation gets larger or the visibility of the investigation to outsiders becomes a larger factor, this list is usually included in the report.

An executive summary or synopsis can help more people get the important points from the report without having to read all the details. In some cases, busy managers will choose not to look through the report itself. In this case, an executive summary or synopsis is needed. These are usually only written for medium- and large-scale analyses (all incident investigations and some apparent cause analyses).

2.2 Tips for Writing Reports

In reviewing numerous investigation reports and participating in many investigations, the authors of these Guidance Notes have developed a number of tips for writing effective reports. These are listed below.

2.2.1 Start Writing the Report at the Beginning of the Investigation

Compile the report continually during the investigation process; do not wait until the investigation is over to begin writing the report. By taking this approach, it will be possible to see the data that will be needed to complete some of the required fields. This will guide some of the data gathering and make the investigation more efficient.

2.2.2 Have the Report Reviewed

Have the report reviewed for technical accuracy, writing clarity, grammatical errors and legal issues. Obvious errors in the report can call into question the technical accuracy of the investigation.

Some organizations perform two reviews. The first is a technical accuracy review. The point of this review is to ensure the accuracy of the sequence of events, as well as the capabilities of equipment, status of current management systems and organizational information. The second review examines the conclusions and recommendations determined by the investigation team.

This two-stage review process is usually performed only on larger investigations. For smaller-scale investigations, a single review is usually conducted.

Using the two-stage review process allows the reviewers to focus on the facts during the first review and to not get distracted by the conclusions and recommendations reached by the team. This also allows the team members to verify the facts that support their conclusions and recommendations before documenting them in the report.

A Report Comment form is included in the MaRCAT Toolkit in Appendix 7. This can be used to obtain and record comments from multiple reviewers. Most word processing programs provide a means to number the lines in the report. Using this feature and printing the file to an Adobe® Acrobat® file will allow reviewers to all refer to the same line number in the report.

2.2.3 Explain Any Contradictory Information

Do not let the reader guess which information is a fact and which is a conclusion drawn by the investigation team. In some cases, the team has to make a determination of the most likely scenario or most likely cause of an incident. There may be contradictory data pointing to alternative scenarios or causes. The data that are needed to resolve the inconsistency or fill in the knowledge gap may not be available or may be too costly to obtain. The team should show the data that support these conclusions. The tools used to analyze the data (causal factor charts and fault trees) should assist with the documentation of this data.

2.2.4 Identify Facts, Conclusions, Hypotheses and Recommendations

Conclusions, hypotheses and recommendations should be presented as such, not as facts. Clearly indicate what the team concluded based on the data and what is a provable fact. Some judgment will be needed to know when enough is enough. For example, for most fires, proving that there is oxygen in the air will not be needed. But, if a fire takes place in a tank that normally has an inert atmosphere, then proving that there was oxygen in the atmosphere will probably be required.

2.2.5 Ensure that the Report Addresses the Needs of the Audience

Recognize that a single report may not satisfy all audiences. You may need to generate multiple reports to meet the varied needs of your audiences. For example, a report that is used during onboard safety briefings may only include a paragraph description of the incident and the two recommendations that apply to the attendee's work. A report produced for the shore-based managers will need to include a summary of the incident and all of the causal factors and recommendations.

2.2.6 Do not Fill up the Report with Unneeded Information

Reference all materials used during the investigation, but only include the information required to communicate the results to your audience. The objective is to change the behavior of the organization and its personnel, not to use up paper.

2.2.7 Do not Use Names of Individuals

Identify items (structures/machinery/equipment/outfitting, etc.) and positions of individuals involved in the incident in sufficient detail to understand the incident, the causes and the recommendations, but do not be any more specific than needed. There is no point in including people's names in the report. It only serves to embarrass them and make them want to never cooperate in one of your investigations again. If witness statements are included in the report, this could inadvertently expose witnesses' names.

2.2.8 Do not Downplay Sensitive Issues

Do not downplay sensitive issues to the point that potential corrective actions associated with the issues are not implemented. Many of the issues discussed in the report are not pleasant. But if they are not discussed sufficiently, no one will understand why the recommendations need to be implemented.

2.2.9 Use Supplemental Information as Needed

Use standard investigation reporting forms, as required, but feel free to attach any additional information that may be necessary. The standard report form cannot anticipate all of the potential reporting needs. Add supplemental data as required.

2.2.10 Issue Reports as Controlled Documents or Records

This includes all drafts of reports. Drafts should be collected before the final report is issued and destroyed. Final reports should be issued as controlled documents or records so it is known who has the information. In addition, ensure that the reports are properly marked, such as "Draft – For Review Only," and that each version of the report is dated with the revision number.

2.2.11 Properly Control Proprietary and Other Sensitive Data

Ensure that all reports, including drafts, are marked as proprietary or with other appropriate markings. The report is supposed to help the organization learn how to improve its operations. It does not need to help your competitors learn about your operations.

2.2.12 Follow Generally Accepted Technical Writing Guidelines

The following general guidelines should be kept in mind when writing the investigation report:

- Write reports in the past tense
- Avoid jargon
- Minimize the use of abbreviations and acronyms
- Do not include information/figures/tables that are not necessary
- Use figures/tables to minimize verbiage when possible
- Use consistent terminology, spelling and report organization

A Report Checklist and Investigation Checklist are included in the MaRCAT Toolkit in Appendix 7.

3 Communicating Investigation Results

Communicating the results of the investigation is an important aspect of the investigation process. In addition to recommendations to communicate the investigation results to those who are affected by the corrective actions, it is also important that those personnel who assisted the investigation team be made aware of the investigation results. Often they are not so much interested in the detailed outcome of the investigation as in knowing that their investment of time in the investigation paid off for the organization in some manner. If they invested an hour of their busy workday in helping the investigation team, they want to see that something useful was done with the information they provided or helped to acquire. With these dual goals in mind, the steps that follow can provide hints for communicating the results of the investigation to those who were involved.

3.1 Decide to Whom

The following provides some ideas about the possibilities for report distribution:

- *Relevant Personnel with Policy and Procedure Responsibility.* Those personnel responsible for managing the upkeep and update of policies and procedures should be provided with the report to determine if changes to the Management System are necessary as a part of the formal corrective/ preventative action system.
- *Affected Employees.* Affected employees will want to know what to do differently and what the company is doing to make sure this type of incident does not happen in the future.
- *All Employees.* Is there a lesson to be learned by everyone? Keep this type of communication short and to the point. Tell them what they need to know and why; nothing more or the primary message will get lost in all the extra information.
- *Other Company Vessels/Sites.* Can other company vessels learn from this incident? The communication should be tailored to provide sufficient information without unnecessary detail.
- *Contractors/Subcontractors.* Can contractors or subcontractors that your organization frequently works with learn from this incident? The communication should be tailored to provide sufficient information without unnecessary detail.
- *Others in Industry.* Can others in the industry learn from this incident without disclosing company secrets? The communication should be tailored to provide sufficient information without unnecessary detail.
- *The Public.* Is there public interest in the incident? Will telling the public about the incident and the investigation help the image of the organization? Are there some other benefits in telling the public about what the organization did in response to the incident?
- *Regulators.* Are there regulatory requirements to file a report? Should you tell the regulator to show your organization's desire to understand your operation and meet the regulator's concerns?

3.2 Decide How

The following provides some ideas about the how to distribute a report:

- *Routing or Posting the Report or a Summary.* When it is desirable to show what is being accomplished with the incident investigation program, post or route the results. Do not think that anyone is actually going to read the details, but letting personnel who helped with the investigation process see that a report was generated can help the long-term sustainability of the program.

- *General Meetings.* If you really want to ensure that a group heard about the incident, include it in a safety briefing or other formal meeting or training course. They still may not understand the details of what they need to do, but at least they will have a general idea of the changes that are coming. Do not expect everyone to like the recommendations, even if they are good ideas; no one likes to change.
- *Formal Training.* This should be very targeted. Provide enough background on the incident to show why you want their behavior to change. Then tell them what THEY need to do differently. Do not tell them about all the other good recommendations the team came up with that will not affect them. Most likely, they do not care. Do not expect everyone to like the recommendations, even if they are good ideas; again, no one likes to change.
- *Publish New and Amended Management System Policies and Procedures as Appropriate.* Since the management system policies and procedures may have been amended as a result of recommendations made in the investigation report, it will be necessary to publish the changes to make all relevant personnel aware of the differences.

3.3 Document the Communication

The following provides some ideas about documenting communications about the investigation status and results.

- *Document your Communication (by memo, e-mail, etc.).* Keep track of how you communicated the investigation results, even if they were just posted. If formal meetings were held, record who was there.
- *Solicit and Document Feedback.* There will probably be something else that could be learned from the incident. Invite personnel to tell you what else they know about what happened and how the results of the investigation can be applied in other areas.

4 Resolving Recommendations and Communicating Resolutions

4.1 Tracking Recommendations

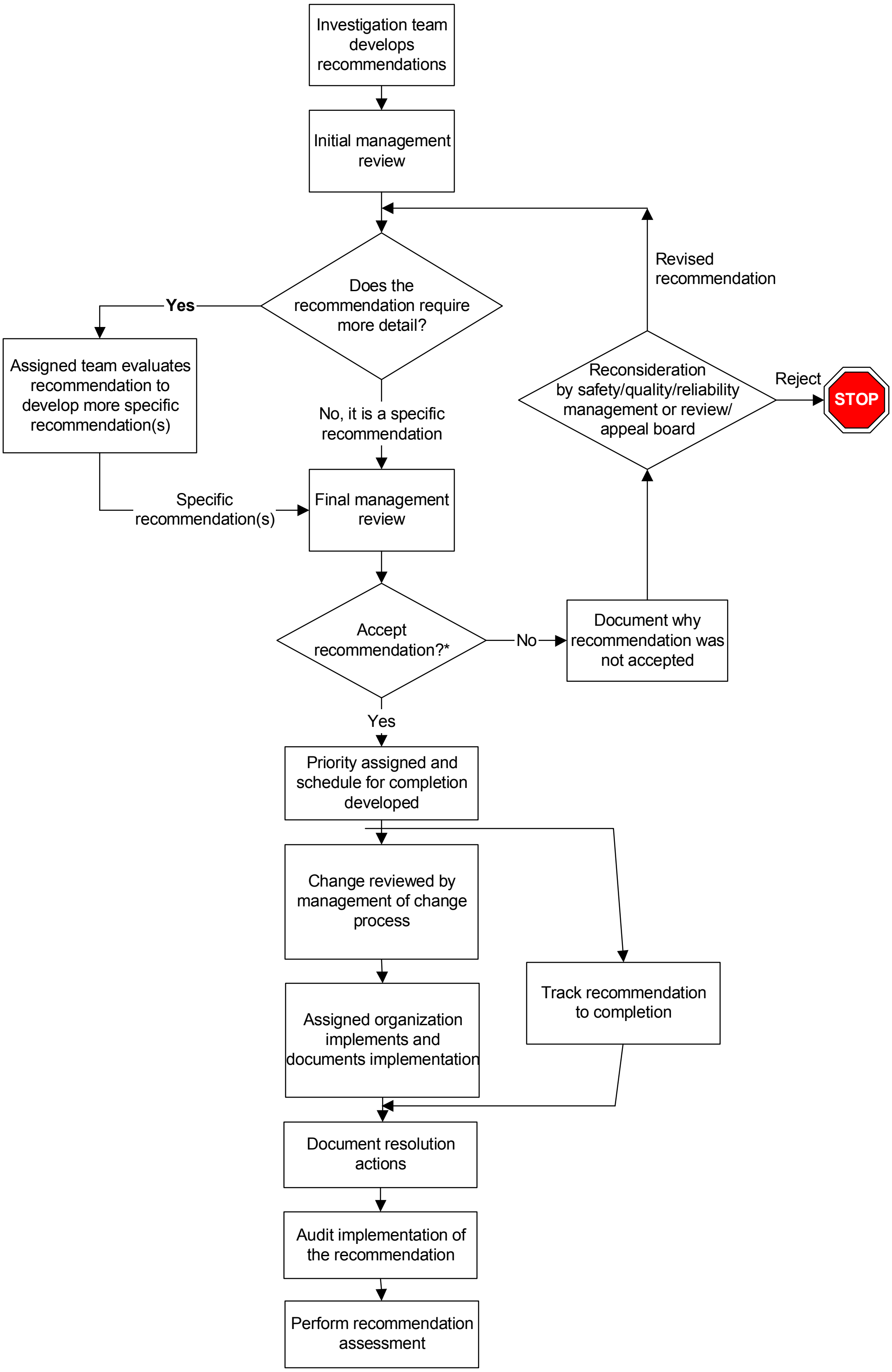
All recommendations must be resolved. Resolution does not necessarily require implementation, but it does require an evaluation and justification for the actions that are taken. Failure to document resolutions can increase legal and regulatory liability. In addition, failure to document a change to a resolution during implementation can also increase liability.

Tracking recommendations should continue until implementation of all of the recommendations is complete. The flowchart in Section 8, Figure 2, "Tracking Recommendations," illustrates a method for tracking recommendations (from incident investigations, hazard analyses, audits, etc.) to their final resolutions.

4.2 Resolution Report Phase and Closure of Files

The final closeout of each report should be documented. The final review of the report should verify that all of the reporting and documentation requirements have been met and that all of the recommendations have been resolved.

FIGURE 2
Tracking Recommendations



*See list of reasons to reject a recommendation in Section 7.8

5 Addressing Final Issues

5.1 Enter Trending Data

If not already entered as part of the normal documentation process, data should be entered into the tracking system so that trending of the investigation data can be performed. Parameters for trending must be thought out ahead of time (incident type, root cause categories, etc.) to make trending effective. Section 10 will discuss the development of a trending program.

5.2 Evaluate the Investigation Process

5.2.1 Types of Evaluations and Communications

Two types of evaluations can be performed: an evaluation of the investigation process and an evaluation of a specific investigation. A final critique of the investigation process helps identify any weaknesses in the current investigation and identify suggestions that will improve future investigations. Ideally, all of the individuals participating in the investigation should participate in the critique.

Usually, the process involves two methods of communication. The *first* is a critique meeting. During the meeting, members share the pluses and minuses of each aspect of the investigation process and how it worked during this particular application. Most organizations find an informal tone to the meeting works best; however, each participant should be specifically asked for his or her input. The *second* method is one-on-one feedback with the team leader or incident investigation program manager. This provides a method for those individuals who are not comfortable sharing issues during the meeting to communicate their concerns.

5.2.2 Example Critique Questions

The following are example critique questions:

i) How well did the investigation satisfy its goals and objectives?

ii) What investigation activities went well?

iii) What improvements could be made?

iv) What additional training would be useful to promote more effective investigations?

v) What additional resources should be available to support investigations?

vi) What items caused inefficiencies in the investigation?

5.2.3 Follow-up of Critique Process

Weaknesses and recommendations for improvement should be passed on to the incident investigation program manager for incorporation into the incident investigation process.

Some organizations score a sample of their investigations against a score card. The score card awards points for meeting specific criteria. Trending of the scores can provide an indication of the performance of the investigation program. The scores can also provide feedback to the investigators to improve their performance. The Causal Factor, Root Cause and Recommendation Checklist, along with the Report Checklist and Investigation Checklist contained in the MaRCAT Toolkit in Appendix 7, can be used as a starting point for developing a scoring system.

6 Application to Apparent Cause Analyses and Root Cause Analyses

Section 8, Table 2, "Investigation Completion Activities for Apparent Cause Analyses and Incident Investigations," outlines some of the differences between apparent cause analyses and incident investigations for the four activities addressed in this section. As noted in previous subsections, this table should be used as a guide only. Specific organizational and investigation needs may require deviation from the guidance provided below.

TABLE 2
Investigation Completion Activities for Apparent Cause Analyses and Incident Investigations

Activity	*Description*	*Apparent Cause Analyses*	*Root Cause Analyses*
Investigation reports	Developing a report to document the results of the analysis	Less detail and supporting information is typically included in the report. Justification for recommendations is typically less thorough because of the lower cost of most ACA recommendations	More details and supporting information provided. Refuted (disproved) theories may also be addressed
Communicating investigation results	Telling others about the results of the analysis	Limited personnel are informed about the results of the analysis. Typically, this is the group immediately affected by the incident	A broader scope of personnel is informed about the results of the analysis. This could include support organizations and others not directly involved in the incident
Resolving recommendations	Resolving the recommendations	All recommendations are resolved	All recommendations are resolved
Evaluating the investigation process	Looking for potential improvements in the investigation process	Typically, no formal critique is performed of individual ACAs. However, an overall review of many ACAs may be performed to determine how the system could be improved	A formal critique is performed for most investigations

7 Summary

Closeout activities for the investigation need to be performed to ensure that the investigation meets its goals. The four basic activities include:

i) Generating a report,

ii) Communicating the results of the investigation,

iii) Resolving recommendations, and

iv) Evaluating the investigation process.

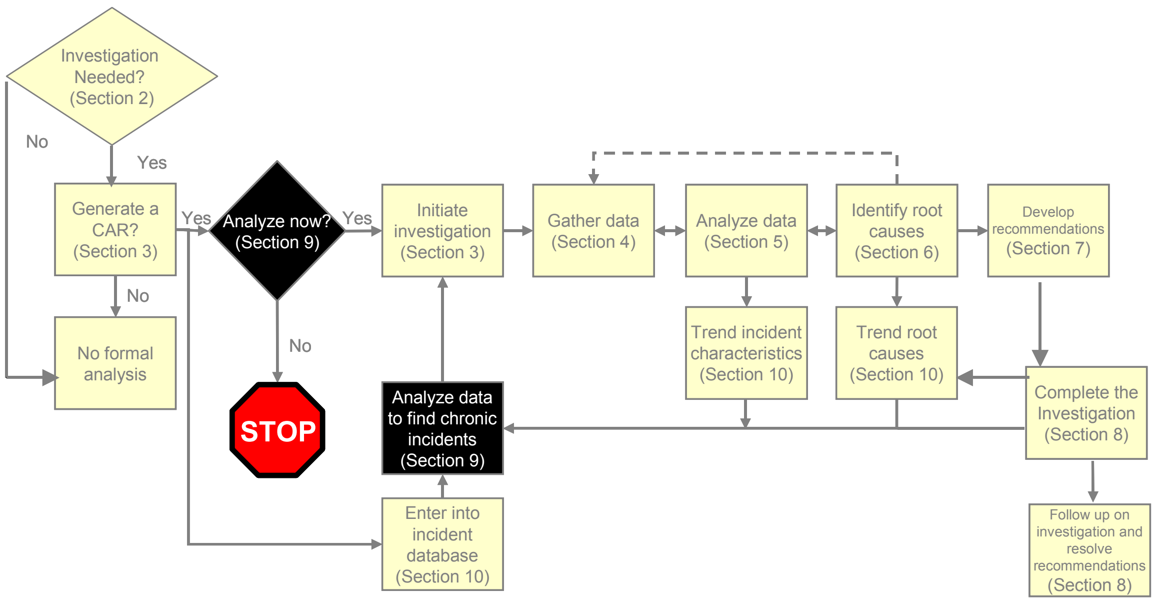
SECTION 9 Selecting Incidents for Analysis

1 Introduction

This Section addresses the issue of determining which incidents should be analyzed. In some cases, the choice of performing an investigation is clear-cut. For example, a grounding of a vessel with a catastrophic spill of cargo would clearly require an investigation. A paper cut while filling out the ship's log would clearly not require any investigation. However, what about all the incidents that are in between these extremes? This Section addresses the methods used to make these decisions.

Section 9, Figure 1 shows this step within the context of the overall incident investigation process.

FIGURE 1
Selecting Incidents for Analysis Within the Context of the Overall Incident Investigation Process

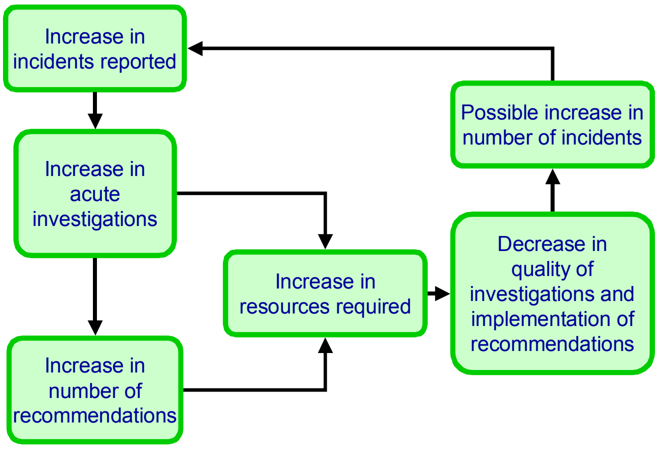


2 Why Be Careful when Selecting Incidents for Investigation?

If reporting of incidents is encouraged, the number of reported incidents will increase. If a thorough investigation is carried out for each of these incidents, then the resources required for investigations will increase greatly. As each investigation is completed, recommendations will be generated; therefore, the resources required to resolve these recommendations will increase. Thus, the overall result is that our resources become overloaded and spread thinner and thinner.

In the end, the quality of investigations and recommendation implementation will degrade because there are fewer resources to address them. This in turn leads to more incidents occurring and, therefore, more incidents being reported. This just keeps the cycle going. Section 9, Figure 2, "Investigation Cycle if Too Many Investigations Are Performed," shows how this cycle can occur.

FIGURE 2
Investigation Cycle if Too Many Investigations Are Performed



If an organization cannot afford to investigate *all* incidents, how should a determination be made about which incidents to investigate?

Most organizations do not have enough resources to analyze all of the incidents that occur. Incidents are prevalent in all parts of the organization, so there are too many to be properly investigated. Some incidents are too small and too trivial to invest significant investigative resources. Even if the investigation and resulting recommendations prevented the incident from recurring, it still would not be worth the effort of the investigation. Pareto analysis indicates that 80% of the losses are caused by 20% of the incidents. Therefore, it is important to identify these 20%, the significant few, where efforts will be concentrated.

Root cause analyses (RCA) and apparent cause analyses (ACA) are undertaken to improve performance and save money. If more money is invested in the investigation than is saved by addressing the underlying causes, then the organization ends up losing money. It is not necessary to expend effort on the 80% of the incidents that are only causing 20% of the losses. It usually makes more sense to live with these incidents and correct the causal factors when they occur.

Investigations take resources away from other useful risk reduction strategies such as proactive analyses and development and implementation of safeguards to control risks. If too many resources are dedicated to reactive analyses, then insufficient resources are available to implement the recommendations through proactive analyses and the development and implementation of management systems. Therefore, organizations must be selective in choosing the incidents to analyze.

Investigating one incident *correctly* usually addresses many underlying causes. If an investigation is properly performed, then many incidents are prevented in addition to the one under investigation. Therefore, the payback is usually larger than you might expect.

Solving the significant few (i.e., the 20% of the incidents that cause 80% of the losses) will probably prevent many of the other insignificant incidents from recurring (i.e., the 80% of the incidents that cause only 20% of the losses).

There are three potential actions that can be taken after an incident is reported:

i) Investigate

ii) Record the data for trending or do nothing as part of the investigation process

iii) Let routine management systems resolve the issue

For all of the reasons noted, an organization must carefully determine the appropriate course of action for each incident identified. The key criterion to consider when making the decision to investigate is the potential opportunity for learning.

3 Some General Guidance

Using the potential opportunity for learning as a criterion for determining which incidents to investigate results in the general guidance in the following Subsections. Section 9, Table 1, "Learning Potential from Incidents", provides a description of incidents and the potential learning value for each.

TABLE 1
Learning Potential from Incidents

Type of Incident	*Situation*	*Frequency*	*Investigated?*	*Learning Potential*
Acute	Actual Losses	1%	Nearly all investigated	High
Non-Acute	Near Miss or Near Hit Deviations	5%	Investigation and trending of chronic events Regardless, all data about events should be entered in database to allow potential for trending	Moderate to low
	Potentially harmful circumstances but no actual loss	~10%		
Not classified as an incident	Variations or Unsafe Acts or Conditions, Errors or Failures	85%	Not investigated. May be dealt with through Behavior-Based Risk Management	Low

3.1 Incidents to Investigate (High Potential Learning Value)

Single incidents (acute) that represent a large enough loss (actual or potential) to justify an immediate investigation are considered high potential learning value.

- *Accidents.* Incidents with large losses
- *Accidents with small losses that are near misses to large potential losses.* Incidents with small losses but with the potential for large losses
- *Near misses with large potential losses.* Incidents with no losses but with the potential for large losses

3.2 Incidents to Trend (Moderate to Low Potential Learning Value)

Some groups of incidents (chronic) represent a large enough loss (actual or potential) to justify an investigation only if they occur on a frequent basis. In these cases, it may be sufficient to trend the losses until enough losses have occurred to justify an investigation.

- *Small losses.* Such as incidents with small losses and no reasonable potential for a large loss. If these incidents were to occur often enough, they would represent a significant loss to the organization.
- *Near misses with small to moderate potential losses.* Such as incidents with no losses and no reasonable potential for large losses. If these incidents were to occur often enough, they would represent a significant potential loss to the organization.

3.3 No Investigation – Behavior-based Risk Management (BBRM) (Low Potential Learning Value)

Routine human errors and minor equipment failures that occur as part of daily work activities may not be considered worthy of an investigation since there would be little potential learning value.

4 Performing the Investigation

All acute incidents should be investigated immediately; all non-acute (potentially chronic) incidents should be logged into a database.

4.1 Incidents to Investigate Immediately (Acute Incidents)

All acute incidents should be investigated as promptly as possible. Acute incidents, by definition, are worthy of the investment of time to uncover the underlying causes. Company personnel can make exceptions to this rule if they deem the incident to have low learning value. In such situations, the incident should still be logged into the database.

4.2 Incidents to Trend (Potentially Chronic Incidents)

Incidents that do not meet the definition of an acute incident should be entered into a database, but an investigation should NOT necessarily be performed. Periodically, a query should be made using the incident database to determine if any of these incidents are occurring frequently enough to justify an investigation. If so, management should initiate an investigation of the group of incidents. Chronic incidents are investigated in the same manner as acute incidents, but much of the specific incident data may no longer be obtainable.

5 Near Misses

Near misses should be investigated or trended when the potential consequences are large enough. In order to request an investigation of these near misses, the organization needs to know about them. To get near misses reported, the organization needs to specifically define what a near miss is and address the barriers to getting near misses reported.

5.1 Factors to Consider When Defining Near Misses

When considering whether to investigate an incident as a near miss, the following factors should be considered:

- What could the consequences of the incident have been? The larger the potential consequences, the more resources should be committed to an investigation. Would the consequences have been more severe if:

  The circumstances had been slightly different?

  It had not been detected so early?

  The external conditions, such as the weather, were slightly different?

  If a less experienced, but competent, person had been performing the task?

- Is the incident considered part of "normal" operation? If so, an investigation may not be appropriate. Should the incident consequences be considered an acceptable risk?
- Is the risk associated with this incident well understood? Is the risk associated with the incident acceptable? If a decision has been made that the risk from this incident is acceptable, then an investigation would not result in any significant changes.
- Are adequate safeguards in place to protect the workers and the public against these incidents? If adequate safeguards are provided, then an investigation would not result in any significant changes.

Some of these criteria will be difficult to assess before an investigation is performed. The best judgment will have to be made based on the limited information available. Some investigation may be needed just to determine the answers to these questions. The criteria should be reassessed as additional information becomes available during the investigation. If the investigator determines that the incident did not have the potential for a large loss, then the investigator may make the decision to terminate the investigation at this point.

5.2 Reasons Why Near Misses Should Be Investigated

Near misses share the same causal factors and underlying causes as accidents. By investigating near misses and correcting the underlying causes of these accidents, other near misses and accidents can be kept from occurring. Near misses cannot be investigated if they are not reported.

5.3 Barriers to Getting Near Misses Reported

There are numerous barriers to getting near misses reported. In most cases, near misses are only known by the individuals involved in the incident. In most cases, the chances they will "get caught" are small. So, in effect, these individuals have the option of reporting the incident or keeping it to themselves. There can be many factors that discourage them from reporting. An organization will have to effectively deal with these barriers to be effective in getting the incidents reported and subsequently investigated. The following subparagraphs list typical barriers that organizations encounter to getting incidents reported.

5.3.1 Fear of Disciplinary Action

Employees are concerned that they will be punished for reporting an incident. Punishment can range from being fired to getting undesirable shifts/watches to receiving disparaging comments from the officers or crewmembers. If the organization does not take a "no-punishment" approach during investigations, there will be limited cooperation from the employees.

5.3.2 Fear of Teasing by Peers (Embarrassment).

Personnel are afraid their peers will embarrass them. This may be difficult to deal with because the organization does not have direct control over this issue.

5.3.3 Fear of Legal Liability

Employees may wonder if they or their company could be held legally liable for the incident or the future consequences of the incident. Most investigations do not have any significant legal impact. For those that do, the organization should get its legal staff involved in the investigation process to limit the organization's legal exposure. Reporting of incidents should be encouraged by the organization's legal department. Preventing incidents will have a long-term beneficial impact on the organization's operations and legal exposure.

5.3.4 Disincentives for Reporting Near Misses

While there may not be outright punishment for reporting, there may instead be a more subtle form of discouragement. Issues including the extra work involved to report the incident, the many forms to complete, interviews and potentially having to leave work/stay on duty later than normal can discourage reporting.

5.3.5 Multiple Investigation Programs

If there are different programs and procedures for reporting safety, reliability, environmental and business issues, the person reporting the incident may be shuffled around to multiple personnel or have to report the incident multiple times. One person should be designated to receive incident reports. That person should be able to determine who else needs to be notified.

5.3.6 Lack of Management Follow-through

Personnel have reported near misses or have seen others report incidents and nothing was done. They conclude that reporting near misses is a waste of time and does not generate any meaningful changes in the organization. Personnel need to receive feedback on the changes made through the investigation program.

5.3.7 No Incentive to Report Near Misses

There is no reward for reporting near misses. Rewards can include money, hats, travel cups and pocketknives. Focus on items that are personally valuable to the individuals whose behavior you are trying to affect. Just because you do not wear a hat does not mean that it will not work for the deckhands.

5.3.8 Apparent Low Return on Effort to Report

There is more work involved in reporting than the benefit to the individual or organization. Of all the things that need to be done, reporting near misses will not be high on the individual's list if the anticipated return is very low. Provide feedback to personnel on what you have done as a result of the investigations.

5.3.9 Lack of Understanding of a Near Miss versus a Non-incident

Define what should be reported and what should be ignored. Specify what the organization wishes to know. Personnel need a clear definition of what should be reported.

5.4 Overcoming the Barriers

The reasons why near misses are not reported are listed above in decreasing level of difficulty to address. The easiest of these can be solved in a week or two. The most difficult of these may take one or two years to address. It is important to tell personnel what is wanted from them. Changing the organizational culture so that personnel believe they will not be punished for reporting incidents will take many years of consistent behavior from management.

The key to overcoming all of these barriers, however, is an effective investigation program. By performing investigations properly, personnel will see how the recommendations that are generated and implemented improve the workplace and how workers are not punished for participating in investigations. With positive changes to the work environment and rewards for participating, employees will want to assist in investigations.

5.5 Acute Analysis versus Chronic Analysis

The main basis for deciding whether to do an acute or a chronic analysis relates to the opportunity for learning – whether enough can be learned from analyzing an incident as a single incident to justify the cost of the analysis. The organization needs to decide what should be investigated using an acute analysis, a chronic analysis or no analysis at all. There is no hard-and-fast rule governing whether the incident warrants an acute or a chronic analysis. Each group (safety, quality, operations, engineering, environmental, etc.) must decide this for itself. The best way to do this is to create examples to show people what is expected.

For example, if a person gets a bad cut, an acute analysis might be appropriate. However, if there was an incident where a person forgot to wear his or her gloves, it could suffice to simply record the details around the incident and add this to our database. Eventually, if it was found that this was a recurring type of incident or if it was observed that many people were not wearing their gloves while performing the task, all of the incidents could be investigated together to determine why people frequently do not wear their gloves.

It is important to remember that even though an incident is investigated with an acute analysis, the incident still should be added to the incident database so that a chronic analysis could be performed later using the complete data set.

6 Identifying the Chronic Incidents that Should Be Analyzed

6.1 Pareto Analysis

Pareto analysis is based on the theory that the majority of the problems or losses are the result of a few key contributors. The intent is to find the key contributors to the organization's losses. By addressing these few items, the greatest return on investment should be achieved.

To perform a Pareto analysis, organize the incidents by a particular attribute (e.g., vessel type, equipment type, time of the day, root cause type, cargo). Then plot the data as a bar chart (many statistical software packages and spreadsheet programs such as Excel include simple ways to construct a bar chart). Examine the Pareto chart to see if the Pareto principle applies – roughly 80% of the incidents come from 20% of the causes or categories. If it is found that the bars are approximately the same length across all values of the attribute (i.e., it looks flat), then this attribute is not one of concern. An effort should be made to keep trying other attributes to plot the data until one is found that shows the sharpest decline (i.e., is not flat).

Once the correct attribute is identified, the analysis focuses on the largest group(s) on the chart. Efforts to eliminate incidents associated with this group should have a significant impact on the operations since it is related to the greatest number of incidents. Investigate the entire group at once. Determine the underlying causes of these events, striving to identify the root causes for this group and define the appropriate recommendations.

Performing an analysis of a group of historical incidents may be difficult because much of the data may no longer be available. The data that are usually available as part of a chronic analysis may have been destroyed or altered before the investigation is begun. The memories of the individual incidents may not be clear for the personnel. They may confuse one incident with another. This poor data quality may make a detailed analysis and investigation impossible.

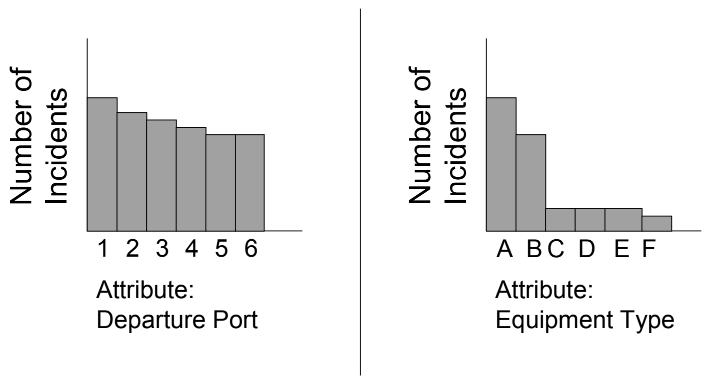
Once the largest group of incidents is analyzed, focus attention on the next largest group. If there is a significant portion of the losses from this group or category, solving these problems should also help the organization. Do not assume that the underlying causes are the same for each category.

During this initial stage, focus on characterizing the group of incidents, NOT on underlying causes. It is not YET important what is causing the incidents. Investigation techniques can be used to identify the causes of the incidents that have significant risk associated with them. This initial data analysis will allow us to focus our analysis efforts on a few select incidents. At this point in the data analysis, the causes are kept very broad. They are only used to trigger our memories of failures that have occurred.

6.2 Examples of Pareto Analysis

Two Pareto charts are shown in Section 9, Figure 3, "Pareto Charts Developed Using Two Different Attributes". In this example, the data were first sorted and plotted by departure port. This first Pareto chart is not very useful because the bars are all approximately the same height. Thus, the departure port attribute does not contain useful trending information for this set of incidents. However, it does tell us that whatever is causing the incidents appears to be present at all of the ports.

FIGURE 3
Pareto Charts Developed Using Two Different Attributes



Next, the data were sorted and plotted by equipment type. The source of most of the incidents is from the first two equipment types. This is a useful trend from the Pareto chart.

This second chart shows that the best opportunity for reducing risk will come from analyzing the underlying causes of failures for Equipment Type A and Equipment Type B. Therefore, the focus would be first on incidents associated with these two equipment types. Once the size of these bars have been reduced or eliminated altogether, other attributes can be focused upon, if applicable. Notice that choosing the proper attributes is essential for performing the chronic analysis. Thus, it is necessary to record all the correct attributes for our incidents. Section 10 will discuss methods for determining the types of parameters to trend.

6.3 Weaknesses of Pareto Analysis

As good as the Pareto method is, it has some significant weaknesses. These weaknesses should be considered when the analysis is performed.

6.3.1 Focus is Only on the Past

Pareto analysis develops characteristics for an organization, area, vessel or equipment type based solely on the characteristics of problems encountered in the past. While Pareto analysis offers a valuable look at key contributors to past incidents, the exclusive reliance on historical data can be misleading in the following ways:

i) Incidents that have luckily not happened yet (or have occurred rarely), but that are just as statistically likely as incidents that have unfortunately occurred more frequently, are underrepresented by the data. This situation can skew decisions and resource allocations, especially when a relatively small total number of problems have occurred for individual systems.

ii) Recent changes in operating practices, maintenance plans, equipment configuration, etc., may invalidate (or at least lessen the accuracy of) historical trends. This situation can also skew decisions and resource allocations, especially when relatively recent changes have not been in place long enough to affect the data (or when data is analyzed over extremely long time intervals during which numerous changes would have been made).

6.3.2 Variability in Levels of Analysis or Resolution

Deciding how to group elements of a vessel, organization or system for a Pareto analysis is subject to the judgment of the individuals involved in performing the analysis. This can produce significant variability in (1) the time required to perform the analysis and (2) the level of resolution of the results. Grouping elements at too high of a level may mask significant variations among the elements in the groups. Conversely, grouping elements at too low of a level will require more work to perform the analysis and may falsely indicate relative importance of individual components.

6.3.3 Availability and Applicability of Data to Analyze

The quality of Pareto analyses is completely dependent on the availability of relevant and reliable data for the organization, vessels and systems being analyzed. A diligent focus on collecting meaningful data is critical to a successful Pareto analysis.

6.4 Other Data Analysis Tools

Other tools may also be helpful in analyzing the available data. If you are already familiar with these other tools or use them in other applications, they may provide you with additional insights into the trending of data. Example methods include:

i) Relative ranking

ii) Failure modes, effects and criticality analysis (FMECA)

iii) Fault Tree Analysis

iv) What-if analysis

v) Hazard and operability (HAZOP) analysis

vi) Influence diagrams

vii) Design of experiments

Of these methods, Fault Tree Analysis is generally the most effective and efficient method (beyond Pareto analysis) for determining the incidents to be addressed through an investigation. It also has an advantage in that it is one of the tools typically used in the investigation process for organizing and analyzing data. Therefore, the general methodology is already familiar to the investigation personnel.

7 Application to Apparent Cause Analyses and Root Cause Analyses

The methods covered in this section help us determine which incidents should be analyzed immediately as either an apparent cause analysis or a root cause analysis. It also describes the methods for selecting near-miss incidents and chronic incidents for analysis. Chronic incident analysis can occur at the apparent cause analysis or root cause analysis level.

8 Summary

This section addressed the need for identifying near misses and chronic incidents for investigation. Much can be learned from analyzing near misses without having the associated loss event. These are free opportunities to learn about the limitations of an organization's operations. Analyzing chronic incidents allows the organization to learn from a series of small losses. Collectively, these small losses may have a significant impact on the organization, so learning what causes these incidents should prove beneficial.

SECTION 10 Results Trending

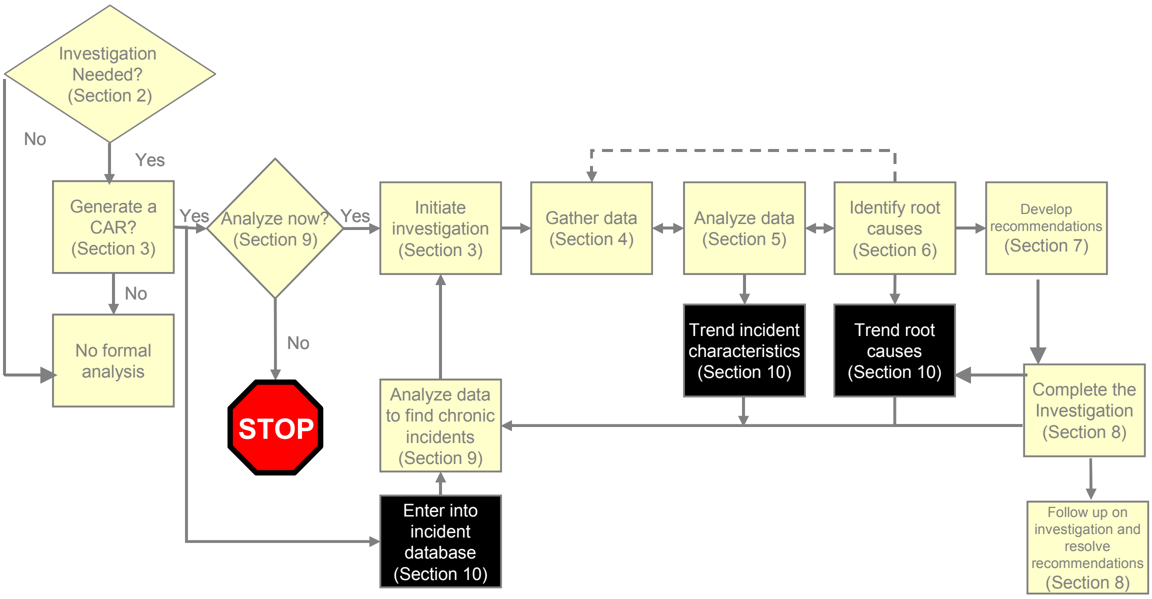
1 Introduction

This section deals with setting up an effective trending program. Trending programs allow organizations to collect and analyze data over a wide spectrum of different types of incidents.

Investigation teams typically focus on the one specific incident they are analyzing and the recommendations they can identify to prevent recurrence of the incident. Organizations, on the other hand, must identify systemic problems that contribute to incidents. Trending of incident data is the key to unlocking this information.

Section 10, Figure 1 shows this step within the context of the overall incident investigation process.

FIGURE 1
Results Trending Within the Context of the Overall Incident Investigation Process



2 Benefits of a Trending Program

Trending of incident investigation data provides information on the overall effectiveness of the incident investigation system and the recommendations implemented as a result of the investigations. If near misses and accidents are properly reported and investigated, and if the recommendations derived from the investigations are implemented, similar types of incidents should not recur. By performing a trending analysis, the overall effectiveness of our incident investigation efforts can be assessed.

Correlation provides the basis for a more holistic investigation of systemic or widespread problems. Some of the benefits of an effective trending program include the following:

i) Facilitates performance status and projections

ii) Identifies persistent management deficiencies (root causes)

iii) Highlights unique, previously unrecognized or improperly defined risks

iv) Identifies misallocated management resources

v) Flags sudden changes in performance (positive and negative)

vi) Provides correlation of changes in performance to incidents producing such changes

vii) Highlights investigation weaknesses

Trending can provide a correlation to a wide variety of parameters. As already discussed in Section 9, trending of data allows a chronic analysis of incidents to be performed, therefore, the trending program needs to be set up with the purpose of identifying incidents for chronic analyses.

3 Determining the Data to Collect

There are an infinite number of data that can be collected about an incident. Examples include:

- Countries of operation
- Flag
- Divisions
- Industry sectors
- Cargo type
- Vessel type
- Vessel age
- Equipment type (system, component, subcomponent)
- Equipment supplier
- Types of incident
- Job position of individuals involved in incidents
- Operating modes of equipment
- Timing (seasons, days, time of day, etc.)
- Environmental conditions
- Contributing events
- Event sequences
- Root causes

3.1 Deciding What Data to Collect

What data should an organization decide to collect or not collect? This is a difficult decision because the decision has to be made before the data are collected. It is necessary to predict what data will be useful in identifying incidents for a chronic analysis and in performing a chronic analysis itself. In Section 9, Pareto analysis of data was discussed as well as the need for charting data to show a difference between various data categories. As a result, it becomes clear that organizations must predict which parameters will help to identify patterns.

For example, it could be predicted that as vessels age, there may be more reliability-related failures. The types of incidents that older vessels experience might be different from those experienced by newer vessels. Therefore, it seems reasonable to collect data for or be able to calculate this parameter for each incident.

The weather conditions would influence some of the incidents that might be of interest to analyze. More severe weather could result in different types of incidents, so this also seems like a reasonable parameter to track.

Would the clothing an individual was wearing at the time of the incident be important to track? In some cases, this appears to be significant. For example, footwear might be important for incidents involving slips, trips and falls, but not for vessel grounding incidents. Therefore, it may be decided to collect the data only when the incident is a personnel injury.

Another parameter that might be helpful to trend is the period that has elapsed since the individual was trained on the task involved in the failure. This may tell us that the period between training is too long for some types of tasks. Determining the periods for every incident could be a time-consuming process. The effort to collect the data may be greater than the payback available from analyzing the data.

3.2 Defining the Data to Collect

The steps involved in defining the data to collect are as follows:

1. Determine what types of decisions should be made based on the data analysis.
2. Identify the trends that are necessary to make these decisions. Determine the information that would be required to determine the actions the organization needs to take.
3. Determine the data that are necessary to identify these trends. Identify the information that can be collected from incidents to identify these trends.
4. Determine if these data can be reasonably collected. Identify the personnel who will be assigned to collect the data. Is it reasonable to think they will allocate the time to collect the data? Can other tasks be eliminated to allocate resources to the data collection task?
5. Determine if there is a synergy with other recordkeeping systems or a way to calculate the data from other information that is already collected. For example, vessel age at the time of the incident can be calculated knowing the incident date and the date the vessel was placed in service.
6. Determine how the data collection and storage system will be managed. Who will ensure that the data that are input into the system are valid?
7. Identify who will analyze the data. Will they know what to look for?
8. Determine a frequency for performing the data analysis.
9. This information will determine the parameters that should be collected as part of the trending system.

3.3 Other Data Collection Guidance

3.3.1 Do not Collect More Information than You Need for Decision Making

Determine what data will really be used for decision making, then start collecting that data. As analyses are performed, monitor the effectiveness of the data-collection efforts. Drop items that do not appear to be useful. Add items to get greater data resolution in appropriate areas.

3.3.2 Develop a Standard Data Collection Form

This form should contain all appropriate fields for investigation teams to complete. This will help speed up the data collection process, making it more likely that the data will be identified by the investigators.

3.3.3 Provide Guidelines for Using the Data Collection Form

This will encourage consistent data reporting. The guidelines should be modified based on experience. As you identify consistent incidents with data reporting, develop guidance to reduce the potential for these same incidents in the future.

3.3.4 Use an Electronic Database to Facilitate Data Management

Electronic databases are the only practical way to track and analyze numerous incidents. One person cannot keep track of all of the information necessary to perform a trending analysis.

3.3.5 Consider How to Incorporate Information from Sources Outside of the Organization.

Can industry data be used to supplement or confirm some of the conclusions from analysis of internal company data? In the absence of organizational data, industry information can often be useful in directing the initial efforts of the organization.

4 Data Analysis

Entering detailed incident data into an elaborate database is a waste of resources unless someone takes the time to analyze the information contained in the database. This may seem obvious, but too many organizations collect data on incidents and then fail to analyze the data in any meaningful way.

Schedule queries of the database at regular intervals. By having the queries on a schedule, they are much more likely to be accomplished. The queries can even be entered into the organization’s action tracking or scheduling system to ensure that completion of the task is tracked and delays or omissions are easily identified.

Develop standard queries of the database. Run standard queries every time the analysis is performed. Examine the results using standard graphing and statistical analysis methods for trending. By looking at the differences in the results over time, additional trends may be identified. Once these standard queries are run, analyze the data to determine where you need to dig more deeply to understand the data trends.

Use the techniques discussed in Section 11, “Developing Incident Investigation Programs”, to perform a chronic analysis of the data.

4.1 Interpreting Data Trends

Trends that are uncovered through data analysis must be carefully interpreted. Many factors influence the number and types of incidents reported and coded into a database, including the following:

4.1.1 Prior History of Reporting

The number of incidents reported might be influenced by the personnel who are reporting. For example, some vessels may be more reluctant to report incidents. As a result, it appears that fewer incidents are occurring on that vessel than on others. The person charged with entering data into the database may choose not to report incidents. When that person leaves, the replacement begins reporting at a higher level. It appears that the incident rate has climbed even though it has not.

4.1.2 Actions taken following Incident Reports

The corrective actions taken following an incident will usually reduce the number of reported incidents. Sometimes, though, the new focus on investigations will increase the reporting rate.

4.1.3 Organizational Culture

Some organizations will report minor incidents or report different types of incidents. For example, one organization or division may use the system to track customer complaints while another organization or division will not.

4.1.4 Organizational and Regulatory Measurements

The amount of day-to-day involvement of regulatory personnel in operations can affect reporting rates. In industries where regulators are routinely watching or stationed at organizational facilities, the organization will often report incidents at higher rates. In some cases, this is to get on the good side of the regulator (to show the regulator that they are reporting everything and, therefore, the regulator should trust the company). In other cases, this is the result of knowing that if they do not report the incident, the regulator will probably find out anyway.

4.1.5 Organizational and Regulatory Goals

Is the organization aggressively pursuing a goal of minimizing the occurrence and consequences of incidents? The more proactive the organization is in dealing with incidents, the more conservative they generally are in reporting.

4.1.6 Investigation Methods and Tools

More structured methods tend to help investigators identify more causes. This leads to different trends. In addition, more structured methods tend to be better at developing effective solutions to problems. This means that the programs are generally more effective and better accepted by employees. This generally leads to a higher reporting rate.

4.1.7 Communication of Reporting Requirements to Employees

When employees have a better understanding of what to report, their reporting rate usually increases.

4.1.8 Changes in Personnel

Personnel with a greater interest in developing proactive solutions are more likely to report incidents. Personnel who are less concerned with the potential negative impacts from reporting incidents will also be more likely to report incidents.

All of these factors should be considered when interpreting trends found in the data. The investigator needs to look beyond the surface trends to determine their underlying causes.

5 Application to Apparent Cause Analyses and Root Cause Analyses

The methods for developing and implementing a trending program that are addressed by this section apply to both apparent cause analyses and root cause analyses. Depending upon the results of the data trending analysis, an apparent cause analysis or root cause analysis may be initiated. Data trending applies to all events that are entered into the database, regardless of the type of analysis (apparent cause analysis or root cause analysis), if any, performed.

6 Summary

Data trending is designed to detect broad trends across multiple investigations. Because investigators typically focus on one incident at a time, it is often difficult for them to identify the overall trends. A data trending program is the key to addressing this issue. Once the data trends are identified, the investigator must be sure to analyze the underlying causes for the observed trends.

SECTION 11 Developing Incident Investigation Programs

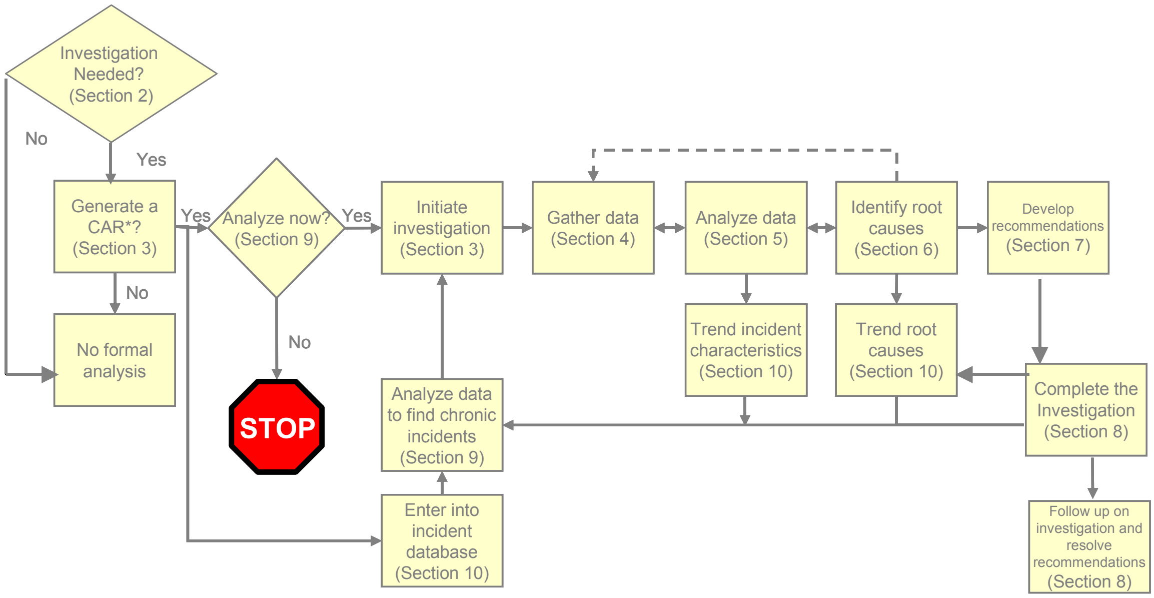
1 Introduction

This section discusses the process of putting together the overall incident investigation program, as well as some issues that will affect all investigations. Topics include the following:

- Incident investigation program implementation
- General considerations for your program
- Legal issues
- Media concerns
- Training guidelines
- Management's influence on the program's success
- Common incident investigation program problems and solutions

Section 11, Figure 1 illustrates the overall incident investigation process.

FIGURE 1
Overall Incident Investigation Process



Note: CAR is an acronym for Corrective Action Request

2 Program Implementation Process

Putting an incident investigation program in place should include the following four steps:

1. Design the program.
2. Develop the program.
3. Implement the program.
4. Monitor the program's performance.

2.1 Design the Program

The first step in designing an incident investigation program or revising an existing program is to establish the goals, roles and responsibilities for the program. In other words, decisions need to be made about how the program will be run. In the development stage, details will be needed for each of the individuals in the process to carry out their incident investigation-related job functions.

2.1.1 Define the Program Scope

First, decide on the scope of the program. Decide if the program will cover all types of incidents or only a subset of these issues. A list of loss types to consider includes the following:

- Traditional occupational injuries and illnesses
- Equipment failures
- Quality problems
- Personnel safety concerns
- Security problems
- Reliability incidents
- Public safety concerns
- Environmental impact
- Loss of revenue
- Missed or late deliveries
- Business interruption
- Customer satisfaction
- Loss of reputation
- Dockside problems
- Cargo handling problems
- Problems with other organizations
- Motor vehicle accidents

Initially, the organization may only want to address a subset of these loss types. This allows the program to gain a hold in a portion of the organization before trying to roll it out to the entire organization. By only selecting a subset of the loss types, fewer people in the organization will initially be involved and fewer investigations will be required. This will make it easier to make decisions and get the program up and running. Once the process is proven in one application and in one part of the organization, it will be easier to sell to other portions of the organization. However, it can have the downside of alienating portions of the organization that are not involved in the initial development of the program. In addition, revisions to the program may be needed to address concerns of the previously uninvolved groups.

2.1.2 Define the Important Elements for Effective Investigations

The following questions can be used to define the important elements for effective investigations.

- Decide who will be responsible for administering the program
- Define the types of incidents (losses and near misses) that should be reported
- Define a categorization scheme for incidents (see Section 4 for guidance)
- Define the means for responding to incidents based on their categorization. Who will respond and what methods will be used to contact them?
- Develop a policy to address logistical issues, such as travel arrangements, hiring experts, renting storage space, etc.
- Develop guidelines for conducting investigations. What tools should generally be used? Provide guidance for when exceptions can be made to these rules.
- Define how management will be involved in the investigations. Will they require periodic briefings during an investigation? Will they review the final results of an investigation? Will different reviews be required based on the level of the investigation? Will management review and prioritize all recommendations? Define the management groups that will be involved in each of these activities.
- Will a database be used to track investigations and recommendations? If so, who will design it? Who will administer it and who will analyze the data stored in it?
- How will the data be entered into the database?

2.1.3 Define Interfaces with other Practices and other Programs

Throughout this process, consideration should be given to interfaces with other existing organization practices and programs (especially emergency response plans. management of change, auditing) when possible. It may be possible to make minor modifications to existing programs to meet the incident investigation needs rather than developing a parallel process. The closer the incident investigation process can be integrated into existing programs, the easier it will be to get buy-in from your organization's personnel.

2.1.4 Define Roles and Responsibilities of Personnel

Establish the roles and responsibilities of positions associated with each element of the investigations so that everyone knows what is expected of them.

2.1.5 Define Training Needs

Develop initial and ongoing training guidelines for those who will participate in investigations. Ensure that this training includes hands-on or skill-oriented training. It is one thing to read about the topic or attend a lecture on the topic; it is quite another to be able to put it into practice.

The results of responding to the items in the list above should address most of the design considerations for your program.

2.2 Develop the Program

After high level decisions have been made about how the program should operate, attention is needed to develop more detailed guidelines to allow each individual involved in the process to perform his or her role consistent with the management decisions made at the program design stage.

2.2.1 Provide Basic Investigation Guidelines

These guidelines should be detailed enough so that the average person performing an apparent cause analysis or a root cause analysis will be able to perform them in an acceptable way. Guidelines should be developed for the following issues:

- Develop a list of individuals who can lead or participate on investigation teams and ensure all members have sufficient and up-to-date training in incident investigation.
- Determine how the investigations will be launched. Develop specific methods for notifying team leaders and team members that they are needed for an investigation. Develop methods of notifying others not on the team of the incident.
- Determine the protocols of working with others in your organization, such as emergency responders.
- Develop a list of the types of data that should typically be collected based on the incident classification. Attempt to make this list as specific to your organization as possible.
- Identify methods for securing and preserving the incident scene, such as capturing data from computer systems and roping off areas.
- Identify methods to gather people, paper, electronic, physical and position data.
- Provide guidelines for the analysis of data. Detail what methods are to be used. Provide specific guidance on such as the procedures for developing causal factor charts, 5-Whys diagrams and fault trees (See Section 5 and Appendices 1 and 2 for reference material).
- Identify the different types of recommendations that should be developed for each category of incident. For incidents of smaller magnitude, the organization may decide to only analyze the event to the causal factor level (an apparent cause analysis). Therefore, recommendations aimed at the root causes of the incident may not be developed.
- Develop report forms and formats to make report development easier. Standard report forms may be all that are required for the incidents with smaller consequences. Writing a report may only be required for higher-level incidents. Having standard forms and formats will speed up the report generation process.
- Designate a method to perform follow-on activities, such as tracking recommendations to conclusion and assessing the effectiveness of recommendations.
- Develop a system for communicating investigation findings and recommendation resolutions (including modifications to the investigation procedures) to affected people.
- Establish auditing requirements for the program.
- Develop and obtain appropriate approval of a written investigation program.
- Distribute the program as a controlled document or record.

2.2.2 Provide Practical Investigation Tools Such As:

- Investigation process checklists
- Witness statement and interview forms
- Data-logging forms, tags and kits
- Tools associated with the various investigation techniques
- Interim and final report forms/outlines

2.2.3 Provide a Program Team that is Diverse

The team that develops the program should include personnel with a broad range of backgrounds. Typical individuals involved in the process include a corporate safety representative, representatives from some of the corporate sites or vessels, facility safety representatives and operations personnel.

A basic incident investigation program can be downloaded from the ABS website at "http://www.eagle.org/rules/downloads.html" under the publication entitled "ABS *Guidance Notes on the Investigation of Marine Incidents*". This program is intended to serve only as an example of the basic content of such programs. Programs with much more detail exist, and your organization may require a more definitive program to effectively manage incident investigations.

2.3 Implement the Program

2.3.1 Provide Training

Perform training of personnel at various levels throughout the organization. For example, most personnel only need a broad overview of the goals of the program while others will need more detailed training. The organization may not need to or want to train individuals to address the most severe incidents that occur. Outside assistance may be the best method to deal with these large, resource-intensive investigations rather than to try to train personnel to the level necessary to conduct large-scale investigations.

2.3.2 Define Program Roll-out

Conduct controlled tests of the program. Start with limited application of the program to work through implementation issues. Address these problems before rolling out the program to the rest of the organization. Controlled rollout can also be used to show the benefits of the process. By beginning the rollout of the program in departments or on vessels that are most supportive of the process, there is a greater probability of initial success.

2.4 Monitor the Program's Performance

Routinely evaluate the performance of the program by looking at the results of individual analyses and overall data trends. Monitor the incident reporting rate. Watch for changes in the rate that may indicate potential problems or potential improvements.

Compliance audits should be conducted to ensure that the program is being implemented as intended.

A detailed Incident Investigation/Root Cause Analysis Program Evaluation Checklist is included in Appendix 7 of these Guidance Notes. It is useful for auditing the implementation and effectiveness of an incident investigation program.

3 Key Considerations

3.1 Legal Considerations

Most investigations do not involve legal issues. Most investigations are intended to improve the overall reliability, environmental performance and safety level of your operations. However, some sensitivity to legal concerns can help in those instances where there is a potential for litigation resulting from the investigation.

3.2 General Legal Guidelines

It is important to consider and be sensitive to legal issues. However, both the investigation team and the legal group must remember that the objective is to prevent similar incidents.

Liability is more of an issue in some countries than in others. It should be noted, however, that an accident that occurs in one country can be used in litigation in another country to show a pattern of unsafe conditions, lack of management follow-through on key points or recommendations, etc. Even without direct legal liability, opponents of an organization can use reports to sway public opinion against a company.

Any documentation that is generated during an investigation may be discoverable. Although barriers can be put in place through a variety of legal doctrines such as the attorney-client privilege, the items may still be discoverable in some jurisdictions. The documentation can be used to demonstrate negligence and sway public opinion. It is important that organizations work with their attorneys to develop the best method for controlling documents.

The following are general guidelines to highlight potential legal considerations:

3.2.1 Legal Assistance

Contact your organization's attorney for advice *before*, *during* and *after* investigations. He or she can help guide you with specific advice during an investigation.

3.2.2 Technical Focus

Focus the incident investigation on the "technical causation." Do not try to answer the ultimate question of legal responsibility. That is a job better left to the legal council.

3.2.3 Investigation Team Credentials

Ensure that investigators and other professionals involved in the investigation have the appropriate credentials. A properly conducted investigation will greatly aid in any legal defense the organization must put forth.

3.2.4 Requirements and Regulations

Follow the requirements of all relevant incident investigation regulations. Ensure that you are meeting your organization's requirements and applicable regulations. In the absence of pertinent regulations, follow the most widely accepted industry practices.

3.2.5 Quality and Ethical Standards

Maintain the highest quality and ethical standards to ensure credibility. Where appropriate, protect confidential information through attorney-client privilege. Follow organization-approved guidelines for protecting proprietary and confidential information.

3.2.6 Witness Statements

Document witnesses' statements "in their own words"; technical and legal jargon may lead others to question the validity of statements if wording is clearly inconsistent with the witnesses' way of speaking. Have witnesses read and initial each page of documents recording their statements. Never misrepresent your identity or purposes to witnesses during interviews. Although audio or video recording will assist in getting word-for-word documentation of the interviews, you should balance this with the desire to gather as much information as possible from the witness. Recording the interview will most likely make the witness nervous and less willing to share information. Remember that if you cannot find out what really happened, mounting an effective legal defense will be difficult and correcting the underlying causes will be impossible.

3.2.7 Formal Interviews

If there is a high probability of legal issues associated with the incident, interviews may have to be performed under more controlled conditions. Depositions may be required with a formal court reporter performing the documentation. Under these conditions, the witnesses should be informed that the interview is being documented in detail. As discussed in the previous subparagraph, try to do all that can be done to relax the witness under these conditions. Although the witness may not share much information, the witnesses should be treated respectfully. The goal of the interview should be to obtain the most information possible from the interview.

3.2.8 Chain-of-Custody

Establish a chain of custody for all evidence. Be aware of legal limitations of access to others' property while collecting data. Be certain that all interested parties approve and/or attend destructive evaluations of evidence or any other activities that permanently alter the physical data. Remember that even taking something apart can be a permanently altering activity. It is not possible to restore the item back to its original condition. Therefore, it is generally a good idea to invite all interested parties to any activity that permanently alters physical data. Using test plans that are agreed upon by all parties will help to ensure that all activities are performed in a systematic, controlled manner.

3.2.9 Clarity in Writing

Use simple and unambiguous wording during interviews and in reports. Have organization attorneys review all incident investigation work products.

3.2.10 Legal DOs

i) Do follow through on each recommendation and document the final resolution, including why it was rejected (if that is the final resolution).

ii) Do involve the legal department as soon as possible if the incident appears to have potential liability for the organization.

iii) Do report, investigate and document near misses to demonstrate the organization's commitment to (1) learning where there are weaknesses and (2) improving risk controls.

3.2.11 Legal DON'Ts

i) Don't use inflammatory statements such as disaster, lethal, nearly electrocuted and catastrophe.

ii) Don't use judgmental words such as negligent, deficient or intentional.

iii) Don't assign blame.

iv) Don’t speculate about potential outcomes (for near misses and minor accidents), lack of compliance, liabilities, penalties, etc.

v) Don’t offer opinions on contract rights, obligations or warranty issues.

vi) Don’t make broad conclusions that can’t be supported by the facts of this investigation. (Let queries of the database demonstrate these conclusions as necessary.)

vii) Don’t offer unsupported opinions, perceptions and speculations.

viii) Don’t oversell recommendations; allow for alternative resolutions of the problems and weaknesses found.

3.3 Media Considerations

Following a major incident, it is best to have individuals deal with the media who are specially trained in facing the media. Many organizations provide effective workshop-oriented training to address this need.

The following guidelines should help you avoid problems when dealing with the media.

i) *Avoid releasing names of victims until families are notified.* Not only does this avoid misleading and inaccurate information in the media, it also conveys the organization’s concern for its personnel and their families.

ii) *Always be truthful.* It is not necessary to tell the media all that is known, but whatever is said should be the truth. Do not speculate or guess about what is not known. This could cause repercussions later. For example, someone may ask you whether you were misleading them (or lying to them) before when you gave them inaccurate information or if you are misleading them (or lying to them) now.

iii) *Avoid speculation.* Avoid expressing opinions, beliefs, speculations and hypotheses before completing the investigation. Describe only confirmed events and solid conclusions. If asked to comment beyond the established facts, highlight the work-in-progress nature of the investigation.

iv) *Be prepared and willing to describe the investigation process and methods.* Tell them what you are doing to discover the underlying causes of the incident to ensure that it does not happen again. Sometimes, being organized will go a long way towards satisfying the public.

v) *Do not bring up old history.* Only discuss the incident under investigation, not other incidents or other organizational problems. There is no need to give them more ammunition to use against the organization.

3.4 Some Regulatory Requirements and Industry Standards

Worldwide, there are many regulations, rules and guidelines that may potentially govern or influence your incident investigation program. This section lists some of the more broadly applicable regulations, codes, rules and guidelines.

When setting up an incident investigation program, an organization should review the appropriate governing documents to ensure that the investigation program will meet all of the applicable requirements. Appendix 4, “Marine Organizations of Interest,” provides a more complete listing of references and organizations. A sampling of potential sources of information is provided in Section 11, Tables 1 through 3 below.

TABLE 1
Regulations and Codes

Code or Regulation	*Website*
International Convention for the Safety of Life at Sea (SOLAS)	http://www.imo.org/home.asp
International Convention for the Prevention of Pollution from Ships (MARPOL)	
International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)	
Convention on the International Regulations for Preventing Collisions at Sea (COLREG)	
International Convention on Load Lines (Load Lines)	
International Maritime Organization (IMO) Resolutions. Circulars and Conventions	
International Safety Management Code (ISM)	
International Security Code (ISPS)	
Port State Code	
Flag Administrations (example – US Coast Guard)	http://www.gpoaccess.gov/cfr

TABLE 2
Classification Information and Rules

Class Society	*Website*
International Association of Classification Societies	http://www.iacs.org.uk/index1.htm
American Bureau of Shipping (ABS)	http://www.eagle.org
Bureau Veritas	http://www.veristar.com
DNV	http://www.dnv.com
Germanischer Lloyd's	http://www.gl-group.com
Lloyd's Register	http://www.lr.org
Korean Register	http://www.krs.co.kr/
Nippon Kaiji Kyokai	http://www.classnk.or.jp/hp/top.asp
Registro Italiano Navale	http://www.rina.org

TABLE 3
Guidelines from Organizations

Organization	*Website*
International Chamber of Shipping (ICS)	http://www.marisec.org/ics/index.htm
International Shipping Federation (ISF)	http://www.marisec.org/isf/index.htm
Society of International Gas Tanker & Terminal Operators (SIGTTO)	http://www.sigtto.org
Oil Companies International Marine Forum (OCIMF)	http://www.ocimf.com
International Association of Independent Tanker Owners (Intertanko)	http://www.intertanko.com
International Council of Cruise Lines (ICCL)	http://www.iccl.org
American Waterways Operators (AWO)	http://www.americanwaterways.com

4 Management Influence on the Program

Management can have a strong influence on the way the incident investigation program is implemented.

A primary driver of the process is how the organization evaluates its investigations, investigators and investigation program. What criteria are used to assess the program and the investigators? Using the criteria in the left-hand column in Section 11, Table 4, "Destructive and Supportive Investigation Evaluation Criteria," will tend to deter the effectiveness of the program. Using the criteria in the right-hand column will encourage thorough investigations that generate effective recommendations.

Think about the criteria your investigators use to judge themselves and their analyses. This is what controls how they will perform their analyses.

TABLE 4
Destructive and Supportive Investigation Evaluation Criteria

Destructive Evaluation Criteria	*Supportive Evaluation Criteria*
Was the investigation completed quickly?	Did they take the time to discover the underlying causes of the incident?
Was there minimal impact on mission operations?	Did the investigation gather the data needed to reach valid conclusions in the most efficient manner?
Did they get to the answer management thought of before they began?	Was the investigation thorough, with factual support for each conclusion and recommendation?
Did they emphasize short-term costs or long-term savings?	Did they develop recommendations that will be effective in preventing future losses?

5 Typical Reasons Why an Incident Investigation Program May NOT Work

The following are typical reasons why most incident investigation programs fail to live up to the organization's expectations.

5.1 There Is No Business Driver to Change

If the organization is performing acceptably with its current practices, then there is no significant driver to get personnel to change from their current practices. The organization and the individuals in the organization need a reason to change. Most people do not like change. Investigating and learning from mistakes usually require a change in the organization's mindset or behavior. A powerful reason is needed to drive this change.

5.2 There Is No Organizational Champion for the Program

A program that changes the way the organization operates needs a champion. This champion within the organization needs to lead by example. They need to participate in investigations and review the reports generated by the teams. They need to take an interest in ensuring that corrective actions are implemented.

The program champion should be someone in a leadership position who can reassure the investigators and investigation team members that performing investigations is consistent with the organization's expectations.

5.3 The Organization Never Leaves the Reactive Mode

Operating in the reactive mode means that the organization reacts to incidents rather than planning ahead. Planning does not occur in reactive organizations; if it does, the plans are seldom carried out or used to guide decisions.

Investigating accidents is reactive because the investigation only takes place after the loss incident has occurred. But investigating near misses is proactive because near misses have to be investigated before actual losses have occurred.

Incident investigation is also proactive in that the corrective actions are taken to prevent the next occurrence. The investigation process requires personnel to stop, analyze what happened and implement corrective actions that eliminate the causes of incidents to prevent them recurring in the future.

Organizations that remain in the reactive mode never have time to conduct thorough incident investigations. They may label them root cause analyses but they do not dig deeply enough to identify the underlying causes. They view investigations as a waste of time. "Let's get on with it and do the investigation when we get time." No one ever gets adequate time to perform the investigation.

Management must be willing to take a longer-term view. This requires a change in workplace culture. Management must also be convinced/willing to see the value of performing quality investigations. This is the only way they will be willing to invest the resources now for a payoff in the future.

To help make this change, the organization needs to find areas where repeated problems/failures/ accidents or near misses are occurring and estimate the true cost of these losses in terms of lost production, repair costs, labor costs, wasted product and wasted resources. An investment in incident investigations now will prevent/reduce these losses in the future.

5.4 The Organization Must Find an Individual to Blame

If management insists on blaming someone rather than figuring out how to prevent the losses from occurring in the future, then the investigation program is destined to fail. It is easier to blame someone than to fix the real problem, which is the management system. Assigning the blame to someone is quick, pinpoints the problem and can be easily fixed by training, relocating or terminating the individual, or so it is believed. It eliminates all the effort required to understand the operation of the organization and to fix the underlying causes.

However, there is no perfect employee who can perform flawlessly in a flawed environment, and organizations are left with the recurring, underlying management system problems. In addition, placing blame discourages reporting of near misses.

Focus on the management system, not blaming individuals. This will lead to the long-term solution of the organization's problems.

5.5 You Are Unwilling to Critique Management Systems

This goes along with the previous point. Management may not be willing to admit that it has ever done anything wrong. A management system focus indicates that somewhere in the management system, something needs improvement. Some managers are unwilling to accept that they could contribute in any way to a deficiency in the organization. In addition, they usually have an incentive not to admit that things did not go quite right.

Again, keep the focus on what needs fixing: (i.e., management system, not managers). Focus on the system, not the individuals who created and manage them. This will lead to long-term solutions and better performance from your managers in the long run.

If you want your managers and other staff to implement the recommendations, you will need to provide some sort of incentives. Reward the implementation of preventative and corrective actions at all levels in the organization, including management, whether successful or not in eliminating the cause(s). There is no means to ensure that all first-time implemented preventative or corrective measure are the right solutions. Follow-up will determine that. The rewards may need to be different for the different levels of the organization. Not everyone views the rewards as having the same value.

5.6 The Organization Tries to Investigate Everything

"We really need to do incident investigations, and the more we do, the better off we'll be. Therefore, let's investigate everything!"

Trying to investigate too many incidents usually results in many poorly performed investigations. It is better to do a couple of investigations correctly and then implement the recommendations. By limiting the number initially performed, the investigator team gets a chance to practice their skills and eliminate the problems in the investigation process before launching it organization-wide. Once there is an improvement of investigation efficiency, it will be easier to handle a larger number of analyses. The phased implementation noted above is consistent with this approach.

Start with a limited definition of incidents to be reported and investigated. Once personnel have some practice in performing the investigations and have proven the process, expand the definition to include more incidents. Review the guidance on program development and phased implementation in sub-section 2.0 of this section.

5.7 The Organization Only Performs Incident Investigations on Large Incidents

If an organization only investigates the big incidents, 80 to 98% of the data available to the organization to prevent the big accidents will be missing – investigating only the big ones is not much different than simply relying on emergency response instead of focusing on accident prevention. Personnel will not be ready to do a good job on the big incidents if they do not practice with the smaller incidents.

Change the focus of your investigations to near misses instead of the large disasters. Include near misses in the definition of incidents that you analyze. Establish a minimum reporting goal of 10 near misses for every loss incident. Hold management and employees accountable for reporting near misses and meeting this goal.

5.8 Recommendations Are Never Implemented

Good investigations are performed but the recommendations are never implemented. As a result, the investigation effort is wasted. Before, personnel did not know what they were doing wrong. Now, it is known yet implementation of recommendations does not occur. This is not a smart way to operate a business.

Typically, this occurs when recommendations are not tracked to completion or there are no rewards/punishments for not implementing the recommendations.

Assign someone the responsibility for tracking recommendations to completion. Review the implementation status periodically with management to raise the visibility of recommendations that are behind schedule. Reward individuals and departments for implementing recommendations and discipline those who do not implement them.

6 Summary

This section addresses some of the programmatic issues that are involved in putting an effective incident investigation program in place. In addition, it addresses some of the global program issues such as legal and media issues.

Finally, some of the typical reasons why incident investigation programs fail were reviewed, along with strategies for dealing with these challenges.

APPENDIX **1** **Marine Root Cause Analysis Map Guidance**

1 Background

The marine industry experiences incidents that range from major casualties to near misses. These incidents should be investigated since many flag administration regulations require it; international agreements mandate it (such as the IMO "International Safety Management Code") and industry initiatives encourage it. Incident investigation is a process that is designed to help organizations learn from past performance and develop strategies to improve safety.

2 Instructions for Using this Appendix with the ABS Marine Root Cause Analysis Map

2.1 Types of Information Provided

This Appendix provides detailed information about each and every item that appears on the ABS *Marine Root Cause Analysis Map*. An explanation is given about the nature of each item. This will assist you with making a decision about which items may have contributed to an incident under investigation.

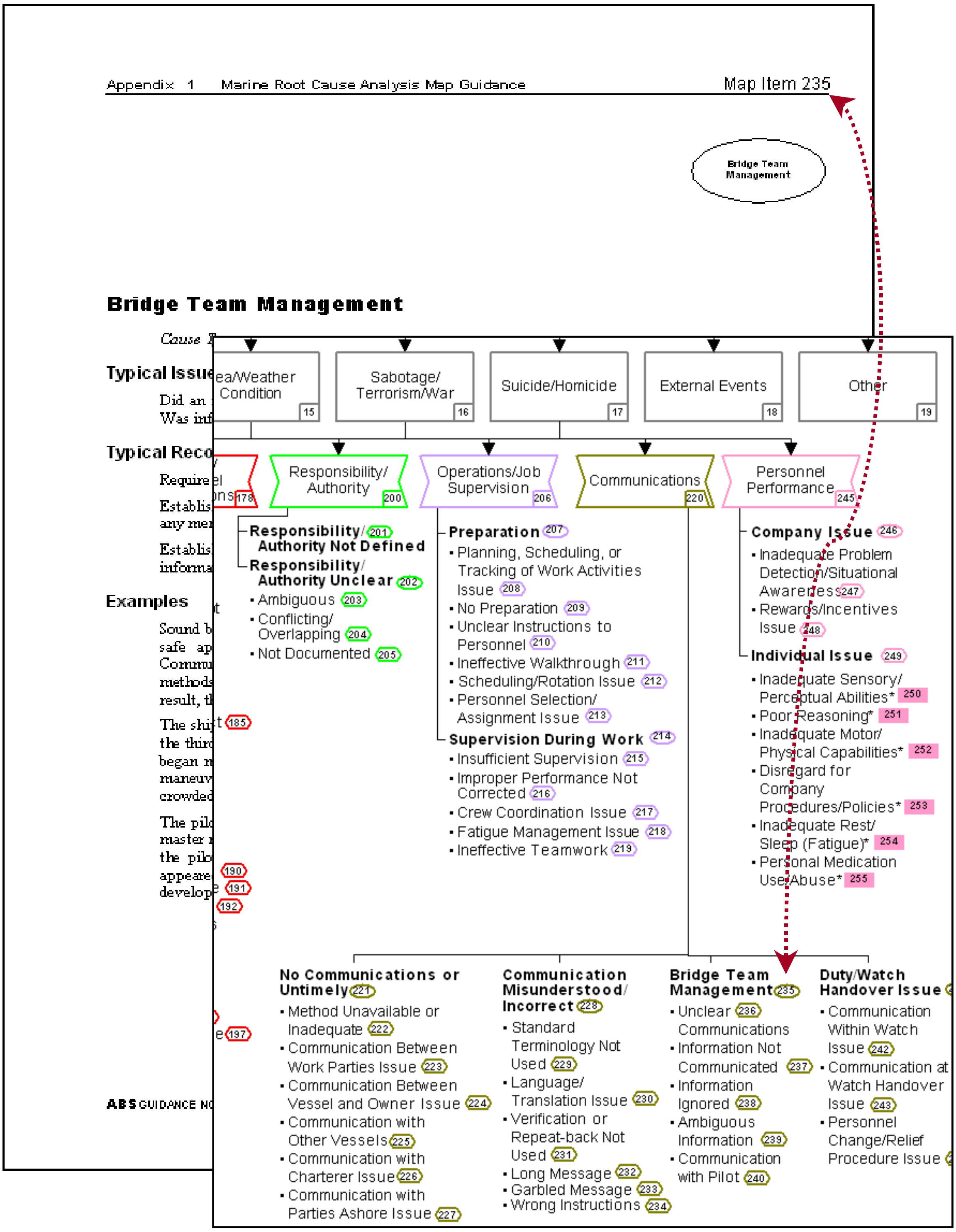
For each item, general information is provided under the title of "Typical Issues". "Typical Issues" can help you distinguish between similar items on the map. For example, the information provided under "Typical Issues" can assist you with differentiating between whether a problem is related to "Machinery/Equipment" or "Outfitting".

For many items, detailed information beyond "Typical Issues" is given. The categories of information include:

- Typical Recommendations
- Examples
- Standard References

Appendix 1, Figure 1, "Numeric Identification of ABS Marine Root Cause Analysis Map Items", demonstrates how Map Item numbers on the tops of the pages in this appendix correlate to the map item or node number beside each entry on the ABS *Marine Root Cause Analysis Map*.

FIGURE 1
Numeric Identification of ABS Marine Root Cause Analysis Map Items



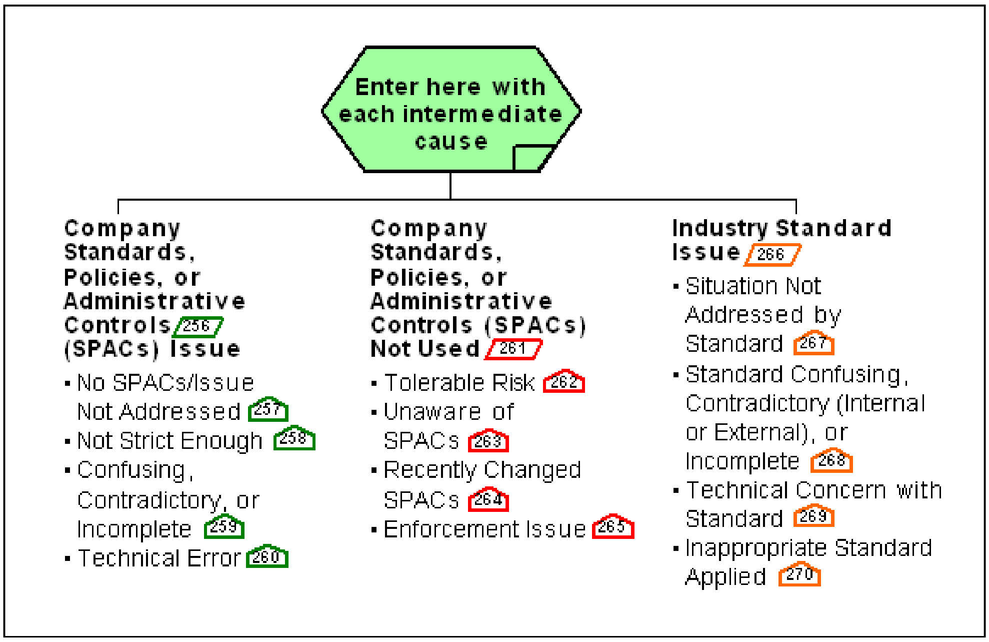
2.2 Method

Beginning with each causal factor (determined from data analysis), select the nature of the problem (i.e., Structural, Machinery/Equipment, Outfitting, Human or External Factors). Read the "Typical Issues" under these problems to determine the correct nature of the problem.

Use the following pages in this appendix to identify appropriate paths through the Root Cause Analysis Map until Root Causes can be determined. This process will take you through the identification of problem categories, cause categories and cause types to intermediate causes. All are listed on Page 1 of the ABS *Marine Root Cause Analysis Map*. Intermediate causes are symbolized on the map by a hexagon (hexagon shape).

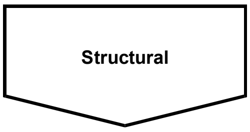
After identifying intermediate causes on Page 1 of the map, continue on to Page 2 to identify a "Root Cause Types" and "Root Causes". Appendix 1, Figure 2, "Page 2 of the ABS Marine Root Cause Analysis Map", shows the path you would use to move from Page 1 to Page 2. Using Page 2, you will select Root Cause Types and Root Causes by making choices based on the predefined taxonomy. For some problems, it may be necessary to choose several paths and determine several root causes.

FIGURE 2
Page 2 of the ABS Marine Root Cause Analysis Map



2.3 Special Considerations

Some of the branches on Page 1 of the map do not end in a hexagon. Examples include *Human - Other (Third-party employee), Sabotage/Terrorism/War* (under the *External Factors* causal factor type) and the asterisked items under *Personnel Performance*. Identification of root causes for these items is not anticipated because these issues are generally outside the control of the organization.



Structural

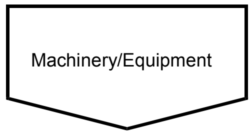
Causal Factor or Problem Type

Typical Issues

These include problems related to vessel hull and structure.

Standards Reference

ISM 10



Machinery/Equipment

Causal Factor or Problem Type

Typical Issues

These include problems related to machinery and equipment such as:

- Engines
- Propulsion systems
- Steering gear
- Maneuvering systems
- Mechanical cargo handling systems
- Mooring system
- Hydrocarbon production and process systems
- Drilling support system
- Mechanical or electronic systems,
- Control and monitoring systems
- Electrical equipment,
- Piping
- Deck machinery.

Standards Reference

ISM 10

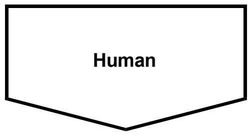
Outfitting

Causal Factor or Problem Type

Typical Issues

These include problems related to furnishing a vessel with fittings other than those related to structure (addressed under *Structural*) and equipment (addressed under *Equipment*). Outfitting includes items such as:

- Accommodations furnishings
- Doors, ports
- Hatches, closures, vents
- Deck/hull fittings
- Life saving devices
- Fire fighting equipment
- Navigational safety appliances
- Stairs, ladders, walkways
- Signs/warning notices
- Manuals and reference books.

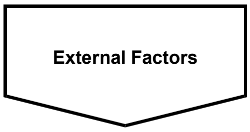


Human

Causal Factor or Problem Type

Typical Issues

These include problems related to personnel.



External Factors

Causal Factor or Problem Type

Typical Issues

These include miscellaneous problems not included in the other causal factor or problem types.

Design Problem

Design Problem

Problem Category

Typical Issues

These include problems related to the design process or the design itself or problems related to the specifications of the vessel structure, machinery, equipment or fittings. This category also includes problems related to design reviews or verifications.

These causal factors usually involve structures/machinery/equipment/outfitting that failed to perform as expected or that were improperly used because of poor design.

Reliability Program Problem

Reliability Program Problem

Problem Category

Typical Issues

These include issues related to the design and implementation of the maintenance program, such as:

- Specifying the wrong type of maintenance for the equipment
- Problems with the analysis process used to determine the appropriate maintenance requirements (such as the reliability-centered or based maintenance process)
- Problems related to performing the maintenance activities
- Problems with monitoring activities implemented to detect deteriorating equipment
- Problems related to the scope of the repair activity.

Standards Reference

ISM 10

Misuse/Overload Problem

Misuse/Overload Problem

Problem Category

Typical Issues

These include problems related to misusing or overloading the vessel structure, machinery, equipment or fittings. Examples include human errors where the equipment was incorrectly used, resulting in an overload of the item or system.

Standards Reference

ISM 7

Installation/Fabrication Problem

Installation/Fabrication Problem

Problem Category

Typical Issues

These include problems with improper installation or fabrication of steel, structure, equipment, systems and machinery.

Permanent/Returning
Officers/Crew

Permanent/Returning Officers/Crew

Problem Category

Typical Issues

These include problems with permanent officers/crew member(s) or those returning to the vessel or company after multiple tours of service.

Newly Assigned/Contract/ Temporary Officers/Crew

Newly Assigned/Contract/Temporary Officers/Crew

Problem Category

Typical Issues

These include problems with officers/crew member(s) who are on their initial period of service aboard the vessel or with the company, as well as problems with officers and crew member(s) who are not company employees but contractors. This category would include short-service employees who may be assigned to a mentor.

Company Employee

Company Employee

Problem Category

Typical Issues

These include problems with company employees who are not part of the vessel's officers or crew.

Other
(Third-party Employee)

Other (Third-Party Employee)

Problem Category

Typical Issues

These include problems associated with contractors, regulatory personnel, working gangs and shipyard employees, including pilots, government employees, longshoremen, dockworkers, crane operators, etc.

Note: It may not be possible to further define intermediate causes or root causes associated with this problem category.

Uncharted/Unknown Hazard to Navigation

Uncharted/Unknown Hazard to Navigation

Problem Category

Typical Issues

These include problems associated with hazards that have not been identified on a chart or through chart correction services such as *Notice-to-Mariners* and *Navtex*.

Note: It may not be possible to further define intermediate causes or root causes associated with this problem category.

Typical Recommendations

Verify that appropriate updates to navigational charts are being provided to each vessel.

Verify that updated charts are available on each vessel.

Example

A small sailing vessel recently sank in the Zombie River channel. The sinking was not reported by the vessel's owner, and the sunken vessel was not shown on any charts.

Sea/Weather Condition

Sea/Weather Condition

Problem Category

Typical Issues

These include problems associated with a freak sea or weather conditions that was not foreseeable by means of weather reporting and mapping services.

Note: It may not be possible to further define intermediate causes or root causes associated with this problem category.

Typical Recommendations

Verify that appropriate sea and weather condition information is available to vessels and shore facilities.

Verify that appropriate equipment is functional aboard each vessel to obtain the information.

Example

A sudden storm came up during a vessel's passage across Lake Superior. The storm was not predicted early enough for the vessel to get to a safe harbor in time. The vessel weathered the storm but sustained damage.

Sabotage/Terrorism/War

Sabotage/Terrorism/War

Problem Category

Typical Issues

These include problems associated with unforeseen attacks on the vessel. Acts that cause or contribute to an incident are identified under this node. Malicious lack of action that contributed to a problem is also identified under Sabotage.

Note: Dual coding under Personnel Performance or Management Systems – Human Resource Issue may be appropriate if the sabotage was committed by someone who is part of the vessel's crew or someone hired by the vessel owner or operator.

Typical Recommendations

Ensure that security plans and equipment are adequate.

Ensure that personnel are properly cleared and that credentials and qualifications are properly verified prior to employment aboard the vessel.

Vessel security procedures should not allow unscheduled vendors/contractors/other persons to board the vessel.

Threats made by disgruntled employees should be taken seriously and reported for follow-up and possible action.

Examples

A mechanic intentionally damaged a piece of equipment. He was disgruntled about being placed in a new assignment.

As a practical joke, vessel engineers sent the cadet to check out the *electrical zerts* (there are no such things) on the generator. As a result of trying to find the *electrical zerts*, the cadet accidentally shut down the generator.

Standards Reference

ISPS Code, SOLAS Chapter XI-2

Suicide/Homicide

Suicide/Homicide*

Problem Category

Typical Issues

These include suicides and murders.

Note: It may not be possible to further define intermediate causes or root causes associated with this problem category.

Typical Recommendation

Verify that appropriate means are used to identify unstable individuals.

Example

One of the deckhands committed suicide after he learned his wife had died in a shooting accident.

* *Note:* Detailed explanation is provided for this problem category since no further investigation may be possible given the nature of this problem. The exception may be that the organization may wish to review its personnel hiring and screening procedures.

External Events

External Events*

Problem Category

Typical Issues

These are problems stemming from external events over which the vessel has no control.

Was the event a result of problems at adjacent facilities or vessels moored nearby?

Was it the result of activities external to the vessel that are not under the organization's or vessel's control?

Note: Coding under Management Systems, Safety/Hazard/Risk/Security Review Issue may also be appropriate.

Typical Recommendations

Coordinate emergency response and planning with nearby facilities.

Develop contingency actions for external events.

Examples

A chlorine tanker accident on a nearby railroad spur required the evacuation of the vessel.

An emergency shutdown of cargo transfer operations was initiated by the terminal facility.

A fire broke out at the terminal facility, forcing shutdown of cargo operations and requiring the vessel to leave the berth.

A vessel maneuvering into the harbor experienced a power failure and drifted into moored vessels along the wharf.

Another vessel ran aground in the harbor approaches, impeding access to the harbor.

* *Note:* Detailed explanation is provided for this problem category since no further investigation may be possible given the nature of this problem. The exception may be that the organization may wish to review its personnel hiring and screening procedures.

Other

Other*

Problem Category

Typical Issues

These include issues that cannot be coded elsewhere on the map (e.g., problems that cannot be coded because of insufficient information).

Note: It may not be possible to further define intermediate causes or root causes associated with this problem category.

Typical Recommendations

Analyze the causal factors that are coded under this node. Determine if additional nodes should be added to the map to categorize these issues.

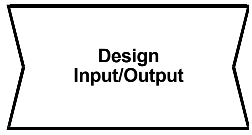
Determine methods for gathering additional information for this type of event when it recurs.

Examples

A buyer complained that the cargo received was out of specification. However, when the lab sample was tested, it was acceptable. When the buyer retested the cargo, his test also indicated that the cargo was acceptable.

A spurious shutdown of a computer in the chartering department caused a delay in fixing a cargo. The problem could not be recreated. It could not be determined whether it was equipment failure or human error that led to the shutdown.

* *Note:* Detailed explanation is provided for this problem category since no further investigation may be possible given the nature of this problem. The exception may be that the organization may wish to review its personnel hiring and screening procedures.



Design Input/Output

Cause Category

Typical Issues

Were all the appropriate design inputs considered during the design phase? Was the design output, such as drawings and specifications, complete? Were the design input and output consistent and complete?

Typical Recommendations

Conduct a feasibility review prior to beginning design to ensure that the criteria can be met and that no conflicting criteria exist.

Develop a pre-construction planning and review process to help ensure that all the specifications are in agreement.

Examples

A valve failed because equipment conditions during operation, such as corrosivity, were not considered during design.

A pump failed to deliver enough cooling water in an emergency because emergency requirements were not considered in the design.

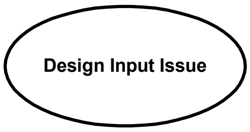
A pump failed in service because of inadequate maintenance. The design output documentation did not specify a critical alignment requirement. Because it was not performed, the pump failed in service.

Standards References

ISO 9001: 2000: Sec 7.3

TMSA 6A: 4.1, 10B: 4.1

SEMP 2.3.5, 3.3.2, 4.2.a, 8.3



Design Input Issue

Cause Type

Typical Issues

Problems include those related to the design process or the actual design itself or problems related to the specifications of the vessel structure, machinery, equipment, or fittings. Were all the appropriate design inputs considered during the design phase? Were the design criteria so stringent that they could not be met? Were some criteria conflicting? Were requirements out of date? Were the wrong standards or bases used? Were the necessary codes and standards available to the designer?

Typical Recommendations

Conduct a feasibility study prior to beginning design to ensure that the criteria can be met and that no conflicting criteria exist.

Develop an independent review process to help ensure that appropriate standards are used in the design.

Develop a tracking system to help ensure that design problems and conflicts are resolved prior to being placed in service.

Develop a tracking system to help ensure that current design criteria are used.

Develop comprehensive system design requirements.

Examples

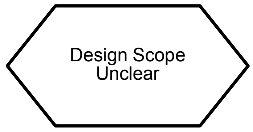
A valve failed because the designer used obsolete materials requirements.

A flow controller could not adequately control flow of liquid into the vaporizer. The controller's sensing range was far too broad for the application, causing the controller to hunt and the control valve to continually cycle.

Operating the bow thruster frequently resulted in the bow thruster circuit breaker tripping on the main switchboard. The circuit breaker was not designed to handle the transient loads caused by large changes in direction and speed of the bow thruster.

Standards Reference

ISO 9001: 2000: Sec 7.3



Design Scope Unclear

Intermediate Cause

Typical Issues

Was the objective of the design effort clearly identified? Were design needs and requirements clearly specified? Were the design boundaries clearly specified? Were interfacing systems and equipment identified so that there are no unknown implications for their functionality? Are requirements changing rapidly?

Typical Recommendations

Establish a requirement to develop a design description and design requirements document prior to development of detailed design documents.

Develop a requirement to have the end users accept the design description prior to development of detailed design documents.

Hold meetings between the design staff and the end users and other stakeholders to ensure that design requirements are adequately understood.

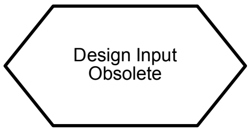
Examples

The design requirements indicated that the equipment should be “capable of handling all appropriate cargos that would be handled by the vessel”. However, the specific cargos anticipated were not specified.

The design requirements specified that the “controls should provide sufficient capability to allow for minimal monitoring by vessel personnel”. However, no further clarification was provided.

Standards Reference

ISO 9001: 2000: Sec 7.3



Design Input Obsolete

Intermediate Cause

Typical Issues

Was design input timely? Did design input reflect design goals and specifications for functionality and use? Was design input based on current drawings and design specifications?

Typical Recommendations

Conduct a pre-design review to verify that design criteria are current and accurate.

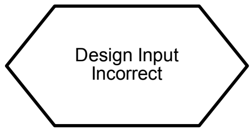
Develop a tracking system for use in the final design to enable verification that criteria are still current and that accurate design criteria are used during a project.

Example

A generator failed because it had inadequate capacity. It had been designed under the original operating requirements and did not address the additional loads added during the design process.

Standards Reference

ISO 9001: 2000: Sec 7.3



Design Input Incorrect

Intermediate Cause

Typical Issues

Was design input based on false assumptions or rapidly changing requirements? Was design input provided by capable and reliable personnel?

Typical Recommendations

Conduct a feasibility review prior to beginning design to ensure that the design criteria can be met and that no conflicting criteria exist.

Include "satisfaction of design input criteria" as a specific review item during intermediate and final design reviews.

Develop a tracking system to help ensure that impractical and/or conflicting criteria are resolved prior to placing the equipment in service.

Include research and design engineers in the interim and final design review to help ensure that the correct process requirements and bases are used in the design.

Develop an independent review process to be used during the design process to help ensure that the appropriate standards are used.

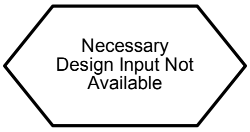
Examples

A flow controller could not adequately control flow during an infrequent operation. The flow requirements for normal, emergency and infrequent operation covered too wide a range for a single controller to operate properly under all of the conditions.

An O-ring failed because the design input specified the wrong operating environment.

Standards Reference

ISO 9001: 2000: Sec 7.3



Necessary Design Input Not Available

Intermediate Cause

Typical Issues

Was design input provided by capable and reliable personnel? Were the design boundaries clearly specified? Were requirements changing rapidly? Was sufficient design time allocated? Was sufficient funding available?

Typical Recommendation

Include end users in the design process to ensure that the design requirements address all of the needs.

Example

The design team attempted several times to obtain needed information from the end user, but was not able to obtain the required information in time to meet the project schedule.

Standards Reference

ISO 9001: 2000: Sec 7.3

Design Output Issue

Design Output Issue

Cause Type

Typical Issues

Was the design output, such as drawings and specifications, complete? Were all operating conditions (normal, startup, shutdown, emergency, close maneuvering, at sea, under way) considered in the design? Were the design documents difficult to read or interpret? Did the final design output include all changes? Were there differences among output documents? Did the design output address all requirements specified in the design input? Did the design output documentation provide sufficient information to develop all required procedures (operating, maintenance, etc.) and all required training materials?

Typical Recommendations

Include satisfaction of design input criteria as a specific review team item during design reviews.

Include experienced operations and maintenance personnel in design reviews to help ensure that all possible operating conditions are considered in the design.

Include designers in construction and pre-startup reviews to help ensure that design information is properly interpreted.

Conduct an independent technical review of the final design to help ensure consistency among various design documents.

Examples

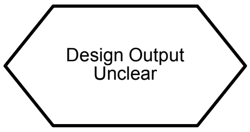
A valve failed because the material specifications were incorrect. The specifications did not agree with the design criteria. The criteria stated that the valve must operate in a corrosive environment, but the specifications did not indicate this condition. Therefore, the valve was constructed of improper materials.

A line ruptured because a gasket failed. The gasket was constructed of the wrong material because the design did not consider all the possible chemical cargoes that might be carried.

A pump did not provide the necessary cooling water during an emergency. The pump was sized incorrectly because the final design specifications did not include changes identified in the safety analysis.

Standards Reference

ISO 9001: 2000: Sec 7.3



Design Output Unclear

Intermediate Cause

Typical Issues

Were design objectives clear? Did design requirements change during design? Were design objectives ambiguous? Were there verification and validation efforts performed throughout design? Were prototype tests conducted? Were the specifications difficult to understand? Could the specifications be interpreted in more than one way? Were the documents difficult to read?

Typical Recommendations

Include designers in construction and pre-startup reviews to help ensure that design information was understood.

Provide additional training to designers to help ensure that design output information is clear and not subject to misinterpretation.

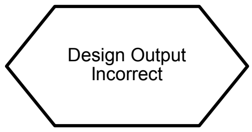
Involve end users in the construction phase to ensure that the design requirements are appropriately interpreted.

Example

A relief valve was improperly sized for a line because the specification sheet for the relief valve was difficult to read; therefore, the wrong size was installed.

Standards Reference

ISO 9001: 2000: Sec 7.3



Design Output Incorrect

Intermediate Cause

Typical Issues

Were the drawings and other specifications incorrect? Did the final design output include all changes? Were prototype tests conducted? Were compatibility studies and tests performed?

Typical Recommendations

Develop a tracking system for specification changes and design changes to help ensure that the final design includes all changes.

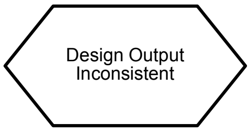
Develop an independent review process during design to help ensure that calculations and analyses are correct and complete.

Example

A display did not show the appropriate range of flow during an emergency. The display did not account for emergency and unusual operating conditions because the design requirement was never addressed.

Standards Reference

ISO 9001: 2000: Sec 7.3



Design Output Inconsistent

Intermediate Cause

Typical Issues

Were there differences among output documents? Did the drawings and other design specifications contain inconsistent requirements?

Typical Recommendations

Develop an independent review process to be used during the design process to help ensure that the output requirements are consistent.

Develop a database of design requirements to assist in identification of inconsistent requirements.

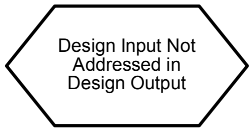
Examples

The procurement specifications for electrical cable were inconsistent with the requirements on the design drawing.

The acceptance test requirements for a fire protection pump were inconsistent with the design requirements.

Standards Reference

ISO 9001: 2000: Sec 7.3



Design Input Not Addressed in Design Output

Intermediate Cause

Typical Issues

Were there management practices in place to track requirements, inputs, designs and design outputs? Did the specifications include all of the requirements? Were some criteria left out of the design output?

Typical Recommendations

Develop an independent review process to be used during the design process to help ensure that all of the design inputs are addressed in the final output.

Develop a tracking system to help ensure that all design inputs are addressed in the design output.

Example

During the initial design review, the company requested that an additional flow indication be added in the cooling water line. The requirement was added to the design requirements document. However, this requirement was never transmitted to the design staff. As a result, the item was not addressed in the design drawings for the system.

Standards Reference

ISO 9001: 2000: Sec 7.3

Design Review/Verification

Cause Category

Typical Issues

Were end users and operations personnel consulted on design alternatives? Was a peer review performed? Did operations personnel and end users review the design and walk through tasks and jobs on mock-ups or drawings? Did the review process fail to detect design errors? Was the scope of the review sufficient to address all operating modes and requirements?

Typical Recommendation

Ensure that the design review is performed by someone other than the designers, preferably the end users of the equipment.

Example

A computer monitor was difficult to operate under close maneuvering conditions. The end users had not been asked to walk through tasks under these conditions, so they had not identified this issue.

Standards References

ISO 9001: 2000: Sec 7.3

SEMP 8.3, 9.1.a

No Independent Review/Verification

Intermediate Cause

Typical Issues

Were end users and mariners consulted on design alternatives? Was a peer review performed? Were consultants brought in to perform an independent design review?

Typical Recommendations

Ensure that the design review is performed by someone other than the designers, preferably the end users of the equipment.

Periodically audit the design change process to verify that independent design reviews and walk-throughs are being performed.

Example

The design of a new loading platform was not wide enough to allow two-way flow of container trucks on the dock. The design was not reviewed as part of the "Management-of-Change" process.

Standards Reference

ISO 9001: 2000: Sec 7.3

Review/Verification Issue

Intermediate Cause

Typical Issues

Did operations personnel and end users adequately review the design and walk through tasks and jobs on mock-ups or drawings? Were consistency checks performed (labeling terminology, control and display conventions, etc.)? Did the review ensure that the input and output agreed?

Typical Recommendations

Develop and implement procedures and training for properly conducting a design review/verification.

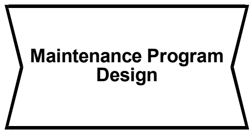
Periodically audit the design review process.

Example

Personnel incorrectly opened the wrong valve during a startup of an air compressor. The valve had been mislabeled on the drawings, and the discrepancy was not identified during the design review/verification process.

Standards Reference

ISO 9001: 2000: Sec 7.3



Maintenance Program Design

Cause Category

Typical Issues

These include problems related to the design and implementation of the maintenance program. Was the wrong type of maintenance specified for the equipment? Are there problems with the analysis process used to determine the appropriate maintenance requirements?

Typical Recommendations

Improve equipment operational and maintenance records to enable selection of the proper type of maintenance.

Assign additional resources to equipment with a demonstrated history of problems.

Reduce maintenance on equipment that has no significant impact on operations, safety or pollution prevention and that can be easily repaired or replaced.

Examples

Maintenance activities had been specified for the running components of an inert gas generator (e.g., bearings, fans), but no maintenance activities had been specified for the safety interlocks associated with the machine. The analysis procedure did not require safety interlocks to be addressed. As a result, the machine began panting and did not shut down before damage had occurred.

A number of pump bearings have failed recently. Predictive maintenance was selected as the appropriate type of maintenance for the pump bearings. However, there was no requirement for periodically monitoring the pump bearings.

Corrective maintenance was assigned to an auger in the garbage processor. This selection was based on a very low expected failure rate and a quick repair time. Actual experience indicates that the failures took much longer to repair than the analysis team estimated. As a result, the risk associated with the failures was much higher than the team thought.

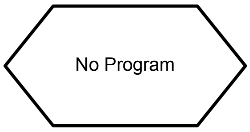
Standards References

ISM Sec 10

ISO 14000: 2000: Sec 4.4.6

TMSA 4A: 1.2, 12A: 1.1, 1.2, 2.1, 2.2

OHSAS 4.4.6



No Program

Intermediate Cause

Typical Issues

Has a maintenance program been assigned for this piece of equipment? Have the maintenance needs for this piece of equipment been analyzed?

Note: If the maintenance needs were analyzed and it was determined that no maintenance was appropriate, code this under "Program Inadequacy (Acceptance Criteria Inadequate)".

Typical Recommendations

Determine the appropriate level of maintenance for all equipment aboard the vessel that is important to safety or reliability.

Identify high to medium risk equipment and assign the appropriate type of maintenance.

Examples

Hydraulic hoses on the stores crane were failing once every year. A review of the maintenance program records indicated that proper maintenance for these hoses had never been determined.

A new fire detection system was installed in the diesel room. No proactive maintenance program was specified for the system prior to startup of the equipment. As a result, numerous false alarms occurred.

Standards References

ISM Sec 10

ISO 14000: 2000: Sec 4.4.6

OHSAS 4.4.6

Program Inadequacy

Program Inadequacy

Cause Type

Typical Issues

These include problems related to the design and implementation of the maintenance program. Was the wrong type of maintenance specified for the equipment? Are there problems with the analysis process that is used to determine the appropriate maintenance requirements?

Typical Recommendations

Ensure that the proper level of risk acceptance is used in determining the level and type of maintenance to perform on equipment.

Ensure that the analysis process addresses all aspects of equipment operation important to safety, pollution prevention and reliability.

Identify high to medium risk equipment and assign additional resources to the maintenance of this equipment.

Improve equipment operational and maintenance records to enable the selection of the proper type of maintenance.

Assign additional resources to equipment with a demonstrated history of problems.

Reduce maintenance on equipment that has no significant impact on operations, safety or pollution prevention and that can be easily repaired or replaced.

Examples

Maintenance activities had been specified for the running components of an inert gas generator (e.g., bearings, fans), but no maintenance activities had been specified for the safety interlocks associated with the machine. The analysis procedure did not require safety interlocks to be addressed. As a result, the machine began panting and did not shut down before damage had occurred.

A number of pump bearings have failed recently. Predictive maintenance was selected as the appropriate type of maintenance for the pump bearings. However, there was no requirement for periodically monitoring the pump bearings.

Corrective maintenance was assigned to an auger in the garbage processor. This selection was based on a very low expected failure rate and a quick repair time. Actual experience indicates that the failures took much longer to repair than the analysis team estimated. As a result, the risk associated with the failures was much higher than the team thought.

Standards References

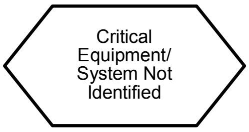
ISM Sec. 10

ISO 14000: 2000: Sec 4.4.6

TMSA 4B: 4.1, 10B: 2.1

SEMP 8.1, 8.5, 8.6.a

OHSAS 4.4.6



Critical Equipment/System Not Identified

Intermediate Cause

Typical Issues

The failure of a critical piece of equipment or system resulted in a hazardous situation.

Typical Recommendations

Identify critical equipment and systems whose sudden operational failure may result in hazardous situations and establish measures to promote their reliability.

Ensure that the personnel are provided with sufficient guidance for selection of critical equipment.

Example

The ship's radar had not been identified as a critical system to be incorporated into the ship's maintenance program. The vessel relied on the radar to continue operation in limited visibility. As a result of a lack of servicing, the radar went out in restricted visibility along a coastline. The vessel was left to maneuver blindly with the exception of the global positioning system (GPS) and a compass in an area with traffic.

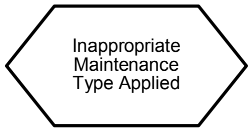
Standards References

ISM Code 10.3

ISO 14000: 2000: Sec 4.4.6

TMSA 4B: 1.1, 2.1

OHSAS 4.4.6



Inappropriate Maintenance Type Applied

Intermediate Cause

Typical Issues

Was the wrong type of maintenance specified for the equipment? Should corrective maintenance be used instead of proactive maintenance? Should predictive maintenance be assigned instead of proactive maintenance?

Typical Recommendations

Review equipment failure records to determine if the failures occur at specific intervals of operation or calendar time. Assign preventive maintenance tasks if the risk associated with equipment failure is high enough.

Determine if the failures can be predicted by monitoring a parameter (e.g., pump vibration, temperature, flow). Assign condition monitoring maintenance tasks if the risk associated with equipment failure is high enough.

Determine if failures occur shortly after certain events (e.g., startup, shutdown). Assign planned maintenance tasks if the risk associated with equipment failure is high enough.

If other types of maintenance are not appropriate or if the risk associated with the failure is low enough, assign corrective maintenance.

Examples

Corrective maintenance was assigned to an auger in the garbage processor. This selection was based on a very low expected failure rate and a quick repair time. Actual experience indicates that the failures took much longer to repair than the analysis team estimated. As a result, the risk associated with the failures was much higher than the team thought.

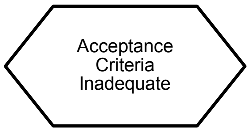
Records indicated that tube failures were occurring in heat exchangers shortly after plant startup. The failures were determined to be caused by hot spots that developed when contaminants collected in portions of the heat exchanger. Proactive maintenance activities were implemented to clean out the system prior to startup. This removed the contaminants and prevented the heat exchanger failures.

Standards References

ISM Sec 10

ISO 14000: 2000: Sec 4.4.6

OHSAS 4.4.6



Acceptance Criteria Inadequate

Intermediate Cause

Typical Issues

Were the wrong acceptance criteria used for analyzing the maintenance needs? Was corrective maintenance assigned even though the consequences of failure are very high?

Typical Recommendations

Ensure that the proper acceptance criteria are used in determining the level and type of maintenance to perform on equipment.

Provide guidance in the analysis procedure to allow consistent assessment of risk.

Provide guidance in the analysis procedure to allow for consistent application of the risk acceptance criteria. Use specific examples.

Examples

The analysis team assigned predictive, proactive and preventive maintenance activities to equipment with failures that resulted in large consequences. They assigned corrective maintenance to equipment with failures that had only low consequences. However, the risk associated with the low consequence, high frequency events was larger than that associated with some of the high consequence, infrequent events. The risk acceptance criteria outlined in the analysis procedure led them to believe that they were not assigning the correct type of maintenance to these different types of risks.

Corrective maintenance was assigned to the cooling water pumps because they were redundant and one would always be on standby should the pump online fail. Experience indicated that repair of a cooling water pump might take up to 24 hours, during which time there would be no standby arrangement available should the standby pump fail. The analysis procedure did not consider potential repair times in regard to overall risk.

Standards References

ISM Sec 10

ISO 14000: 2000: Sec 4.4.6

OHSAS 4.4.6

Maintenance Program Implementation

Cause Category

Typical Issues

These include problems related to the implementation of maintenance activities. Was the repair incorrectly performed? Was the troubleshooting less than adequate? Did the monitoring activity fail to detect a failing component? Was maintenance performed when it should have been (i.e., following a shutdown, before a startup, when vibration readings reached a trigger point)?

Typical Recommendations

Provide troubleshooting guides based on equipment failure analyses for diagnosis of failed components.

Review the frequency of preventive maintenance. If the same activity routinely needs to be performed between scheduled intervals, shorten the preventive maintenance interval.

Ensure that equipment monitoring for condition monitoring maintenance is appropriate for the component.

Examples

A number of pump bearings have failed recently. Condition monitoring maintenance was selected as the appropriate type of maintenance for the pump bearings. However, periodic monitoring of the pump bearings was never performed even though it was identified as a requirement in the equipment reliability program. As a result, the pump failed before the condition monitoring maintenance activity was implemented.

Preventive maintenance (a calibration) was being performed on cargo level sensors every six months. However, vessel personnel performed additional calibrations about once every three months as they noticed the scale drifting. The frequency of the calibration was changed to once every three months.

Standards References

ISM Sec 10

ISO 14000: 2000: Sec 4.4.6

TMSA 4A: 1.1, 1.2, 1.3, 2.2, 2.3, 2.5, 3.1, 3.2, 3.3, 4.1, 4.3, 4B: 4.2, 4.3, 4C: 1.1, 2.1, 3.1, 4.1, 5A: 2.1

SEMP 1.2.1.g all of Sec 8

OHSAS 4.4.6

Planned Maintenance Issue

Planned Maintenance Issue

Cause Type

Typical Issues

These include routine maintenance performed at assigned intervals.

Was the frequency of the planned maintenance correct (i.e., too long or too short)? Was the scope of the planned maintenance activity appropriate (i.e., too broad or too narrow)? Was the activity incorrectly performed?

Typical Recommendations

Review the frequency of planned maintenance. If the same activity routinely needs to be performed between scheduled intervals, shorten the planned maintenance interval.

Review maintenance procedures to ensure that they provide adequate guidance based on the experience level of personnel.

Provide training for personnel on preventive maintenance techniques.

Examples

Zinc anodes on the generator lube oil coolers were required to be inspected every 6 months. If they were more than approximately 50% wasted, they were to be replaced with new anodes. The anodes were found to be approximately 20% to 25% wasted. The planned maintenance for the generator lube oil coolers was changed to require inspection of zinc anodes at 12-month intervals.

Planned maintenance (a calibration) was being performed on cargo level sensors every six months. However, vessel personnel performed additional calibrations about once every three months as they noticed the scale drifting. The frequency of the calibration was changed to once every three months.

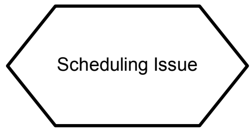
Standards References

ISM Sec 10.2

ISO 14000: 2000: Sec 4.4.6

TMSA 4A: 4.3, 4B: 1.2, 3.1, 3.2, 6B: 1.1, 1.2

OHSAS 4.4.6



Scheduling Issue

Intermediate Cause

Typical Issue

Was the frequency of the planned maintenance correct (i.e., too often or not often enough)?

Typical Recommendations

Review the frequency of planned maintenance. If the same activity routinely needs to be performed between scheduled intervals, shorten the planned maintenance interval.

Review the frequency of planned maintenance. Consider reducing the frequency of planned maintenance on components. Monitor equipment performance to determine the effects of a reduced frequency.

Examples

Zinc anodes on the generator lube oil coolers were required to be inspected every six months. If they were more than approximately 50% wasted, they were to be replaced with new anodes. The anodes were found to be approximately 20% to 25% wasted. The planned maintenance for the generator lube oil coolers was changed to require inspection of zinc anodes at 12-month intervals.

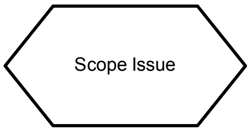
Planned maintenance (a calibration) was being performed on cargo level sensors every six months. However, vessel personnel performed additional calibrations about once every three months as they noticed the scale drifting. The frequency of the calibration was changed to once every three months.

Standards References

ISM Sec 10.2.1

ISO 14000: 2000: Sec 4.4.6

OHSAS 4.4.6



Scope Issue

Intermediate Cause

Typical Issue

Was the scope of the planned maintenance activity appropriate (i.e., too broad or too narrow)?

Typical Recommendations

Ensure that the scope of planned maintenance activities covers all portions of the equipment that need repair or service.

Ensure that all of the components requiring planned maintenance are covered by the procedures.

Examples

An auxiliary diesel engine was scheduled to have its oil changed periodically as one of several routine maintenance tasks performed at the same time. The maintenance activities did not include changing the lube oil filters. As a result, over time the lube oil filters became clogged, impeding the proper flow of lube oil to the engine.

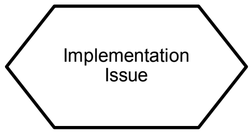
Planned maintenance procedures require rotating equipment that is not in operation to be rotated to prevent bearing damage from vessel vibration. Equipment that is shut down is scheduled to be rotated once per week. However, spare rotating equipment carried aboard the vessel is not covered by the procedure. As a result, the bearings in a piece of equipment that had remained idle for over six months failed soon after start up.

Standards References

ISM Sec 10.1

ISO 14000: 2000: Sec 4.4.6

OHSAS 4.4.6



Implementation Issue

Intermediate Cause

Typical Issues

Was the planned maintenance activity incorrectly performed? Were all required components serviced? Were some items included on the schedule that were never performed?

Note: Dual coding under "Training/Personnel Qualifications or Procedures" may also be appropriate.

Typical Recommendations

Review maintenance procedures to ensure that they provide adequate guidance based on the experience level of personnel.

Provide training for personnel on planned maintenance techniques.

Review the planned maintenance schedule and completed work orders to ensure that all required activities are being performed.

Perform post-maintenance testing to ensure that the maintenance is properly performed.

Example

An inexperienced mechanic incorrectly installed a pump seal, which subsequently leaked. He inserted one of the rubber seals backwards. The procedure provided no guidance other than to say "install the rubber seals".

Standards References

ISM Sec 10.1

ISO 14000: 2000: Sec 4.4.6

OHSAS 4.4.6

Condition Monitoring Maintenance Issue

Condition Monitoring Maintenance Issue

Cause Type

Typical Issues

This maintenance type includes periodic monitoring of equipment and taking actions when the monitoring results indicate potential problems with the equipment. Examples include vibration monitoring and infrared thermography monitoring.

Did the monitoring activity fail to detect a failing component? Was the monitoring activity performed? Was the correct parameter being monitored to detect failure? Was the condition monitoring maintenance incorrectly performed?

Typical Recommendations

Provide guidance on the typical parameters that can be monitored to predict failures for different types of components.

Ensure that equipment monitoring is appropriate for the component.

Ensure that equipment monitoring is being performed.

Ensure that the scope of equipment monitoring is adequate.

Examples

A number of pump bearings have failed recently. Condition monitoring maintenance was selected as the appropriate type of maintenance for the pump bearings. However, periodic monitoring of the pump bearings was never performed even though it was identified as a requirement in the equipment reliability program. As a result, the pump failed before the condition monitoring maintenance activity was implemented.

Monitoring of a pump indicated an upcoming failure (e.g., from condition maintenance monitoring). The pump was repaired incorrectly.

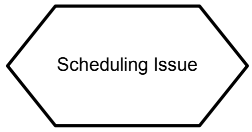
Standards References

ISM Sec 10.2

ISO 14000: 2000: Sec 4.4.6

TMSA 4A: 4.3, 6B: 1.2

OHSAS 4.4.6



Scheduling Issue

Intermediate Cause

Typical Issues

Did scheduling of the maintenance activity ensure the continued reliability of the equipment? Were there scheduling conflicts that prevented the maintenance activity from being performed on time?

Typical Recommendations

Develop a computerized method for scheduling of maintenance to ensure that the work is properly scheduled.

Ensure that scheduling is used to level the workload.

Example

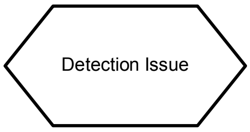
Engine operating temperatures and parameters indicated that main engine number three cylinder liner and piston rings would require changing within the next month of operation. A 24-hour stay in port was required to perform the maintenance. Though two port calls were scheduled over the following month, neither was planned for 24 hours. Instead of extending one of the port calls and scheduling the maintenance for the required repair, the vessel continued in operation. Number three cylinder liner failed shortly thereafter while the vessel was at sea.

Standards References

ISM Sec 10.2.1

ISO 14000: 2000: Sec 4.4.6

OHSAS 4.4.6



Detection Issue

Intermediate Cause

Typical Issues

Did the condition monitoring activity fail to detect a failing component? Was the correct parameter being monitored to detect failure? Is there sufficient time to detect an impending failure before the failure actually occurs?

Note: This node addresses what parameters should be monitored. "Monitoring Issue" addresses the actual performance of the monitoring in the field.

Typical Recommendations

Provide guidance on the typical parameters that can be monitored to predict failures for different types of components.

Ensure that equipment monitoring for predictive maintenance is appropriate for the component.

Examples

Pump bearings were being monitored for failure. However, by the time the impending failure could be detected, there was insufficient time to perform the maintenance.

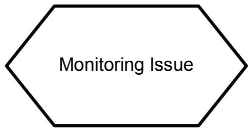
Turbine bearing temperatures were being monitored to predict impending failures. However, failures occurred even though there was no prediction of failure based on temperature levels. Vibration should also have been monitored because it was a better predictor of impending failures.

Standards References

ISM Sec 10.2

ISO 14000: 2000: Sec 4.4.6

OHSAS 4.4.6



Monitoring Issue

Intermediate Cause

Typical Issues

Were monitoring activities being performed? Were all the pertinent equipment and all components monitored?

Note: This node addresses the actual monitoring activity. Determining which parameters to monitor is addressed by "Detection Issue".

Typical Recommendations

Ensure that equipment monitoring is being performed.

Ensure that all pertinent components (points) are being monitored.

Examples

A number of pump bearings have failed recently. Condition monitoring maintenance was selected as the appropriate type of maintenance for the pump bearings. However, periodic monitoring of the pump bearings was not performed even though it was identified as a requirement in the equipment reliability program. As a result, the pump failed before the condition monitoring activity was implemented.

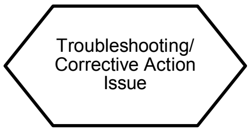
The three engine room supply fans were all supposed to be monitored for vibration as part of condition monitoring maintenance. Only two of the three fans were being monitored. The third fan was difficult to access. As a result, the third fan seized while in service.

Standards References

ISO 9000:2000: Sec 8.2.3

ISO 14001:2000: Sec 4.5.1

OHSAS 4.5.1



Troubleshooting/Corrective Action Issue

Intermediate Cause

Typical Issues

Was the scope of the work to correct the problem appropriate? Did the maintenance address the problem?

Note: This node addresses the actions taken to troubleshoot the system as a result of the adverse trends in the monitoring data (figuring out what to fix or replace). Detection and monitoring activities are addressed by "Detection Issue" and "Monitoring Issue," respectively. The actual fixing/replacement is covered under "Implementation Issue".

Note: Dual coding under "Training/Personnel Qualifications or Procedures Cause Categories" may be appropriate.

Typical Recommendations

Provide guidance on the typical failures that occur in various components.

Provide troubleshooting guides based on equipment failure analyses for diagnosis of failed components.

Provide training for personnel on troubleshooting processes.

Perform post-maintenance testing to ensure that the maintenance is properly performed and that it corrects the problem.

Examples

Ship's engine department personal performance evaluations include a review of how many maintenance items are completed each month. As a result, personnel attempt to complete maintenance task assignments as quickly as possible. This led to rework when hastily performed maintenance/repairs failed to correct the problem.

High vibration readings generally indicated a bearing problem in the pump. The mechanics replaced the bearing even though it did not look worn or damaged. When the pump was restarted, the high vibration readings were still present. The pump impeller had been damaged and caused the high vibration. This was not considered to be a potential cause of the high vibration.

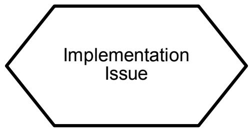
Standards References

ISM Code 9

ISO 9001: 2000: Sec 8.5.2

ISO 14001: 2000: Sec 4.5.2

OHSAS 4.5.2



Implementation Issue

Intermediate Cause

Typical Issue

Was the predictive maintenance incorrectly performed?

Note: This node addresses the corrective action implementation (fixing or replacing the equipment). “Troubleshooting/Corrective Action” addresses figuring out what to fix/replace.

Note: Dual coding under “Training/Personnel Qualifications” or “Procedures”.

Typical Recommendations

Review maintenance procedures to ensure that they provide adequate guidance based on the experience level of personnel.

Provide training for personnel on predictive maintenance techniques.

Review the planned maintenance schedule and completed work orders to ensure that all required activities are being performed.

Example

An inexperienced mechanic incorrectly installed a pump seal. He inserted one of the rubber seals backwards. The procedure provided no guidance other than to “install the rubber seals”.

Standards References

ISM Sec 10.1

ISO 14001: 2000: Sec 4.4.6

OHSAS 4.4.6

Shore-based
Maintenance Issue

Shore-based Maintenance Issue

Cause Type

Typical Issues

This type of maintenance includes maintenance that is event driven, such as that performed during a shipyard period, when bringing a vessel out of lay-up or during scheduled port calls. This may also include breakdown of equipment during these periods for inspection in order to determine maintenance needs.

Was maintenance performed when it should have been (i.e., following a shutdown, before a startup, while in port, during lay up or dry dock, at the beginning of winter)?

Was the work incorrectly performed?

Was the scope of the activity broad enough?

Typical Recommendations

Ensure that triggering events for such maintenance are appropriate for the component.

Ensure that monitoring is performed to determine when triggering events occur.

Review maintenance procedures to ensure that they provide adequate guidance based on the experience level of personnel.

Provide training for personnel on maintenance techniques.

Review the planned maintenance schedule and completed work orders to ensure that all required activities are being performed.

Examples

The control air system must be thoroughly blown down with dry air and purged of moisture prior to being placed back in operation after a shipyard period or lay-up where the system has not been in continuous use. Further, controls require purging and testing to ensure proper operation prior to startup of controlled equipment. The purging procedure was conducted several days prior to placing the control air system back into continuous use and reactivation of the plant. In the interim, moisture accumulated in the system and caused a number of control problems during startup, requiring the purging procedure to be performed again. The maintenance requirements were edited to include an instruction to withhold purging of the control air system until immediately before putting it back into full operation.

Stores cranes were supposed to be inspected and lift-tested prior to lifting any item that was greater than 70% of the crane's rated capacity. These inspections and tests were never performed because the crane operators were unaware of this requirement and a lift of 95% of the crane's capacity subsequently damaged the crane. The lift landed on deck injuring a crew member and resulting in a lost-time accident.

Standards References

ISM Sec 10

ISO 14001: 2000: Sec 4.4.6

TMSA 4A: 4.3

OHSAS 4.4.6

Event Specification Issue

Intermediate Cause

Typical Issue

Is the correct triggering event specified for the maintenance? Examples of triggering events include: bringing a vessel out of lay-up, the onset of cold weather, when a new type of cargo will be loaded and prior to an entry to a port.

Typical Recommendation

Ensure that triggering events for such maintenance are appropriate for the component.

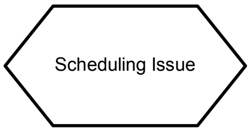
Examples

Heat exchangers using salt water service cooling are opened and cleaned regularly during each dry-dock period. The vessel changed trade routes from waters that included mostly cooler northern climates to almost exclusively tropical climates. The cooling efficiency of some of the heat exchangers dropped below requirements prior to dry-docking and required cleaning ahead of the planned schedule.

The control air system must be thoroughly blown down with dry air and purged of moisture prior to being placed back in operation after a shipyard period or lay-up where the system has not been in continuous use. Further, controls require purging and testing to ensure proper operation prior to startup of controlled equipment. The purging procedure was conducted several days prior to placing the control air system back into continuous use and reactivation of the plant. In the interim, moisture accumulated in the system and caused a number of control problems during startup, requiring the purging procedure to be performed again. The maintenance requirements were edited to include an instruction to withhold purging of the control air system until immediately before putting it back into full operation.

Standards Reference

ISM Sec 10.2.1



Scheduling Issue

Intermediate Cause

Typical Issues

Are triggering events monitored? Were tasks scheduled following the occurrence of the triggering event? Did scheduling of the maintenance activity ensure the continued reliability of the equipment? Were there scheduling conflicts that prevented the maintenance activity from being performed on time?

Note: This node addresses scheduling the tasks based on identifying that the triggering event has occurred.

Typical Recommendations

Ensure that monitoring is performed to determine when triggering events occur.

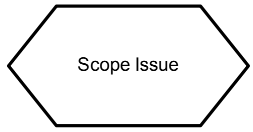
Review the shore-based maintenance schedule and completed work orders to ensure that all required activities are being performed.

Example

Engine operating temperatures and parameters indicated that main engine number three cylinder liner and piston rings would require changing within the next month of operation. A 24-hour stay in port was required to perform the maintenance. Though two port calls were scheduled over the following month, neither was planned for 24 hours. Instead of extending one of the port calls and scheduling the maintenance for the required repair, the vessel continued in operation. Number three-cylinder liner failed shortly thereafter while the vessel was at sea.

Standards Reference

ISM Sec 10.1



Scope Issue

Intermediate Cause

Typical Issues

Was the scope of the maintenance activity sufficient to prevent the problem?

Typical Recommendations

Review the scope of the shore-based maintenance procedures to ensure that they are broad enough to address the issue.

Perform post-maintenance testing to ensure that the maintenance is properly performed and corrects the problem.

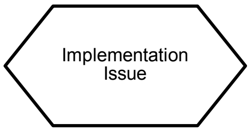
Examples

The control air system must be thoroughly blown down with dry air and purged of moisture prior to being placed back in operation after a shipyard period or lay-up where the system has not been in continuous use. The system was purged with dry air, but upon plant startup, difficulties were encountered with moisture that had remained in the control air system. The purge procedure was changed to include an individual blow down of each pneumatic control component supplied by the control air system.

Stores cranes were supposed to be inspected and lift tested prior to lifting any item that was greater than 70% of the crane's rated capacity. The lift tests were only performed at one boom angle even though they should have been performed at a number of different boom angles.

Standards Reference

ISM Sec 10.1



Implementation Issue

Intermediate Cause

Typical Issue

Was the maintenance activity incorrectly performed?

Note: Dual coding under "Training/Personnel Qualifications" or "Procedures" may also be appropriate.

Typical Recommendations

Review maintenance procedures to ensure that they provide adequate guidance based on the experience level of personnel.

Provide training for personnel on repair techniques.

Review the shore-based maintenance schedule and completed work orders to ensure that all required activities are being performed.

Examples

An inexperienced mechanic incorrectly installed a pump seal. He inserted one of the rubber seals backwards. The procedure provided no guidance other than to say "install the rubber seals."

An engineer was performing a maintenance check on a pressure relief valve pilot. During performance of the check, a high-pressure signal was simulated in the instrument loop. Because the loop was not properly isolated, it resulted in a pressure relief valve lifting and a release to the environment.

Prior to each load or discharge operation aboard an LNG carrier, an insulation test (megger reading) is scheduled to be performed of the wiring between each cargo pump motor controller and its corresponding cargo pump. The insulation tests had been overlooked for several voyages. Upon commencing discharge, the number two port cargo pump failed. Insulation test readings indicated that the pump wiring was grounded. As a result, cargo operations were conducted at half rate and the vessel failed to meet charter requirements.

Standards References

ISM Sec 10.1

ISO 14000: 2000: Sec 4.4.6

OHSAS 4.4.6

Corrective Maintenance Issue

Corrective Maintenance Issue

Cause Type

Typical Issues

This type of maintenance generally includes maintenance performed in response to operational failure or evidence of impending failure. It may be intentionally planned; however, more often this type of maintenance is performed as the result of a nonconforming situation where maintenance of another type was not adequate or was improperly performed.

Items within this category will consider the failure of corrective maintenance to achieve an adequate repair.

Note: Dual coding under "Training/Personnel Qualifications" or "Procedures" may also be appropriate.

Note: If evidence of impending failure is discovered as part of structured, planned maintenance activity (such as condition monitoring maintenance), it should be coded in other portions of the map.

Typical Recommendations

Provide troubleshooting guides based on equipment failure analyses for diagnosis of failed components.

Review maintenance procedures to ensure that they provide adequate guidance based on the experience level of personnel.

Provide training for personnel on troubleshooting processes.

Provide training for personnel on repair techniques.

Perform post-maintenance testing to ensure that the maintenance is properly performed and corrects the problem.

Examples

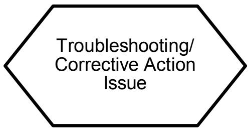
An inexperienced mechanic incorrectly repaired a pump seal, which subsequently leaked. He inserted one of the rubber seals backwards. The procedure provided no guidance other than to say "install the rubber seals".

Ship's engine department personal performance evaluations include a review of how many maintenance items are completed each month. As a result, personnel attempt to complete maintenance task assignments as quickly as possible. This sometimes leads to rework of hastily completed maintenance or repair items.

Standards References

ISM Sec 10.2.2, 10.2.3

TMSA 4B: 1.1



Troubleshooting/Corrective Action Issue

Intermediate Cause

Typical Issues

Was the problem misdiagnosed? Was the wrong problem corrected because the troubleshooting was less than adequate?

Note: This node addresses figuring out what to fix/replace. "Repair Implementation Issue" addresses performing the repair activity.

Note: Dual coding under "Training/Personnel Qualifications" or "Procedures" may also be appropriate.

Typical Recommendations

Provide troubleshooting guides based on equipment failure analyses for diagnosis of failed components.

Provide training for personnel on troubleshooting processes.

Perform post-maintenance testing to ensure that the maintenance is properly performed and corrects the problem.

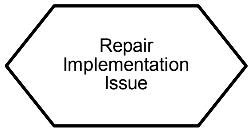
Examples

Ship's engine department personal performance evaluations include a review of how many maintenance items are completed each month. As a result, personnel attempted to diagnose a problem as quickly as possible. This led to rework when the original repairs failed to correct the problem.

The electricians were attempting to isolate a ground in a feeder circuit. They thought they had isolated the problem to a portion of the circuit, but they were mistaken. They had misread the electrical diagrams and misinterpreted their instrument readings.

Standards Reference

ISM Sec 10.2.3



Repair Implementation Issue

Intermediate Cause

Typical Issue

Was the corrective maintenance repair performed correctly?

Note: This node addresses the repair activity. Figuring out what to repair is addressed by the "Troubleshooting/ Corrective Action Issue" node. "Repair Implementation Issue" addresses performing the repair activity.

Note: Dual coding under "Training/Personnel Qualifications" or "Procedures" may also be appropriate.

Typical Recommendations

Review maintenance procedures to ensure that they provide adequate guidance based on the experience level of personnel.

Provide training for personnel on repair techniques.

Examples

An inexperienced mechanic incorrectly repaired a pump seal, which subsequently leaked. He inserted one of the rubber seals backwards. The procedure provided no guidance other than to say "install the rubber seals".

During corrective maintenance, mechanics identified a problem with a seal on a pressure transmitter. To correct the problem, a new rubber gasket should have been installed. However, the mechanic would have had to go to the engine room to get a new gasket and it was close to coffee time. Instead, the engineer applied a sealant to the gasket. This caused problems during subsequent repairs when the old gasket could not be removed.

Standards References

ISM: 10.2.3

ISO 9001: 2000: Sec 8.2.3

ISO 14001: 1996: Sec 4.5.1

OHSAS 4.5.1

Failure Finding Maintenance Issue

Failure Finding Maintenance Issue

Cause Type

Typical Issues

This type of maintenance includes maintenance performed in response to unsatisfactory test results of standby and emergency equipment or the detection of hidden failures in systems.

Did hidden failures contribute to the loss event? Could these hidden failures have been detected by testing the equipment?

Typical Recommendations

Ensure that standby systems are periodically tested to determine their operability.

Verify that redundant machinery is periodically used to ensure readiness for operation should primary components fail.

Check failure finding testing procedures to ensure that the entire system is tested and not just a portion of it.

Ensure that the frequency of testing is correct (not too often, but often enough).

Examples

A standby diesel generator provides power to vital equipment during a loss of power. No testing had been performed on the diesel generator for the past four months. As a result, when there was a loss of power, the diesel generator did not work.

A second cooling pump is installed as a spare. It is designed to start when the primary pump fails. The standby pump is smaller than the primary and so it is seldom used. The pump is tested when it is periodically placed in service (although this is not done on any schedule). However, the autostart system is never tested. As a result, the standby pump failed to start following an emergency shutdown of the primary pump.

Routine testing of a computer backup power supply (an uninterruptible power supply with batteries) was performed once a year. However, the batteries had an expected lifetime of 18 months. As a result, many of the battery failures were not detected for months after they occurred.

Standards References

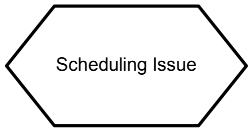
ISM: 10.2.1, 10.3

ISO 9001: 2000: Sec 8.2.3

ISO 14001: 2000: Sec 4.5.1

SEMP: 8.5

OHSAS 4.5.1



Scheduling Issue

Intermediate Cause

Typical Issues

Was the frequency of failure finding maintenance correct? Was the maintenance performed too frequently? Was it not performed often enough?

Note: This type of maintenance is usually applicable to standby and emergency systems or the detection of hidden failures in systems.

Typical Recommendations

Ensure that standby systems are periodically tested to determine their operability.

Ensure that the frequency of testing is correct (not too often, but often enough).

Assess the impact of failure finding maintenance on the system. What impact does the maintenance have on the equipment? Adjust the frequency accordingly.

Examples

A standby diesel generator provides power to vital equipment during a loss of power. No testing had been performed on the diesel generator for the past four months. As a result, when there was a loss of power, the diesel generator did not work.

Routine testing of a computer backup power supply (an uninterruptible power supply with batteries) was performed once a year. However, the batteries had an expected lifetime of 18 months. As a result, many of the battery failures were not detected for months after they occurred.

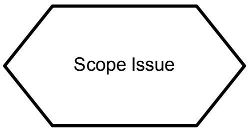
Standards References

ISM 10.4 and 10.2.1

ISO 9001: 2000: Sec 8.2.3

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.5.1



Scope Issue

Intermediate Cause

Typical Issues

Did the testing include all applicable portions of the system (i.e., detection system, control systems, actuation systems and the actual components)? Did the testing include all applicable modes of operation?

Note: This type of maintenance is usually applicable to standby and emergency systems or the detection of hidden failures in systems.

Typical Recommendations

Check failure finding testing procedures to ensure that the entire system is tested and not just a portion of it. Check to see that the following portions of the system are included:

- Detection systems (i.e., a system that detects low voltage to start an emergency generator)
- Actuation systems (i.e., the part of the system that tells the standby component to start)
- The component itself (i.e., the diesel generator)

Examples

The fire pump is operated at every fire drill. It is started from the engine room operating console but is never started from the bridge. As a result, when a small fire broke out while the engine room was not manned, bridge personnel found that they could not start the fire pump from the bridge console.

A second cooling pump is installed as a spare. It is designed to start when the primary pump fails. The standby pump is smaller than the primary pump, so it is seldom used. The pump is tested when it is periodically placed in service (although this is not done on any schedule). However, the autostart system is never tested. As a result, the standby pump failed to start following a shutdown of the primary pump.

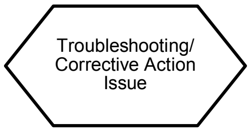
Standards References

ISM: 10.1

ISO 9001: 2000: Sec 8.2.3

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.5.1



Troubleshooting/Corrective Action Issue

Intermediate Cause

Typical Issues

Was the scope of the repair appropriate? Did the repair correct the problem? Was the scope of the repair broad enough to correct the problem?

Note: This type of maintenance is usually applicable to standby and emergency systems or the detection of hidden failures in systems.

Note: This node addresses figuring out how to fix/replace/repair. “Implementation Issue” addresses performance of the fix/replacement/repair.

Typical Recommendations

Provide guidance on the typical failures that occur during testing.

Provide troubleshooting guides based on equipment failure analyses for diagnosis of failed components.

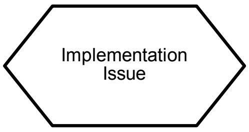
Provide training for personnel on troubleshooting processes.

Example

During testing, a standby generator failed to start. Troubleshooting revealed a failure in the starting circuit. No post-maintenance testing was performed. As a result, a failed fuel line was not discovered.

Standards Reference

ISM 10.2.3



Implementation Issue

Intermediate Cause

Typical Issues

Was an error made in performing the repair activity? Were problems introduced as a result of performing the repair? Were hidden failures introduced into the system as a result of performing the maintenance?

Note: This type of maintenance is usually applicable to standby and emergency systems or the detection of hidden failures in systems.

Note: Dual coding under "Training/Personal Qualifications" or "Procedures" may also be appropriate.

Note: This node addresses performance of the repair/replacement activity. Determining what to fix/repair/replace is addressed by the "Troubleshooting/Corrective Action Issue" node.

Typical Recommendations

Review maintenance procedures to ensure that they provide adequate guidance based on the experience level of personnel.

Provide training for personnel on repair techniques.

Perform an analysis of procedures to determine the types of errors that could be reasonably made.

Ensure that the procedures adequately address each of these.

Examples

A standby diesel generator (DG) provides power to vital equipment during a loss of power. To perform testing of the DG, the engineer takes the DG offline. After testing, the engineer failed to return the DG to an online condition. As a result, when there was a loss of power, the diesel generator did not work.

A secondary cooling pump is installed as a spare. It is designed to start when the primary pump fails. A failure in the auto starting system was found during a test. However, the pump was not repaired for several weeks because it was not put on the maintenance schedule. When the primary pump tripped, the secondary pump was still inoperable.

Standards References

ISM 10.1

ISO 9001: 2000: Sec 8.2.3

ISO 14001: 2000: Sec 4.5.1

TMSA 4B: 4.3, 12A: All

OHSAS 4.5.1

Servicing and Routine Inspection Issue

Servicing and Routine Inspection Issue

Cause Type

Typical Issues

This type of maintenance includes maintenance performed as a result of identifying abnormalities during routine rounds.

Are routine inspections of equipment performed? Are personnel aware of the types of problems they should look for? Do they know how to document the problem and feed it into the maintenance system?

Typical Recommendations

Develop guidance for watchkeeping and maintenance rounds.

Ensure that personnel are aware of the process for initiating corrective maintenance.

Make the process of reporting problems as simple as possible to encourage reporting problems.

Example

Deck officers are supposed to inspect the cargo system for problems at the beginning of each watch and once every hour. They often skip rounds because they have too much paperwork to complete.

Standards References

ISM 10.2.1

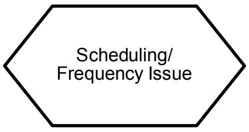
ISO 9001: 2000: Sec 8.2.3

ISO 14001: 2000: Sec 4.5.1

TMSA 4A: 4.3, 6A: 2.2

SEMP 8.5

OHSAS 4.5.1



Scheduling/Frequency Issue

Intermediate Cause

Typical Issue

Was the frequency of the rounds correct (i.e., too often or not often enough)?

Typical Recommendation

Review the frequency of the rounds to determine if they are performed at the required frequency.

Example

Cargo watch personnel are supposed to inspect the cargo system for problems at the beginning of each watch. Frequently, significant valve gasket or packing leaks are found. More frequent rounds resulted in detections of leaks while they were still very small.

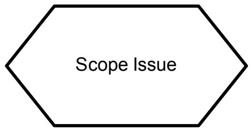
Standards References

ISM 10.2.1

ISO 9001: 2000: Sec 8.2.3

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.5.1



Scope Issue

Intermediate Cause

Typical Issues

Was the scope of the rounds appropriate (i.e., too broad or too narrow)? Are all portions of the vessel covered by routine rounds?

Typical Recommendations

Ensure that all areas of the vessel are covered by periodic rounds.

Provide guidance on the activities that are to be performed during routine rounds.

Examples

The vessel's engine room machinery was operated from an air-conditioned operating station. No specific guidance had been provided in regard to performing rounds. The engine room personnel also had confidence in the automation. As a result, rounds were often not thorough and areas of the vessel's plant were overlooked.

Engineers were told to perform rounds, which included the steering gear room, but were not told what activities they were to perform. As a result, the engineers poked their head in the door of the steering gear room and glanced around, but did nothing else.

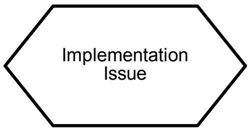
Standards References

ISM 10.1

ISO 9001: 2000: Sec 8.2.3

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.5.1



Implementation Issue

Intermediate Cause

Typical Issues

Are the rounds performed? Are they performed at the specified frequency? Do the rounds cover all areas that are specified?

Note: Dual coding under “Training/Personnel Qualifications or Procedures” may also be appropriate.

Typical Recommendations

Ensure that rounds are performed as required.

Ensure that all equipment is covered on rounds as required.

Example

Engineers are supposed to check for leaks throughout the engine room. However, they usually only tour the part of the engine room that is in proximity to the engine control room.

Standards References

ISM 10.1

ISO 9001: 2000: Sec 8.2.3

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.5.1

Equipment Records

Cause Category

Typical Issues

Does an equipment records program exist? Is it adequate and up-to-date? Does it contain the correct information? Does it contain all the information necessary to ensure equipment reliability?

Typical Recommendations

Develop a system for tracking equipment histories.

Collect information from other sources (e.g., vendors) to help complete existing equipment histories.

Examples

A tank overflowed because of faulty liquid level instrumentation. The records indicated that a calibration was called for and performed three months prior, but did not indicate how much adjustment was made during calibration. A large adjustment might have indicated pending failure.

A pressure vessel was not properly tested to full pressure after a modification. The design information for the pressure vessel had been lost.

Standards References

ISM: Sec 11

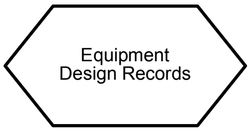
ISO 9001: 2000: Sec 4.2.1, 4.2.3

ISO 14001: 2000: Sec 4.4.5

TMSA 4A: 2.3, 4B: 3.3, 6A: 2.2, 2.3, 12A: 3.2

SEMP 2.3.1, 2.3.4, 4.2.f, 8.5.c

OHSAS 4.4.5



Equipment Design Records

Intermediate Cause

Typical Issue

Have problems with design records caused problems with the operation, maintenance or modification of equipment?

Typical Recommendation

Ensure that design information is retained on equipment and is accessible to personnel responsible for operation, maintenance and modification of the equipment.

Examples

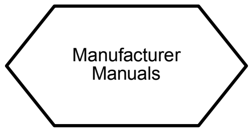
As part of a capacity upgrade, engineers attempted to determine the design throughput of a blender. No equipment records could be located to determine the design capacity of the equipment.

Maintenance procedures were being developed for a new freezer. Lack of design information required extensive field verification of equipment configuration to develop the procedure.

Standards References

ISO 9001: 2000: Sec 7.3

TMSA 4B: 3.4



Manufacturer Manuals

Intermediate Cause

Typical Issues

Did a missing, deficient or poorly maintained manufacturer's manual contribute to a problem or result in a failure to provide needed information that would have been useful in solving a problem? Were manufacturer's manuals containing important design information missing? Were the manufacturer's manuals deficient in providing useful and necessary design information? Had manufacturer's manuals been poorly maintained?

Typical Recommendation

Establish a plan for inventory and maintenance of manufacturer's manuals. Contact manufacturers in regard to missing information.

Examples

The vessel had only one copy of the oily water separator manual. It was in poor condition with some torn and missing pages, indicating that it had been well used. The section regarding maintenance was missing several pages, so the maintenance on the oily water separator was not performed according to manufacturer's recommendations. The ship's engineers had great difficulty in operating the oily water separator.

The oily content meter on the overboard discharge from the oily water separator was changed for a newer model of the same meter. The section in the manufacturer's manual regarding the oil content meter was not updated. As a result, maintenance and operation requirements for the new oil content meter were not performed, and the ship's engineers soon had difficulty with its operation.

Standards References

ISM: 11.2.1

ISO 9001: 2000: Sec 4.2.1, 4.2.3

ISO 14001: 2000: Sec 4.4.5

OHSAS 4.4.5

Equipment Operating/Maintenance History

Intermediate Cause

Typical Issues

Was the history for the equipment that malfunctioned complete? Did the history contain information about similar equipment? Would knowledge of the history of the equipment involved in the event and similar equipment have prevented the incident or lessened its severity?

Typical Recommendations

Collect available information from other sources (e.g., vendors) to help complete existing equipment histories.

Improve the system for tracking equipment histories to help ensure that all pertinent information is retained.

Assign responsibility for maintaining and analyzing equipment repair and maintenance records.

Periodically audit the equipment history files to help ensure that the records system is being followed.

Assess the adequacy of engineer rounds and the information collected on rounds.

Assess the adequacy of maintenance tasks that collect information on the status of equipment.

Ensure that information collected on rounds is analyzed to determine if problems exist with equipment.

Examples

A number of vessels of the same type within the fleet were experiencing compressor failures. The failures were being caused by a similar problem; however, because equipment maintenance record procedures did not require the cause of failures to be documented, the ship superintendents were not able to identify the failure trend in a key component.

A tank overflowed because of faulty liquid level instrumentation. Previous problems had occurred with the instrumentation under similar conditions. This was not known by current vessel personnel because no equipment history was available.

Standards References

ISM: Sec 11.1

ISO 9001: 2000: Sec4.2.1, 4.2.3

ISO 14001: 2000: Sec 4.4.5

TMSA 4A: 2.3, 2.5, 3.1, 3.2, 3.3, 4.1, 4B: 3.3, 5A: 2.1, 6B: 1.2

SEMP 4.1, 8.6.c, 13.3.f

OHSAS 4.4.5

Management System

Cause Category

Typical Issues

Are safety/hazard/risk reviews inadequate? Are corrective and planned actions identified and implemented? Was there a problem implementing a change? Did the problem result from a lack of documentation or operational control? Did inadequate material, procurement or configuration control contribute to the problem? Was there a problem with the charterer/customer interface or with the service provided?

Typical Recommendations

Track and document the resolution of all corrective and preventative action recommendations.

Inspect materials for damage upon arrival at the vessel.

Ensure that acceptance requirements are documented and match the design requirements.

Review and approve field changes.

Periodically solicit feedback from customers and end users.

Examples

An emergency shutdown actuation failed to stop the discharge of cargo to the shore receiving facility, resulting in a release of hazardous material. The emergency shutdown system had recently undergone a modification. The company's procedures required that a HAZOP analysis be performed of any newly installed or modified systems. The HAZOP procedure was not well-suited for analyzing the emergency shutdown system. (FMEA would have been a better choice of technique).

Audit procedures do not require that sampling size be increased when a problem is discovered. As a result, records indicating that a fire extinguisher was three months overdue for inspection and servicing were identified as a minor nonconformity. In reality, a major problem existed, as more than 50% of the vessel's fire extinguishers were overdue for inspection and servicing.

Spare acetylene and oxygen bottles were stored in the same locker located on the main deck above the engine spaces. Regulations and safety precautions require that these gases must be stored in separate spaces to prevent the increased danger of explosion in the event of a gas release and/or fire involving the space.

A product carrier was chartered to lift a cargo from a terminal where it regularly loaded a heavy petroleum product. The vessel was not made aware that it would be picking up a much lighter product, which would require tank cleaning prior to arrival. As a result, the vessel arrived at the load terminal with unacceptable tank conditions.

Standards References

ISM Sec 7

ISO 9001: 2000: Sec 4.2

ISO 14001: 2000: Sec. 4.4.5

SEMP 1.2

OHSAS 4.4.5

Health, Safety, Environment Issue

Health, Safety, Environment Issue

Cause Type

Typical Issues

Program design. Design of HSE management systems. Reporting and record keeping. Emergency preparedness planning. Health hazards threats. Mechanical, electrical and chemical safety threats. Environmental threats.

Typical Recommendations

Allocate personnel in sufficient number and with sufficient flexibility to respond to HSE objectives and goals.

Ensure that all hazard review recommendations are documented and reviewed by management personnel.

Management should address all HSE safety recommendations and document the manner in which the recommendation will be addressed (i.e., assign a responsible party for completion or reject the recommendation with documented reason for doing so).

Ensure that implementation of HSE recommendations are assigned to a specific group or individual.

Ensure that the record keeping procedures are implemented.

Provide sufficient guidance and training to ensure that the scope of record keeping is both understood and followed.

Provide a safety/reliability/quality/security review procedures that result in the generation of contingency and emergency plans

Ensure that the hazard review procedure is readily available to personnel who will generate the plans.

Examples

A tank overflowed because of faulty liquid level instrumentation. Previous problems had occurred with the instrumentation under similar conditions. This was not known by current vessel personnel because no equipment history was available, and procedures were inadequate.

An incident investigation recommended that small drain holes be drilled in the discharge line of all fire monitors to prevent accumulation of water that could freeze and plug the monitor. This recommendation had not been implemented by management before another fire occurred, and two of the three monitors failed because they were plugged with ice.

Record keeping procedures do not require that sampling size be increased when a problem is discovered. As a result, records indicating that a fire extinguisher was three months overdue for inspection and servicing was identified as a minor nonconformity. In reality, a major problem existed as fully one-half of the vessel's fire extinguishers were overdue for inspection and servicing.

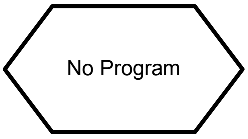
A vessel ran aground as the pilot hesitated to board due to high winds and waves. Voyage planning had failed to adequately identify the hazard posed by a shoal in close proximity the point where pilots typically board arriving vessels.

Standards References

ISM: Sec 10.3

TMSA 1A: 4.1, 1B: 3.1, 4.1, 4.2, 4.3, 3A: 2.5, 3.5, 4.4, 3B: 3.3, 5A: 1.3, 2.2, 2.3, 4.1, 4.2, 6A: 1.1, 1.3, 6B: 3.1, 8B: All, 9A: 3.3, 9B: 1.1, 1.2, 1.3, 2.1, 10A: 1.1, 1.2, 1.3, 2.3, 10B: 1.1 thru 3.1, 3.3, 12B: All

SEMP 1.2.1.k, 5.2.d, 6.1, Sec 11



No Program

Intermediate Cause

Typical Issues

Has a safety management program been designed and personal allocated to the function? Have the safety needs for this operation or piece of equipment been analyzed? Have health, safety or environmental threats been identified?

Typical Recommendations

Determine the appropriate level of management for all operations aboard the vessel that is important to safety or reliability.

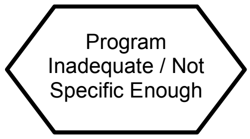
Identify high to medium risks and assign the appropriate type of management.

Examples

Provision of HSE procedures for safety and environmental hazards due to risk of spills. For example, procedures for bunkering, fuel transfer and ballasting.

Standards Reference

ISM: Sec 10.3



Program Inadequate/Not Specific Enough

Intermediate Cause

Typical Issues

Is the HSE safety management program sufficiently organized with enough personnel to fulfill the HSE Function? Are financial resources available?

Typical Recommendations

Allocate personnel in sufficient number and with sufficient flexibility to respond to HSE objectives and goals.

Examples

A number of vessels of the same type within the fleet were experiencing spill events. The pollution was being caused by a problem with the bilge system. Procedures were inaccurate and incomplete with regard to valve alignment.

A tank overflowed because of faulty liquid level instrumentation. Previous problems had occurred with the instrumentation under similar conditions. This was not known by current vessel personnel because no equipment history was available, and procedures were inadequate.

Standards Reference

ISM: Sec 10.3

Management Inadequate

Intermediate Cause

Typical Issues

Lack of management. Roles of management and staff unclear or unspecified. Lack of appropriate management oversight. Excessive management oversight. Inability to take appropriate action. Poor planning. Inability to provide positive feedback.

Typical Recommendations

Provide clear definition of roles and responsibilities. Provide subjective and objective means to assess personal performance. Detailed task planning, scheduling and monitoring.

Ensure that all hazard review recommendations are documented and reviewed by management personnel.

Management should address all HSE safety recommendations and document the manner in which the recommendation will be addressed (i.e., assign a responsible party for completion or reject the recommendation with documented reason for doing so).

Ensure that implementation of HSE recommendations are assigned to a specific group or individual.

Examples

Because the bow doors on a Ro-Ro passenger vessel could not be clearly seen from the bridge, it was decided that cameras would be mounted in the interior of the main deck to provide a view of the bow doors via a video monitor on the bridge. An item was added to the vessel pre-departure checklist to confirm that the bow doors were closed prior to leaving the berth. While awaiting the installation of the cameras, an interim corrective action was developed to have the bosun physically confirm closure of the bow doors and report the closure to the bridge watch. Before the measure was implemented, the vessel put to sea with the bow doors still open. There was an unusually rough sea outside the breakwater to the harbor, which caused water to enter the vessel over the bow and through the bow doors. The vessel capsized within minutes of exiting the harbor.

An incident investigation recommended that small drain holes be drilled in the discharge line of all fire monitors to prevent accumulation of water that could freeze and plug the monitor. This recommendation had not been implemented by management before another fire occurred, and two of the three monitors failed because they were plugged with ice.

Standards References

ISM: Sec 10.3

TMSA 9B: 3.1, 3.2

Recordkeeping Issue

Intermediate Cause

Typical Issues

Are records properly stored? Are the accessible? Are they easily located? Are records complete?

Typical Recommendations

Ensure that records for periodic audits of systems important to safety, reliability and quality are maintained.

Ensure that the record keeping procedures are implemented.

Provide sufficient guidance and training to ensure that the scope of record keeping is both understood and followed.

Examples

An audit of vessel security awareness and measures was performed aboard each vessel in the fleet; however, adequate record keeping was not performed and attempt to trend safety performance could not be reliably developed as a result.

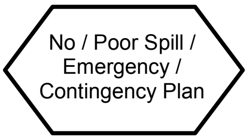
Record keeping procedures do not require that sampling size be increased when a problem is discovered. As a result, records indicating that a fire extinguisher was three months overdue for inspection and servicing was identified as a minor nonconformity. In reality, a major problem existed as fully one-half of the vessel's fire extinguishers were overdue for inspection and servicing.

Standards References

ISM: Sec 11

TMSA 6B: 3.1, 9A: 2.2

SEMP All of Sec 13



No/Poor Spill/Emergency/Contingency Plan

Intermediate Cause

Typical Issues

Presence of emergency and contingency plans. Emergency or contingency plans and procedures poorly thought out (e.g., don't address the conditions of hypothesized events). Plan procedures ineffective.

Typical Recommendations

Provide a safety/reliability/quality/security review procedures that result in the generation of contingency and emergency plans

Ensure that the hazard review procedure is readily available to personnel who will generate the plans.

Periodically audit hazard review plans and reports.

Ensure that all newly installed and/or modified equipment is included in a hazard review and incorporate findings in emergency planning

Examples

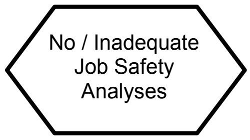
A vessel ran aground as the pilot hesitated to board due to high winds and waves. Voyage planning had failed to adequately identify the hazard posed by a shoal in close proximity the point where pilots typically board arriving vessels.

Standards References

ISM: Sec 7

TMSA 11A: All, 11B: All

SEMP 1.2.1.i, 7.1, all of Sec 10, 13.3i



No/Inadequate Job Safety Analyses

Intermediate Cause

Typical Issues

Proper risk assessment

Conduct of job analysis and of safety analysis

Adequacy of safety controls

Management practices in monitoring and stressing Job Safety Analysis

Typical Recommendations

Appoint a risk assessor with detailed knowledge of the working environment and work processes

Perform a Job Safety Analysis identifying the areas where hazards exist

Introduce controls to mitigate or eliminate hazards.

Ensure that suitable actions have been taken to implement controls.

Examples

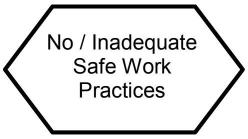
A 15-foot access ladder was not subjected to a Job Safety Analysis because a similar ladder in a different compartment had already undergone analysis, however, this ladder was located directly adjacent to a ventilation exhaust. A crewmember was climbing the ladder with a small rectangle of quarter inch plywood when the exhaust motor started. The sudden flow of air caught the plywood and the crewmember lost balance and fell 6 feet.

An hydraulic valve was replaced with a motor operated valve. No a Job Safety Analysis was performed as it was viewed as a basic valve replacement task, consequently no electrical lockout precautions were incorporated in maintenance procedures. As a result, a member of the engineering department received a electrical burn and severe shock.

Standards References

ISM: Sec 9

TMSA 6B: 3.1, 7B: 1.1, 3.2, 9A: 2.1, 2.3, 2.4, 2.5, 3.2, 9B: 1.4, 2.3



No/Inadequate Safe Work Practices

Intermediate Cause

Typical Issues

Proper risk assessment

Space occupant protection

Worksite containment of hazardous or caustic substances

Specialized maintenance, access, cleaning methods, products and devices

Avoidance of using prohibited work practices.

Typical Recommendations

Load carrying capacity and material handling

Training on safety of using ladders, confined space entry and maintenance safety

Provision of good housekeeping strategies

Identifying safe work practices based on hazards revealed through Job Safety Analyses

Examples

An hydraulic valve was replaced with a motor operated valve. No a Job Safety Analysis was performed as it was viewed as a basic valve replacement task, consequently no electrical lockout precautions were incorporated in maintenance procedures. As a result, a member of the engineering department received a electrical burn and severe shock.

A new crewmember was instructed to inspect the coating on a sealed tank. While the inspection procedures required a gas check of a tank before entry, the procedure was not followed. The crewmember was about to enter the tank when another crewmember stopped him, as part of the Behavioral Based Safety program.

Standards References

ISM: Sec 3.2

TMSA 9A: 1.4

SEMP 1.2.1.e, all of sec 6, 7.1, 8.5a, 9.1g

Human Resource Issue

Human Resource Issue

Cause Type

Typical Issues

Did an effective employee screening program exist? Did it correctly identify requirements for particular jobs? Did a lack of sufficient manpower contribute to the problem?

Typical Recommendations

Assess critical personal capability requirements for each job position.

Consider requiring a physical exam/drug-screen test as a condition of employment.

Consider the manning levels and qualifications necessary to operate the vessel and meet company objectives for safe operation and quality of service.

Examples

An engineer made a mistake operating a process on a color-coded control system because he was color blind. Although a screening program existed for the job, it did not specify the ability to differentiate colors as a requirement.

Company charter arrangements required a certain high standard of vessel maintenance and safe operating condition of machinery and systems. To accomplish this, the company used vessel crew to keep the vessel up between shipyard periods. Due to competitive pressures, the company cut back on vessel manning but failed to take other measures to maintain the vessel in accordance with charter requirements.

Standards References

ISM: Sec 6

ISO 9001: 2000: Sec 6.2.1, 6.2.2

ISO 14001: 2000: Sec 4.4.2

TMSA 2A: 1.2, 1.3, 1.4, 2.2, 4.1, 3A: 1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3, 3.4, 4.1, 4.2, 4.3, 4.5, 3B: 1.1, 3.1, 3.2, 4.1, 4.2

SEMP 4.3, 7.2.2

OHSAS 4.4.2

Employee Screening/Hiring Issue

Intermediate Cause

Typical Issues

Did an effective employee screening program exist? Did it correctly identify requirements for particular jobs? Did it screen employees against those requirements?

Typical Recommendations

Assess critical personal capability requirements for each job position.

Communicate all required job tasks to potential employees before extending employment opportunities.

Ask job interviewees if they can perform job-related tasks.

Consider requiring the passing of a physical exam/drug-screen test as a condition of employment.

Have prospective employees perform a test that simulates the actual work as closely as possible to determine if they can perform the work.

Example

An engineer made a mistake operating a process on a color-coded control system because he was color blind. Although a screening program existed for the job, it did not specify the ability to differentiate colors as a requirement.

Standards References

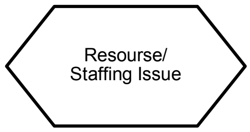
ISM Code: Sec 6.2

ISO 9001: 2000: Sec 6.2.1 and 6.2.2

ISO 14001: 2000: Sec 4.4.2

TMSA 2A: 1.3, 1.4

OHSAS 4.4.2



Resource/Staffing Issue

Intermediate Cause

Typical Issues

Is the vessel properly manned with sufficient skilled and qualified crew to operate safely? Did a lack of sufficient manpower contribute to the problem?

Typical Recommendation

Consider the manning levels and qualifications necessary to operate the vessel and meet company objectives for safe operation and quality of service.

Example

Company charter arrangements required a certain high standard of vessel maintenance and safe operating condition of machinery and systems. To accomplish this, the company used vessel crew to keep the vessel up between shipyard periods. Due to competitive pressures, the company cut back on vessel manning but failed to take other measures to maintain the vessel in accordance with charter requirements.

Standards References

ISM Code: Sec 6

ISO 9001: 2000: Sec 6.2.1, 6.2.2

ISO 14001: 2000: Sec 4.4.2

TMSA 2A: 3.2, 3B: 1.1, 1.2, 1.3, 4.1, 4.2

SEMP 1.2.1h, 3.5

OHSAS 4.4.2

Safety/Hazard/Risk/Security Review Issue

Cause Type

Typical Issues

Was the error caused by an inadequate hazard review of the system? Was a risk assessment of the system performed? Have the safety, reliability, quality and security hazards been identified?

Typical Recommendations

Ensure that all newly installed and/or modified equipment is included in a hazard review prior to startup.

Track and document the final resolution for all recommendations.

Ensure that personnel, equipment and environmental losses are all addressed in the review.

Examples

Because the bow doors on a Roll-on/Roll-off (Ro-Ro) passenger vessel could not be clearly seen from the bridge, it was decided that cameras would be mounted in the interior of the main deck to provide a view of the bow doors via a video monitor on the bridge. Prior to installation of the cameras and video monitor, the vessel put to sea with the bow doors still open. There was an unusually rough sea outside the breakwater to the harbor, which caused water to enter the vessel over the bow and through the bow doors. The vessel capsized within minutes of exiting the harbor.

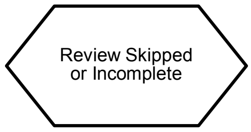
An emergency shutdown actuation failed to stop the discharge of cargo to the shore receiving facility, resulting in a release of hazardous material. The emergency shutdown system had recently undergone a modification. The company's procedures required that a HAZOP be performed of any newly installed or modified systems. The HAZOP procedure was not well-suited for analyzing the emergency shutdown system. (FMEA would have been a better choice of technique).

Standards References

ISM Code: Sec 10.3

TMSA 5A: 1.1, 2.2, 4.1, 4.2, 7B: 1.1, 3.2, 9A: 1.1, 1.2, 1.3, 2.1, 2.3, 2.5, 3.2, 4.1, 4.2, 9B: 1.1, 1.4, 2.3

SEMP 1.2.1b, 2.2.2, 2.3.3, all of Sec 3, 5.2.c, 6.3, 8.6.c, all of Sec 9



Review Skipped or Incomplete

Intermediate Cause

Typical Issues

Was the safety and hazard review complete? Did it consider all modes of operation/maintenance, and were other required hazard review issues considered? Was the review done according to all applicable requirements, regulations, Rules and Guides? Was a safety/hazard/risk review performed?

Typical Recommendations

Provide a safety/reliability/quality/security review procedure that complies with all applicable requirements, regulations, Rules and Guides.

Ensure that the hazard review procedure is readily available to personnel who will conduct the review.

Periodically audit hazard review procedures and reports.

Establish minimum training criteria for hazard review leaders.

Ensure that all newly installed and/or modified equipment is included in a hazard review prior to startup.

Ensure that hazard review documentation is readily available to document the content of the review and to confirm that a review was performed.

Examples

An explosion occurred in the cargo tank number two port because of hot work being performed in the number three port cargo tank. A crack at a weld joint on the bulkhead separating the two tanks was being repaired. A safety/hazard review was not performed prior to beginning the job, so the need to ensure that the tank number two port was regularly tested and maintained in a gas-free state during the course of the work was not identified. A combustible mixture was created in tank number two port as hydrocarbon residue evaporated and became mixed with air.

The vessel ran aground as the pilot hesitated to board due to high winds and waves. Voyage planning had failed to adequately identify the hazard posed by a shoal in close proximity the point where pilots typically board arriving vessels. The vessel slowed during the pilot’s indecision and lost weigh and steerage, allowing it to be blown by the wind onto the shoal.

Standards Reference

SEMP 2.2.2

Recommendations Not Yet Implemented

Intermediate Cause

Typical Issue

Have the recommendations from the safety/reliability/quality/security review been implemented?

Typical Recommendations

Ensure that all hazard review recommendations are documented and reviewed by management personnel.

Management should address all hazard review recommendations and document the manner in which the recommendation will be resolved (i.e., assign a responsible party for completion or reject the recommendation with documented reason for doing so).

Communicate hazard review recommendations to all affected parties.

Document the final resolution or implementation of each recommendation.

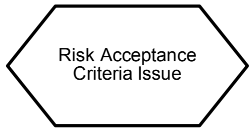
Publish periodic reports of resolution status for management.

Ensure that implementation of the recommendations is assigned to a specific group or individual.

Examples

Because the bow doors on a Ro-Ro passenger vessel could not be clearly seen from the bridge, it was decided that cameras would be mounted in the interior of the main deck to provide a view of the bow doors via a video monitor on the bridge. Prior to installation of the cameras and video monitor, the vessel put to sea with the bow doors still open. There was an unusually rough sea outside the breakwater to the harbor, which caused water to enter the vessel over the bow and through the bow doors. The vessel capsized within minutes of exiting the harbor.

As an additional security measure, it was decided that an attendees list would be provided to the gangway watchperson. No persons were to be allowed aboard the vessel unless their names indicated attendance of the vessel and suitable ID was produced. While the master was provided with the visitors list by e-mail each voyage, the gangway watchperson was not provided with the attendees list and the procedure was not implemented aboard the vessel. The gangway watchperson allowed anyone who signed in to board the vessel. As a result, the master was robbed at gunpoint.



Risk Acceptance Criteria Issue

Intermediate Cause

Typical Issues

Were the risk acceptance criteria used during the safety/hazard/risk/security review set inappropriately? Were risks deemed acceptable that should have been reduced?

Typical Recommendations

Ensure that a diverse team (able to reasonably assess risk) is involved in the hazard review.

Develop more objective criteria for judging risk levels (e.g., a simplified risk scoring scheme or listing required safeguards for specific situations).

Provide guidance to team members to help ensure that the reviews are conducted properly.

Examples

A Ro-Ro passenger vessel capsized when water came in through the open bow doors as the vessel departed the harbor breakwater. While the hazard review had identified the potential consequences of water entering through the bow doors, it had not given proper weight to human error in ensuring that the doors were properly closed prior to departure. As a result, no recommendations regarding means to ensure confirmation of bow door closure prior to sailing were made.

During the design and construction of the world's largest passenger ship, the safety/hazard/risk/security review did not give proper weight to the vessel's increased size, increased speed capabilities and proportionally smaller rudder. These represented substantially different maneuvering characteristics than previously built and conventional ships of the time. As a result, the need for officer familiarization and training regarding the maneuvering characteristics of the vessel were not identified as significant. The vessel hit an iceberg that would have otherwise been easily avoided by conventional ships of the day running at full speed.

Ineffective Review

Intermediate Cause

Typical Issues

Was the safety/hazard/risk/security review procedure less than adequate? Did it provide adequate guidance for the scope of the review? Were the resources needed to perform the review available? Were personnel trained in the use of the procedure?

Typical Recommendations

Ensure that the hazard review technique is appropriate for the complexity of the process.

Ensure that all newly installed and/or modified equipment is included in a hazard review prior to startup.

Ensure that hazard reviews comply with all applicable requirements, regulations, Rules and Guides (e.g., some provide specific checklists for the safety/hazard review).

Ensure that the review procedure addresses the scope of analyses and the training of hazard analysis team leaders.

Examples

An emergency shutdown actuation failed to stop the discharge of cargo to the shore receiving facility, resulting in a release of hazardous material. The emergency shutdown system had recently undergone a modification. The company's procedures required that a HAZOP be performed on any newly installed or modified systems. The HAZOP procedure was not well-suited for analyzing the emergency shutdown system. (FMEA would have been a better choice of technique.)

Damage was sustained to an older vessel subsequent to a change in trade. While the safety/hazard/risk/security review identified the risks and hazards associated with the change in cargo, the vessel's age and the ports of call, the review did not take into account the different sea conditions and weather patterns the vessel would be likely to encounter. As a result, when pressed to make schedule, the vessel was driven into sea and weather conditions that should have been avoided considering the cargo change and age of the vessel.

Problem Identification/
Control Issue

Problem Identification/Control Issue

Cause Type

Typical Issues

Was an event caused by failure to provide corrective action for known deficiencies or failure to implement recommended corrective actions before known deficiencies recurred? Had the problem occurred before and never been reported? Did an audit fail to discover the problem? Did the corrective actions implemented fail to correct the problem?

Note: If the problem/deficiency could/should have been identified or was identified in a safety/hazard/risk/security review, then code the event in that portion of the map and not here.

Typical Recommendations

Track implementation of corrective actions to ensure timely completion.

Consider implementing the same corrective actions for similar situations aboard this and other vessels.

Measure the effectiveness of corrective actions.

Periodically compare the results of audits with events that occur aboard the vessel to ensure that audits are effective in identifying problems.

Examples

A tank overflowed because an engineer ignored an auditory alarm in the control system. The alarm, which sounded spuriously about every 15 minutes, had been broken for more than six months and was routinely silenced and ignored. The malfunction was reported but had not been repaired.

A tank had overflowed when someone started the wrong pump. None of the pump control switches were labeled. A corrective action from this event was to install labels on the pump switches. Prior to installation of the labels, another pump was damaged when the engineer started the wrong pump. The switches for these pumps were not labeled either.

Standards References

ISM Code: Sec 12

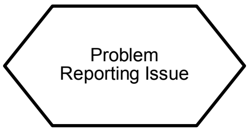
ISO 9001: 2000: Sec 8.5.2

ISO 14001: 2000: Sec 4.4.2

TMSA 3A: 3.3, 4A: 1.3, 2.2, 2.4, 3.2, 4B: 1.1, 5A: 2.1, 2.2, 2.3, 4.1, 4.2, 9A: 1.1, 1.2, 1.3, 2.5, 3.1, 3.4, 9B: 1.2, 10A: 3.1, 12A: 3.2, 12B: All

SEMP 1.2.1k, 3.6, 7.5, 8.6.d

OHSAS 4.5.2, 4.4.2



Problem Reporting Issue

Intermediate Cause

Typical Issues

Are personnel reporting events that have significant impacts on health, safety, security or reliability? Are personnel aware of the types of events that should be reported? Do they know how to report the events? Are employees punished for reporting problems?

Note: Coding under "Rewards/Incentives Issue" may also be appropriate.

Typical Recommendations

Develop event-reporting guidelines.

Provide training to personnel on the types of events that should be reported. Make these examples as operation or job-specific as possible.

Ensure that the event-reporting process is as simple as possible.

Examples

A crew member on cargo watch reported a large air leak on a manifold valve actuator, which required it to be placed in the manual mode of operation. The first officer then required that the crew member remain on duty after his watch to stand by the valve. The crew member had been looking forward to going ashore at the completion of his watch. As a result, the crew member did not report problems with cargo system valves in the future.

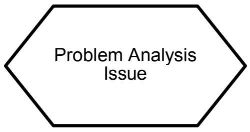
An engineer noted oil dripping from a pump seal. The process for reporting and documenting the problem required a lot of forms to be filled out. The engineer did not want to take the time to complete the forms. As a result, he did not report the problem.

Standards References

ISM Code: Sec 9., 9.1, 10.2.2

ISO 14001: 2000: Sec 4.4.3

OHSAS 4.4.3



Problem Analysis Issue

Intermediate Cause

Typical Issues

Was the problem misdiagnosed? Were knowledgeable personnel involved in the problem analysis? Was proper emphasis placed on problem diagnosis?

Typical Recommendations

Develop generic methods for problem analysis such as the 5-Whys technique, fault tree analysis and/or causal factor analysis.

Provide appropriate experts to assist analysis teams.

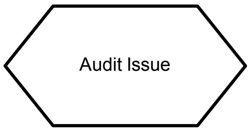
Have the results of the analysis reviewed by someone outside the organization.

Example

During ballasting operations at the loading terminal, the vessel suddenly listed 12 degrees to port due to the effect of free surface. The officer performing the ballasting operations was immediately relieved of duties and fired. The cause of the incident was documented as “human error” and the corrective action as “the officer was replaced.” Two months later, the vessel again listed suddenly during ballast operations at the loading port. A further investigation identified that a number of ballast tank level transmitters required calibration and that a significant amount of water remained in these ballast tanks when their level indicators indicated that they were empty.

Standards Reference

ISM Code: Sec 9.7, 12.2



Audit Issue

Intermediate Cause

Typical Issues

Do audits find problems before they cause safety, reliability, security or quality problems? Are audits performed at regular intervals? Is the scope of the audit appropriate? Are the sampling sizes/methods used appropriate?

Typical Recommendations

Ensure that procedures for periodic audits of systems important to safety, reliability and quality are developed.

Ensure that the audit procedures are implemented.

Provide sufficient guidance and training to ensure that the scope of the audit is appropriate.

Examples

An audit of vessel security awareness and measures was performed aboard each vessel in the fleet; however, similar security audits are not being conducted periodically to verify that officers and crew remain aware and security measures remain implemented despite a continual turnover of vessel personnel.

The internal audit program does not take into account the level of importance of various activities and functions upon safety, reliability or security. All activities and functions are treated with equal weight. As a result, some problems with greater impact upon safety, reliability and security are overlooked or missed by internal audits.

Audit procedures do not require that sampling size be increased when a problem is discovered. As a result, records indicating that a fire extinguisher was three months overdue for inspection and servicing was identified as a minor nonconformity. In reality, a major problem existed as fully one-half of the vessel's fire extinguishers were overdue for inspection and servicing.

Standards References

ISM Code 12.1, 12.3

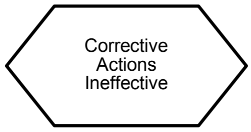
ISO 9001: 2000: Sec 8.2.2

ISO 14001: 2000: Sec 4.4.5

TMSA 4A: 2.4, 9A: 3.1, 3.4, 12B: All

SEMP All of Sec 12

OHSAS 4.5.4, 4.4.5



Corrective Actions Ineffective

Intermediate Cause

Typical Issues

Were implemented corrective actions unsuccessful in preventing recurrence? Should other corrective actions have been identified? Were corrective actions focused on correcting the root causes of the problem?

Typical Recommendations

Involve a multidisciplinary team in identifying corrective actions to ensure that the problem has been fully analyzed.

Refer design/development of corrective actions to specialists when teams have difficulty identifying practical solutions.

Develop measures to determine the effectiveness of corrective actions.

Trend event causes and root causes to determine if corrective actions are effective in preventing recurrence.

Examples

During an internal audit, it was discovered that the ballast tank covers had not been opened prior to commencing ballast pumping operations in accordance with ship operations procedures. The corrective action stated “All officers have been reminded that ballast tank covers must be opened prior to pumping ballast.” Six months later, and after a number of officers had been replaced, another internal audit identified the same problem.

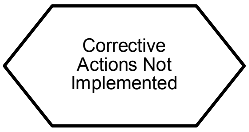
During ballasting operations at the loading terminal, the vessel suddenly listed 12 degrees to port due to the effect of free surface. The officer performing the ballasting operations was immediately relieved of duties and fired. The cause of the incident was documented as “human error” and the corrective action as “the officer was replaced.” Two months later the vessel again listed suddenly during ballast operations at the loading port.

A problem with crew members bypassing alarms had been identified. The corrective action was to administratively control alarm bypasses. After a couple of years, the administrative control requirements were being ignored. Physical changes to equipment may have been more successful in preventing bypassing of alarms.

The procedure development process was modified to ensure that precautions and warnings were placed in procedures, where appropriate. However, an audit of procedures performed a year later identified a number of procedures that did not include precautions and warnings.

Standards References

ISM Code: Sec 9.1, 10.2.3	ISO 14001: 2000 4.4.2
ISO 9001: 2000: Sec 8.5.2, 8.5.3	OHSAS 4.5.2, 4.4.2



Corrective Actions Not Implemented

Intermediate Cause

Typical Issue

Was a recommended corrective action for a known deficiency not implemented (because of delays in funding, delays in design, normal length of implementation cycle, tracking deficiencies, etc.) before recurrence of the deficiency? Are corrective actions assigned to specific groups or individuals for implementation? Does management monitor the implementation of corrective actions?

Typical Recommendations

If a system is deficient and requires corrective actions that cannot be implemented immediately, interim measures should be taken (implementing a temporary operating procedure, making process parameter changes, shutting equipment down, etc.).

Corrective actions affecting safety and security should not be delayed because of lack of funding, delays in project design or normal length of the implementation cycle.

The cost of implementing corrective actions with significant impacts on reliability, prevention of pollution and quality should be balanced against the anticipated savings from implementation.

Ensure that management periodically reviews the status of corrective actions.

Reward personnel for completing corrective actions.

Examples

Because the bow doors on a Ro-Ro passenger vessel could not be clearly seen from the bridge, it was decided that cameras would be mounted in the interior of the main deck to provide a view of the bow doors via a video monitor on the bridge. An item was added to the vessel pre-departure checklist to confirm that the bow doors were closed prior to leaving the berth. While awaiting the installation of the cameras, an interim corrective action was developed to have the bosun physically confirm closure of the bow doors and report the closure to the bridge watch. Before the measure was implemented, the vessel put to sea with the bow doors still open. There was an unusually rough sea outside the breakwater to the harbor, which caused water to enter the vessel over the bow and through the bow doors. The vessel capsized within minutes of exiting the harbor.

An incident investigation recommended that small drain holes be drilled in the discharge line of all fire monitors to prevent accumulation of water that could freeze and plug the monitor. This recommendation had not been implemented before another fire occurred, and two of the three monitors failed because they were plugged with ice.

Standards References

ISM Code: Sec 9.2, 12.3, 12.6

ISO 9001: 2000: Sec 8.5.2, 8.5.3

ISO 14001: 2000: Sec 4.4.2

OHSAS 4.5.2, 4.4.2

Change Control Issue

Change Control Issue

Cause Type

Typical Issues

Were any of the following changed or modified without review and/or authorization?

- Operations
- Maintenance practices
- Vessel design
- Materials
- Equipment or machinery

Was control of the changes inadequate? Was an error caused by improper review of the potential hazards or consequences that could arise from the change? Were changes inadequately verified as completed correctly? Was there inadequate documentation (drawings, procedures, safe job analysis, etc.) of the change or the implications of the change? Was documentation, including drawings and procedures, updated to reflect the change? Is there a means for accommodating temporary versus permanent changes?

Typical Recommendations

Train all employees to understand the difference between a change and a replacement-in-kind.

Changes should be reviewed and approved prior to implementation.

Changes should be verified as completed correctly after implementation.

The change process and all its steps should be documented.

Periodically audit to verify that all changes have been documented.

Examples

A buoy was dragged 300 meters south of its original position by ice floes during the previous winter. A Notice-to-Mariners documented this occurrence so that vessels could update their charts accordingly. A particular vessel did not update the charts as required. During a voyage in the area, that buoy was used as the sole navigational reference even though using three references is normal practice. Both undocumented changes to the charts and the deviations from good operating practices contributed to the grounding of the vessel.

A test valve was installed on an emergency bilge pump discharge line without a non-return capability. The valve was left open after testing, and the vessel undertook a voyage with the valve open. While leaving the harbor, high level bilge alarms began to sound and the vessel began to flood. After investigating the source of the flooding, it was determined that the crew must ensure that the test valve is closed when not being used for testing.

Standards References

ISO 9001: 2000: Sec 7.3.7

TMSA 7A: 1.1, 1.2, 2.1, 2.2, 2.3, 3.1, 3.2, 4.1, 4.2, 7B: 1.1, 2.1, 3.1, 3.2, 4.1, 4.2

SEMP 1.2.1c, 3.4, all of Sec 4, 5.3, 7.4, 8, 5.d, 8.6.e, 9.1.f

Change Not Identified

Intermediate Cause

Typical Issues

Was the change identified? Was the definition of change inadequate? Did personnel understand the definition of "change" versus "replacement-in-kind"? Was the change not documented because it was considered temporary?

Typical Recommendations

Ensure that authorization signatures were obtained from key personnel before changes are implemented.

Train all employees to understand a change versus a replacement-in-kind.

Train employees on how to initiate a request for change.

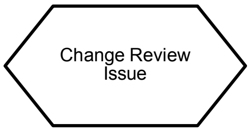
Train employees of the change process requirements for both temporary and permanent changes.

Provide specific examples of what is and is not a change requiring review.

Examples

An automatic steering shutoff control was changed. The new device released the automatic steering upon movement of the wheel without providing notice to the bridge personnel. This was contrary to the old device that required a separate control action to release automatic steering.

A steel workboat changed duties from daily use to a standby role (i.e., used approximately once per week). While preparing to disembark after loading, it was noticed that the bow was low in the water. It was found that the forward space was flooded. The source of the water ingress was a 50-cm hole below the waterline. Further investigation determined that stray electrical currents between the steel pier and the vessel hull had accelerated wastage of the anodes and thus the corrosion rate of the vessel.



Change Review Issue

Intermediate Cause

Typical Issues

Was a change review completed? Did it consider all modes of operation/maintenance, and were other required safety/reliability/quality/environmental/security review issues covered? Was the change review process clear and complete? Are personnel trained in the change process? Was the change intended as temporary but no review or reinstatement of original conditions occurred?

Typical Recommendations

Provide a change process that describes the necessary level of review based on the type or extent of change.

Ensure that the change process is documented for personnel who will conduct the review.

Periodically audit change reviews to check for appropriateness and completeness.

Establish training requirements relating to the change review process.

Ensure that all changes are adequately reviewed prior to implementation.

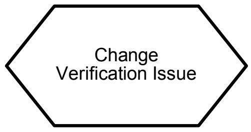
Ensure that the change review is documented and proper authorizations are obtained prior to change implementation.

Examples

A gasket of composition materials was substituted where a flexatalic gasket was required in a piping flange. As a result, a leak occurred.

An unauthorized alteration occurred where the oily water separator was bypassed, resulting in discharge of oil overboard.

A deck crane was stowed after the failure of a piston rod for the jib control cylinder. The piston rod failed at the site of an earlier temporary welded repair. The temporary repair used unsuitable materials for a permanent, safety-critical, load-bearing component.



Change Verification Issue

Intermediate Cause

Typical Issues

Were changes verified to conform with details outlined and approved in the change request documentation? Were new or modified systems, equipment or components functionally tested prior to installation? Were materials verified to be appropriate and correct prior to installation?

Typical Recommendations

Conduct a change review for new or modified systems, equipment or materials and ensure that all requirements of the review have been met prior to use.

Conduct an assessment of changes to ensure proper installation.

Examples

A control valve failed to the wrong position upon loss of instrument air. A change review was not performed because the valve was installed as part of a replacement-in-kind.

A new model of air compressor was installed. A change review was conducted to ensure the appropriateness of the change. However, the compressor was not tested prior to installation. As a result, the compressor failed soon after startup because of an insufficient cooling water supply.

Change Not Documented

Intermediate Cause

Typical Issues

Were drawings and documents updated when changes were made? Was a procedure not updated in response to a corrective action taken? Was a procedure not updated in regard to an equipment upgrade? Did documents/drawings reflect the current status? Were documents used aboard ship marked up to make them useful? Do documents contain all of the required information?

Note: This node applies primarily to whether changes were documented or not. If the documentation is inaccurate, incomplete or unavailable, or if it was not properly reviewed, then the problem should fall under the "Document (Drawing) Control Issue" node and the appropriate subordinate node.

Typical Recommendations

Require authorization signatures for changes.

Include the task of updating drawings and procedures in the change process.

Involve employees in periodic reviews of changed documentation.

Consider conducting mandatory walkthroughs on the vessel to verify that changes were implemented as intended.

Examples

Two system modifications were being implemented concurrently; however, the design engineers did not know this. The drawings did not indicate that changes were pending from these two modifications. As a result, changes implemented by the first modification were undone by implementation of the second modification.

An oil spill occurred while repairing a section of piping. Isolations of the line had been made based on current drawings. The drawings were not up to date and did not show that a new line had been tied into the section of piping three months earlier. The system for ensuring that documentation was kept up-to-date was not adequate. The drawings on the vessel were six months out of date.

A buoy was dragged 300 meters south of its original position by ice floes during the previous winter. A Notice-to-Mariners documented this occurrence so that vessels could update their charts accordingly. A particular vessel did not update the charts as required. During a voyage in the area, that buoy was used as the sole navigational reference even though using three references is normal practice. Both undocumented changes to the charts and the deviations from good operating practices contributed to the grounding of the vessel.

Standards References

ISM Code: Sec 11	TMSA 7A: 2.3, 7B: 2.1
ISO 9001: 2000: Sec 4.2	SEMP 12.6
ISO 14001: 2000: Sec 4.4.5	OHSAS 4.4.5

Document (Drawing) Control Issue

Document (Drawing) Control Issue

Cause Type

Typical Issues

This node includes issues pertinent to ensuring that relevant and current information is available where needed.

Were drawings or documentation not complete or up to date? Was a newly issued procedure entered into the operations manual? Was control of aboard vessel changes inadequate? Was the error caused by improper control of original manufacturer's manuals? Was an uncontrolled copy of a procedure/drawing used? A newly issued revision to a procedure was not entered into the operations manual to replace the previous (now obsolete) revision.

Note: This node does NOT apply to procedures. Procedures are covered in their own section.

Note: This section applies to both hard copies and software copies of documents.

Typical Recommendations

Vessel changes to system drawings should be reviewed and approved.

Periodically audit to verify that all controlled documentation is up-to-date.

Examples

The main engine manual issued by the manufacturer to the vessel at delivery was for a previous modification of the engine model. The information contained in the manual pertaining to the turbochargers was for a unit other than the one installed on the engine.

The vessel's drawing of the saltwater service system did not include the emergency crossover line into the fire main system.

The drawing for the steam supply system was not updated after a change. As a result, a leak occurred during maintenance activities (a line break) when all of the supply lines were not isolated.

Standards References

ISM Code: Sec 11

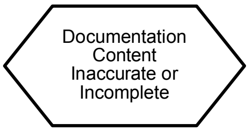
ISO 9001: 2000: Sec 4.2

ISO 14001: 2000: Sec 4.4.5

TMSA 1B: 1.1, 9A: 2.2, 4A: 2.1, 7A: 3.1, 12B: 3.1

SEMP 1.2.1.I, 2.2.1, 2.2.2, 2.3.1, 3.6, 9.1.c, all of Sec 13

OHSAS 4.4.5



Documentation Content Inaccurate or Incomplete

Intermediate Cause

Typical Issues

Were drawings and documents accurate? Did drawings and documents contain sufficient information for the need? Were sufficient details provided to make operational and maintenance decisions?

Typical Recommendations

Edit drawings to accurately reflect the vessel's cargo piping configuration.

Revise drawings and documents to provide sufficient information for personnel to make operational and maintenance decisions.

Revise the content of documentation, such as personnel information documents, loading manifests, schedules, list of contacts and navigational charts, to provide sufficient and accurate information.

Develop/revise the process for updating documents to ensure that they are kept up to date.

Examples

The main engine manual issued by the manufacturer to the vessel at delivery was for a previous modification of the engine model. The information contained in the manual pertaining to the turbochargers was for a unit other than the one installed on the engine.

The vessel's drawing of the saltwater service system did not include the emergency crossover line into the fire main system.

Standards References

ISM Code: Sec 11

ISO 9001: 2000: Sec 4.2

ISO 14001: 2000: Sec 4.4.5

OHSAS 4.4.5

Required Documents Not Available or Missing

Intermediate Cause

Typical Issues

Are documents readily available to personnel who may need them in the performance of their work? Does the distribution of controlled documents make pertinent documents available where they are needed?

Typical Recommendation

Ensure that controlled copies of documentation necessary for the proper performance of work are readily available to personnel responsible for performing the work.

Examples

Contact information for port personnel was routinely updated. However, the updated list could not be located. The old list had been thrown out. As a result, the vessel had difficulty contacting the proper individuals regarding provisions for the vessel.

Equipment additions in the bridge required the storage location of navigational charts to be moved to an inconvenient location.

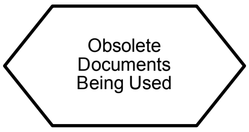
Standards References

ISM Code 11.2.1

ISO 9001: 2000: Sec 4.2

ISO 14001: 2000: Sec 4.4.5

OHSAS 4.4.5



Obsolete Documents Being Used

Intermediate Cause

Typical Issues

Were documents that were in use out of date? Do document control procedures ensure that obsolete documents are removed from points of use when new revisions are issued? Are uncontrolled documents that are in use that are not subject to replacement and disposal when new versions are issued?

Typical Recommendations

Do not allow the use of uncontrolled documentation.

Require obsolete documentation to be destroyed or returned to document control when new revisions are issued.

Ensure that procedures at the point of use (placards and summary procedures mounted on equipment) are routinely reviewed and updated as part of the management of change process.

Examples

The drawing for the steam supply system was not updated after a change. As a result, a leak occurred during maintenance activities (a line break) when all of the supply lines were not isolated.

An uncontrolled copy of the emergency response contact call list was posted in the radio room. A revision was made to a number of documents in the emergency response manual, including the emergency contact call list. Because the posted copy was not controlled, it was not replaced with the new contact call list. A minor spill occurred that required persons in the emergency response organization to be contacted. The posted emergency response contact call list was used, resulting in failure to make critical contact.

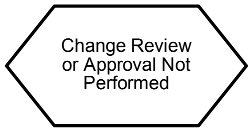
Standards References

ISM Code 11.2.1 and 11.2.3

ISO 9001: 2000: Sec 4.2

ISO 14001: 2000: Sec 4.4.5

OHSAS 4.4.5



Change Review or Approval Not Performed

Intermediate Cause

Typical Issues

A documentation change was not reviewed and approved by someone knowledgeable in the process.

A documentation change was not reviewed by parties potentially affected by the change.

Note: Dual coding under "Change Review Issue (Change Control Issue)" may also be appropriate.

Typical Recommendations

Documents for making procedural changes should include a review and sign-off by parties potentially affected by a proposed procedure change.

Documentation changes should be reviewed and approved by persons knowledgeable in the affected process.

Examples

A change was made to the fuel oil supply system. However, no review was performed of the revised system drawing. As a result, the wrong piping material was used.

A delay occurred in the fabrication of a new display system for the engine compartment. The drawings did have the proper approval signatures, so the manufacturer would not proceed with work on the display.

Standards References

ISM Code 11.2.2

ISO 9001: 2000: Sec 4.2

ISO 14001: 2000: Sec 4.4.5

OHSAS 4.4.5

Vessel Spares/Stores Issue

Vessel Spares/Stores Issue

Cause Type

Typical Issues

Was the problem caused by inadequate material handling, storage, packaging or shipping? Was an unauthorized material substitution made? Were spare parts inadequately stored?

Typical Recommendations

Ensure that spares/stores are stored in a proper environment.

Inspect materials for damage upon arrival at the vessel.

Provide proper packaging of materials to avoid damage during shipping.

Examples

A spare motor was being loaded aboard the vessel using the stores' crane. The crane operator hurried the operation and attempted to traverse the crane horizontally while lifting the motor toward the deck. His timing was poor, and the motor's shaft impacted the vessel side plating just below the deck level, damaging the motor.

A spare motor was stored in the steering gear room. The motor was not properly lashed down, and in heavy weather, it broke loose and freely slid around the steering gear room, causing damage to other stored items and the motor itself.

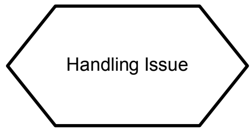
A printed circuit board was sent ashore for repair and recalibration. The circuit board was not wrapped in bubble wrap and properly placed in a box with packing material as required by instructions. The circuit board was cracked when it arrived at the vendor's facility, making it useless.

As a result of improper labeling, a particular type of grease was placed into inventory on the wrong shelf in the stores room. Subsequently, a pump failed when this grease was used instead of the one specified for that pump.

Standards References

ISO 9001: 2000: Sec 7.5.4

TMSA 4A: 3.1, 4.2, 10B: 2.1



Handling Issue

Intermediate Cause

Typical Issues

Were spares/stores damaged during handling? Was the equipment used for moving materials appropriate for the items? Were adequate procedures in place to ensure that items were placed in the assigned storage location?

Typical Recommendation

Consider the size, weight and hazards associated with transporting materials and choose a mode of transport that is appropriate.

Examples

Several packages of frozen foods were accidentally mixed with boxes containing machinery spares while being loaded aboard the vessel. The mix-up was discovered after the foods had thawed and were effectively unsuitable for incorporation into the vessel's food supplies.

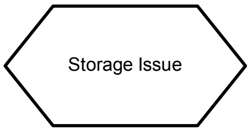
A net was being used in conjunction with the engine room crane to lower gas bottles from the vessel's main deck into the lower engine room. The openings in the net were not small enough to prevent a small-size gas bottle from slipping through the net and falling to the lower engine room. The cap had been placed loosely on the bottle and came off at first impact as the bottle fell into the engine room. The subsequent impact broke the valve off and caused the bottle to rocket through the engine room as the gas was instantly expelled.

A spare motor was being loaded aboard the vessel using the stores' crane. The crane operator hurried the operation and attempted to traverse the crane horizontally while lifting the motor toward the deck. His timing was poor, and the motor's shaft impacted the vessel side plating just below the deck level, damaging the motor.

A box containing oxygen sensors was loaded in the stores crane net with a number of other items, including some heavy metal objects. During the lift, the boxes containing the oxygen sensors were damaged. Upon inspection, the sealed packages containing two of the sensors had been pierced, eliminating any shelf life and possibly damaging the sensors.

Standards Reference

ISO 9001: 2000: Sec 7.5.2



Storage Issue

Intermediate Cause

Typical Issues

Was material stored improperly? Was it damaged in storage? Did it have weather damage? Was it stored in an environment (heat, cold, acid fumes, etc.) that damaged it? Was product properly stored? Were material/equipment/parts issued after their shelf life was exceeded? Did materials continue to be used after the shelf life was exceeded? Were spare parts and equipment stored properly? Was adequate planned maintenance (cleaning, lubrications, etc.) performed on spares?

Note: Dual coding under "Planned Maintenance Issue (Maintenance Program Implementation)" may also be appropriate if spares are damaged in storage as a result of lack of maintenance.

Typical Recommendations

Ensure that materials that require a controlled environment for storage are not exposed to the weather.

Promptly correct problems affecting storage in controlled environments (failures of heating/cooling systems, humidity control systems, etc.).

For materials with a shelf life, develop a system to document the material's shelf life, date of manufacture and date of distribution.

Ensure that spare parts are not exposed to adverse weather conditions.

Promptly correct problems in equipment storage conditions or environmental controls in warehouses.

Examples

Gas sampling tubes received to replenish used supplies were hastily stored at the front of the gas sampling equipment cabinet rather than drawing existing supplies toward the front and placing new stock toward the back in order to facilitate stock rotation. Sampling tubes were pulled from the front of the cabinet when required, and the stock located toward the back was not used. After the use of a number of sampling tubes, the older inventory located toward the back of the cabinet came into use. The gas sampling tubes were found to be out of date, and the results of tests performed with them were of questionable validity.

Spare acetylene and oxygen bottles were stored in the same locker located on the main deck above the engine spaces. Regulations and safety precautions require that these gases must be stored in separate spaces to prevent the increased danger of explosion in the event of a gas release and/or fire involving the space.

A spare motor was stored in the steering gear room. The motor was not properly lashed down, and in heavy weather it broke loose and freely slid around the steering gear room, causing damage to other stored items and the motor itself.

Standards Reference

ISO 9001: 2000: Sec. 7.5.4

Packaging/Transport Issue

Intermediate Cause

Typical Issues

Was material packaged properly? Was it damaged because of improper packaging? Was equipment exposed to adverse conditions because the packaging had been damaged? Was the material transported properly? Was it damaged during shipping?

Typical Recommendations

Inspect materials for damage upon initial arrival aboard the vessel.

Ensure that packaging specifications are documented, communicated and clearly understood by the vendor.

Examples

A cardboard box containing a number of ball valve parts was damaged and broken open. Upon inspection of the contents, two parts listed on the packing list were missing. The box contained the spares with no packing materials to absorb impacts and minimize handling damage. It appeared as if the contents of the box itself served to break the package open during some point in transit.

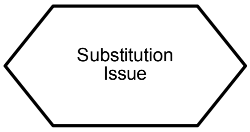
A printed circuit board was sent ashore for repair and recalibration. The circuit board was not wrapped in bubble wrap and placed in a box with packing material as required by instructions. The circuit board was cracked when it arrived at the vendor's facility, making it useless.

The cardboard packaging containing powdered chemicals arrived aboard the vessel water damaged. Upon inspection, the powdered chemicals were found to be clumped, indicating that some moisture had entered the packaging and damaged the chemicals.

A printed circuit board incurred water damage because it was not packaged in waterproof packaging as specified in the packaging requirements.

Standards Reference

ISO 9001: 2000: Sec 7.5.4



Substitution Issue

Intermediate Cause

Typical Issues

Were incorrect stores or spares substituted? Were parts substituted without authorization? Did the requirements specify no substitution? Did substitution of different stores or spares have an adverse effect on a job or a repair?

Note: Items under this category may require dual coding under "Changes to Purchasing Specifications (Purchasing Issue)" or "Change Control Issue".

Typical Recommendations

Implement a management of change program.

Assess the impact of substitutions on the quality of spares.

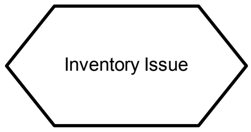
Examples

A replacement cylinder liner made by an after-market manufacturer was substituted for one made by the engine manufacturer. The replacement cylinder liner was manufactured of inferior materials and under a different process than the original. It required replacement within less than half the time expected of the original equipment.

USDMA Notices-to-Mariners were substituted for Admiralty Notices-to-Mariners. They were incompatible with Admiralty Charts.

A printed circuit board was sent ashore for repair and recalibration. The circuit board was not wrapped in bubble wrap and properly placed in a box with packing material as required by instructions. The circuit board was cracked when it arrived at the vendor's facility, making it useless.

A valve failed, causing a spill to the environment. The valve was not the one specified for this service. Because the specified one was not available, a substitute had been installed without the proper review and authorization.



Inventory Issue

Intermediate Cause

Typical Issues

Are inventory allowance levels sufficient to meet operating needs? Are inventory levels replenished in a timely manner? Are recorded inventory levels accurate?

Typical Recommendations

Set inventory allowance levels appropriate to operating needs.

Ensure that an adequate inventory of spares for critical equipment is maintained.

Develop an inventory tracking system that maintains an accurate count of inventory items.

Ensure timely order and supply of used spares.

Example

Oily water separators may only be operated with a functioning oil content meter (OCM). The vessel is required to maintain a calibrated spare OCM onboard at all times. The OCM had to be changed and a replacement was ordered immediately upon changeout. A replacement OCM was not supplied at several port calls, and the vessel went without a replacement for over a month. The in-service OCM failed and, as a result, the vessel was without a spare. The ship had to retain all oily water aboard until reaching port where a reception facility was available to receive the oily water.

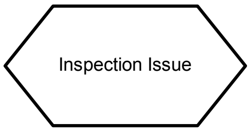
Standards References

ISM Code: Sec 10

ISO 14001: 2000: Sec 4.4.6

SEMP 1.2.1.a

OHSAS 4.4.6



Inspection Issue

Intermediate Cause

Typical Issues

Are spares, stores or other materials inspected for conformity with requirements prior to incorporation into the ship's inventory?

Are requirements easy to understand and suitable for ensuring conformity?

Note: This node applies to the inspection of items for conformity with requirements prior to being incorporated into vessel inventory. Inspection upon receipt, including reviewing accompanying documentation and/or packing slips and ensuring that received spares, stores and materials are not damaged and are in good order, is addressed under Inspection on Receipt Issue (Purchasing Issue). In a number of cases, vessels may perform an inspection activity that includes both the subject of this node and that of the Inspection on Receipt Issue node. Coding will depend upon the activity being performed.

Typical Recommendation

Inspect items to ensure conformity with requirements prior to incorporation into the ship's inventory of spares or stores.

Examples

A replacement cylinder liner made by an aftermarket manufacturer was substituted for one made by the engine manufacturer. The cylinder liner was not inspected prior to incorporation into spares. The replacement cylinder liner was manufactured of inferior materials and under a different process than the original. After being placed in service, it required replacement within less than half the time expected of the original equipment.

The vessel requisitioned six injector part replacement kits. After receipt, the inspection prior to incorporation into the ship's spares did not identify that the parts were for another model of injector. As a result, the vessel did not have spares when required.

Standards Reference

ISO 9001: 2000: Sec 7.5.3

Purchasing Issue

Purchasing Issue

Cause Type

Typical Issues

Were complete specifications for the ordered item provided in purchasing documentation? Was the error the result of inadequate control of changes to procurement specifications or purchase orders? Was an incorrect item received? Were proper specifications and evaluations used to select contractors?

Typical Recommendations

Procurement specifications should not be changed without review and approval by knowledgeable personnel.

Ensure that acceptance requirements are documented and match the design requirements.

Ensure that the contractor selection process considers the impact on overall cost, reliability, prevention of pollution and quality.

Example

The purchasing description for ball valve parts stated the size of the valve and manufacturer but did not clearly state the model number. As a result, parts for a similar valve designed for a different service were provided.

Standards References

Part of Operational Controls under ISO 14001: 2000 Sec 4.4.6

ISO 9001:2000: Sec 7.4.1

TMSA 5A: 2.4

SEMP 6.3, 8.2, 8.5.c, 13.3.g

OHSAS 4.4.6

Purchasing Specifications Issue

Intermediate Cause

Typical Issue

Did the purchasing specifications include drawings or references to drawings? Was an adequate description provided of the ordered parts, stores or materials?

Did the purchase specifications include (1) a schedule for delivery of the materials, (2) material packaging and shipping requirements, (3) safety requirements, (4) liability clauses and (5) payment schedules?

Note: This node applies to HOW items are obtained, not WHAT is obtained. See "Inspection on Receipt Issue" for problems related to specifications of spares, stores or materials that are received.

Typical Recommendation

Develop purchase specifications with input from the technical contacts, procurement specialists, attorneys and others in your company to ensure that all contractual requirements are addressed.

Examples

The purchasing description for ball valve parts stated the size of the valve and manufacturer but did not clearly state the model number. As a result, parts for a similar valve designed for a different service were provided.

The urgency of a purchasing requirement was not indicated with the requisition ordered by the vessel. This resulted in the required parts not being supplied in time for a needed repair.

Standards Reference

ISO 9001: 2000: Sec 7.4.2

Changes to Purchasing Specifications

Intermediate Cause

Typical Issues

Were changes made to purchase orders or procurement specifications without the proper reviews and approvals? Did the changes result in purchase of the wrong materials? Did changes in contract language cause safety, reliability, environmental, security, quality or legal problems?

Typical Recommendations

Include procurement control procedures in the management of change program.

Provide receipt inspection that compares the materials supplied against the original purchasing documents.

Examples

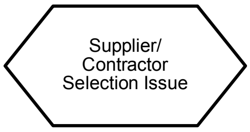
The vessel requisitioned six injector replacement kits. The corresponding purchase order issued by the vessel superintendent was for three kits. There was no communication between the vessel and the superintendent regarding the change. The vessel did not have enough kits to complete the scheduled overhaul of injectors.

The vessel requisitioned mooring wires for a much needed replacement. The specifications used matched those specified in the ship's drawings. The specification was changed on the purchase order to a much less expensive wire claiming the same breaking strength. The line received was of larger diameter and inferior quality and was difficult to handle.

A contract to hire subcontractors originally required the contractors to provide hazardous material handling training to their personnel at the contractor's expense. This requirement was subsequently dropped. As a result, the company had to pay for the training and pay the contractors for the time their personnel spent in the training.

Standards Reference

ISO 9001: 2000: Sec 7.4



Supplier/Contractor Selection Issue

Intermediate Cause

Typical Issue

Do the supplier selection/qualification process criteria take into account the supplier's ability to deliver required materials undamaged, on time and in conformance with requirements?

Does the contractor selection process address the following: (1) safety, environmental and security requirements, (2) training, (3) liability and (4) scheduling?

Typical Recommendations

Procedures for supplier/subcontractor selection should include an evaluation of the supplier's capability to provide required materials on time.

Subcontractor selection criteria should include evaluating whether the subcontractor's resources are sufficient to perform service in accordance with requirements and in a timely manner.

Develop purchase specifications for contract services with input from the technical contacts, procurement specialists, attorneys and others in your company to ensure that all contractual requirements are addressed.

Examples

A supplier was selected based on price to service and calibrate measurement and control equipment. The supplier's ability to perform in a timely manner was not considered and, as a result, measurement and control equipment took a long time to service, calibrate and return to the vessel.

A contract to hire subcontractors did not specify who was responsible for paying for hazardous material handling training for the contract personnel. As a result, the company had to pay for the training and pay the contractor for the time its personnel spent in the training.

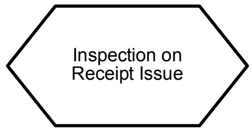
The contract for supplying maintenance personnel did not specify that equipment supplied and used by the contractor be subject to approval by the company. As a result, the contractor used substandard equipment.

Standards References

ISO 9001: 2000: Sec 7.4.1

TMSA 10B: 4.2

SEMP 1.1.2, 6.1, 6.2, 6.4, 7.5, App A



Inspection on Receipt Issue

Intermediate Cause

Typical Issues

Are inspection/acceptance criteria for received spares, stores or other purchased materials clear and easy to understand? Does accompanying documentation or packing slips indicate receipt of an ordered item? Does the accompanying documentation confirm that goods received match procurement specifications? Were all the items indicated on the delivery receipt received?

Note: This item applies to inspection on receipt, including reviewing accompanying documentation and/or packing slips and ensuring that received spares, stores and materials are not damaged and are in good order. Inspections of items for conformity with requirements prior to being incorporated into vessel inventory are taken into account under "Inspection Issue (Vessel Spares/Stores Issue)". In a number of cases, vessels may perform an inspection activity that includes both the subject of this node and that of the "Inspection Issue" node. Coding will depend upon the activity being performed.

Typical Recommendations

Develop inspection/acceptance criteria for spares, stores or other purchased materials received by the vessel.

Ensure that inspection/acceptance requirements can be reasonably implemented considering the vessel's limited time in port.

Examples

A number of boxed items were delivered to the vessel. Two packages were damaged. Further inspection to determine if the contents of the packages were in good order was not performed. The shipment of items was signed for without indicating any damage. When the boxes were unpacked in order to incorporate the contents into the ship's inventory, items contained in them were found to be damaged. The handler claimed the items were delivered in good order.

A shipment of 15 boxes of spares and stores items were received by the vessel. The accompanying documentation indicated that there were 16 boxes in the shipment. Vessel personnel signed for the shipment of 16 boxes without counting what was actually received. The supplier claimed that 16 boxes were delivered and that vessel personnel verified by signature that they had all been received.

Standards Reference

ISO 9001: 2000: Sec 7.4.3

Charter/Contract Fulfillment Issue

Charter/Contract Fulfillment Issue

Cause Type

Typical Issues

Are customer requirements clearly understood and communicated? Are charter/contract requirements documented? Is the chartered/contracted vessel suitable for customer requirements?

Note: This item and subordinate items address contract arrangements. The terms "charter" and "contract" can be used interchangeably within this context.

Typical Recommendations

Document charter requirements that are negotiated and fixed verbally. Provide the vessel with pertinent contract documentation.

Ensure that all charters/contracts are reviewed by pertinent parties prior to fixture or acceptance.

All vessel particulars and design capabilities pertinent to the charter/contract should be available to chartering/sales personnel.

Any exceptions or temporary limitations in regard to a vessel's design capabilities should be communicated to the chartering/sales department.

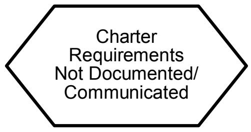
Examples

A product carrier was chartered to take on a cargo from a terminal where it regularly loaded a heavy petroleum product. The vessel was not made aware that it would be picking up a much lighter product, which would require tank cleaning prior to arrival. As a result, the vessel arrived at the load terminal with unacceptable tank conditions.

A vessel with a tall superstructure was chartered to lift cargo in a port where a number of bridges crossed the channel on the way to the loading terminal. The tides and air draft were not taken into account when the charter agreement was made. The vessel was delayed a number of hours for maneuvering from pilot station to berth upon arrival and from berth to pilot station upon departure in order to clear the bridges with sufficient air draft. As a result, the terms of the charter regarding scheduled delivery of the cargo were not fulfilled.

Standards Reference

ISO 9001: 2000: Sec 5.5.6



Charter Requirements Not Documented/Communicated

Intermediate Cause

Typical Issues

Are charter/contract requirements documented? Have all pertinent charter/contract requirements been communicated to the vessel? Have changes to existing long-term charter/contract agreements been recorded and communicated?

Typical Recommendations

Document charter requirements that are negotiated and fixed verbally.

Provide the vessel with pertinent contract documentation.

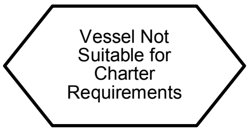
Examples

The change in a charter agreement to lift 30,000 tons of product on May 1 instead of May 2 was not communicated to the vessel. The vessel slow-steamed to the load port for a May 2 arrival and, as a result, missed the rescheduled load date of May 1.

A product carrier was chartered to lift a cargo from a terminal where it regularly loaded a heavy petroleum product. The vessel was not made aware that it would be picking up a much lighter product, which would require tank cleaning prior to arrival. As a result, the vessel arrived at the load terminal with unacceptable tank conditions.

Standards Reference

ISO 9001: 2000: Sec 5.5.6



Vessel Not Suitable for Charter Requirements

Intermediate Cause

Typical Issues

Is the vessel suitable for the intended charter or service? Are the charter/contract requirements reviewed by all affected parties? Are all pertinent considerations taken into account?

Typical Recommendations

Ensure that all charters/contracts are reviewed by pertinent parties prior to fixture or acceptance.

All vessel particulars and design capabilities pertinent to the charter/contract should be available to chartering/sales personnel.

Any exceptions or temporary limitations in regard to a vessel's design capabilities should be communicated to the chartering/sales department.

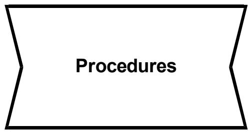
Examples

A vessel was chartered to carry a cargo that was required to be maintained at 45°C. However, the vessel heating coils were no longer functional in a number of the tanks in which the cargo would be carried.

A vessel with a tall superstructure was chartered to lift cargo in a port where a number of bridges crossed the channel on the way to the loading terminal. The tides and air draft were not taken into account when the charter agreement was made. The vessel was delayed a number of hours for maneuvering from pilot station to berth upon arrival and from berth to pilot station upon departure in order to clear the bridges with sufficient air draft. As a result, the terms of the charter regarding scheduled delivery of the cargo were not fulfilled.

Standards Reference

ISO 9001: 2000: Sec 5.5.6



Procedures

Cause Category

Typical Issues

Was a procedure used to perform the job? Was the procedure incorrect or incomplete? Was a procedure developed for the job? Was a procedure required to perform the job?

Note: Procedures provide detailed, step-by-step directions on how to accomplish a task. Guidance documents that provide general guidance and principles should be addressed under "Company Standards, Policies or Administrative Controls (SPACs) Issue" or "Company SPACs Not Used" (see the root cause level on page 2 of the map).

Typical Recommendations

Ensure that copies of procedures are available for worker use at all times.

Ensure that procedures are in a standard, easy-to-read format.

Perform a walkthrough of new and revised procedures.

Use look-up tables instead of requiring calculations to be performed.

Examples

A crew member failed to complete a critical step in an operation because the procedure he obtained from the procedure files was not the most recent revision.

A new mate failed to complete a critical step because the procedure was not detailed enough. It was written as a guideline/reminder for experienced crew members.

Standards References

ISM Code 7, 11.2.1

ISO 9001: 2000: Sec 4.2

ISO 14001: 2000: Sec 4.4.5

TMSA 1A: 2.3, 1B: 1.4, 2.1, 2.2, 3.2, 5A: 1.1, 1.4, 3.4, 6A: 1.1, 1.3, 2.1, 2.4, 3.1, 3.2, 6B: 1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 3.2, 4.1, 7A: 1.2, 3.4, 2.5, 3.2, 8A: All, 8B: 3.1

SEMP 1.2.1d, 1.2.4, 3.3.2.e, all of sec 5, 6.3, 7.1, 7.2.2, 8.5.a, 9.1.b, Sec 11

OHSAS 4.3.4, 4.4.4, 4.4.5

Not Used

Not Used

Cause Type

Typical Issues

Was a procedure used to perform the job? Was a copy of the procedure available to the worker? Did the procedure system require that the procedure be used as a task reference or was it just for training? Were personnel required to take copies of the procedure to the field? Was a procedure written for this task?

Typical Recommendations

Ensure that copies of procedures are available for worker use at all times.

Develop procedures with sufficient detail for the least experienced, qualified worker.

Supplement training and reference materials with easy-to-carry checklists that parallel a procedure.

Examples

An engineer made a mistake lining up valves. He performed the task without using the controlled procedure because he would have had to make a copy of the master.

A mechanic incorrectly performed a repair job on a pump without using the procedure. Mechanics were not required to use the procedure because it was for training purposes only. However, using the procedure would probably have prevented the error made by the mechanic.

Standards References

ISM Code 11.2.1

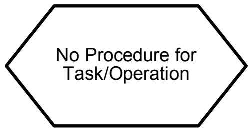
ISO 9001: 2000: Sec 4.2

ISO 14001: 2000 Sec 4.4.5

TMSA 1B: 1.3, 2.1, 8B: 3.1

SEMP 8.3

OHSAS 4.3.4, 4.4.4, 4.4.5



No Procedure for Task/Operation

Intermediate Cause

Typical Issue

Was there a procedure for this task?

Typical Recommendations

Develop a procedure for the task.

Ensure that all modes of operation, all maintenance activities and all special activities have written procedures.

Example

A mechanic undertorqued a flange. He performed the job without a procedure because one did not exist for the task.

Standards References

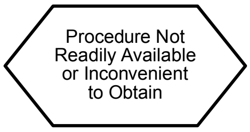
ISM Code 11.2.1

ISO 9001: 2000: Sec 4.2

ISO 14001: 2000: Sec 4.4.5

TMSA 6B: 1.1, 1.3, 2.1, 2.2, 2.3, 3.2, 4.1, 7A: 2.4, 2.5

OHSAS 4.3.4, 4.4.4, 4.4.5



Procedure Not Readily Available or Inconvenient to Obtain

Intermediate Cause

Typical Issues

Did a procedure exist for the job or task being performed? Was the procedure readily available? Was there a copy of the procedure in the designated file, shelf or rack, or was one available on the computer system? Was there a master copy of the procedure available for reproduction?

Was procedure use inconvenient because of working conditions (e.g., quarters, weather, protective clothing)?

Typical Recommendations

Place copies of operations and maintenance procedures in the appropriate work areas so that the procedures are ALWAYS available for personnel use.

Maintain master copies of all procedures and control access to these masters.

Develop a procedure for controlling photocopies of procedures used aboard ship or train personnel to be made aware of revisions or destroy copies upon completion of the task.

Examples

A crewmember made a mistake lining up valves. He did not use the controlled procedure. Instead, he used a copy of the procedure he had at his workstation. This procedure was out-of-date.

An electrician was troubleshooting the bow thruster breaker. After determining what the problem was, she should have referred to the procedure for replacement of the charging springs. But that would have required her to return to the engine room operating station. So she replaced the spring based on memory. As a result, a departure was delayed when the breaker failed to close.

Standards References

ISM Code 11.2.1

ISO 9001: 2000: Sec 4.2

ISO 14001: 2000: Sec 4.4.5

TMSA 1B: 1.3

OHSAS 4.3.4, 4.4.4, 4.4.5

Language Difficulty

Intermediate Cause

Typical Issue

Are documented procedures written in a language that is not understood by crew members?

Typical Recommendation

Develop pertinent procedures in a language understood by crew members.

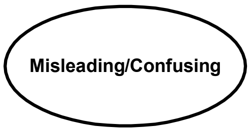
Better screen crew members for language competency.

Examples

Instructions provided to crew members upon signing on are in both English and Spanish. In recent months, the vessel has been signing on Russian nationals as crew members. As a result, the Russian crew members do not understand the instructions and so do not use them.

Standards Reference

ISM Code 6.6



Misleading/Confusing

Cause Type

Typical Issues

Was an event caused by an error made while following or trying to follow a procedure? Was the procedure misleading or confusing?

Typical Recommendations

Ensure that procedures are in a standard, easy-to-read format.

Ensure that procedures use the appropriate level of detail for the complexity and frequency of a task.

Use look-up tables instead of requiring calculations to be performed.

Use specific component identifiers.

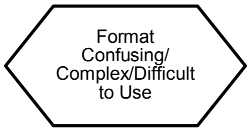
Examples

An engineer incorrectly completed a step of a procedure requiring him to open six valves. He skipped one of the valves. The corresponding checklist did not have a check-off space for each valve.

An engineer overfilled a tank. The procedure required him to calculate the running time of the fill pump. A look-up table with the initial tank level and the corresponding fill pump run time should have been provided.

Standards Reference

TMSA 1B: 2.1



Format Confusing/Complex/Difficult to Use

Intermediate Cause

Typical Issues

Did the layout of the procedure make it difficult to follow? Did the format differ from that which the user was accustomed to using? Were the steps of the procedure logically grouped?

Do warnings or cautions contain information that should be contained in procedure steps? Are important warnings and cautions embedded in procedure steps?

Is the procedure format appropriate for the task? Is a flowchart used when a checklist is more appropriate? Is a checklist used when a T-bar format is more appropriate?

Considering the training and experience of the user, was the procedure too difficult to understand or follow? Was the procedure designed for the "less practiced" user?

Was the error made because of a mistake in recording or transferring data? Were calculations performed incorrectly? Was the formula or equation confusing? Did it have multiple steps?

Note: Consider dual coding with "Ambiguous/Confusing Wording Issue" or "Multiple Actions per Step".

Typical Recommendations

Ensure that procedures are in an easy-to-read format. Use color codes (or change paper color) when appropriate.

Avoid using the narrative or paragraph format. Personnel tend to get lost in a sea of print. The T-bar, flowchart or checklist formats are highly effective.

Choose one or two effective formats and use these same formats consistently throughout the management system (the format for a troubleshooting guide may be inappropriate for a step-by-step startup procedure).

List procedure steps in a logical, sequential order. Also, be sure that any special precautions are listed at the beginning of the procedure.

Review procedures to ensure that warnings and cautions are presented in a consistent format in all procedures.

Involve procedure users in the procedure development process. Have an inexperienced user review the procedure to ensure that sufficient detail is provided.

Use checklists for verification processes and initial alignments of systems.

Use flowcharts when decisions affect which part of the procedure is implemented (e.g., a troubleshooting guide or an emergency procedure that requires diagnosis of the problem).

Avoid procedures that require employees to make manual calculations. Instead, provide them with pre-calculated tables or worksheets with easy-to-fill-in blanks and provide thorough training in their use. Alternatively, automate calculations.

Examples

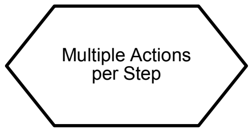
An engineer made a mistake while performing a startup procedure. The procedure was confusing because it required the engineer to complete part of section A, then B, back to A, then to C, back to A, then to D and E. The engineer failed to go back to A after completing C.

Each step in the procedure was numbered. Subsequent levels of sub-steps were numbered by adding a decimal point and another set of numbers. The procedure used too many levels on sub-steps (i.e., a step was numbered 2.3.6.5.1.1.1.1.5). As a result, the crew member skipped a step in the procedure.

A troubleshooting guide was developed using a checklist format. The mechanics did not understand how to move through the procedure. They just completed the items they thought were appropriate.

A procedure was developed by an engineer in a paragraph format. About half of the information in the procedure was design information that the engineers did not need.

A procedure required crew members to calculate the weight of material in a tank based on the empty weight of the tank and the current weight of the tank. Both of these values were displayed on the computer. An error was made in subtracting the numbers. The computer could have displayed the calculated value, eliminating this potential error.



Multiple Actions Per Step

Intermediate Cause

Typical Issues

Did any steps in the procedure have more than one action or direction to perform? Did some steps in the procedure state one action, which, in practice, actually required several steps to perform?

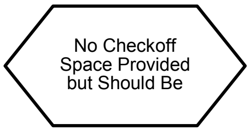
Typical Recommendations

Avoid broad procedure steps such as “line up the system.” Instead, use this as a subheading and include all the steps associated with lining up the system below the heading.

Do not assume that an employee will remember all the steps associated with an action item. Clearly communicate all the required steps associated with an action item so that the least experienced employee can successfully perform the required job tasks.

Example

Someone failed to close a valve, resulting in a tank overflow. The instruction to close the valve was one of six actions required in one step of the procedure. He completed the other five actions but overlooked closing the valve, which was the fourth action in the step.



No Check-off Space Provided but Should Be

Intermediate Cause

Typical Issues

Was an error made because each separate action in a step did not have a check-off space provided? Is the procedure complex and critical enough to require check-offs?

Typical Recommendations

For actions that require multiple steps, ensure that all the steps are specifically defined. When appropriate, include a check-off space for each of these individual steps so that the employee can be certain that he/she has performed this step.

It is a good practice to design procedures with enough "white space" (through indentation, line spacing, etc.) to allow users to keep their place when using the procedure.

Example

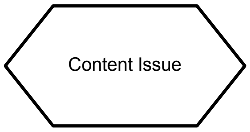
Someone failed to open a valve. The procedure required him to open seven valves. He missed one, opening the other six. A separate check-off space for each valve manipulation was not provided in the procedure.

Standards References

ISM Sec 7

ISO 9001: 2000: Sec 7.5.1

OHSAS 4.4.6



Content Issue

Intermediate Cause

Typical Issues

Did the procedure identify the step(s) that had been revised?

Was the procedure user required to carry out actions different from those he was accustomed to doing? Did the procedure identify that the step for the action had been revised? Did the procedure user perform the action as the previous revision specified rather than the current revision?

Did each instruction (regardless of format) clearly indicate what was required? Was a detailed checklist required for a task that was not very important? If a checklist was necessary, was it confusing? Was enough room provided for the response or did it require unique responses for each step?

Typical Recommendations

Develop a checklist for all safety-critical tasks to provide a quick reference for inexperienced and experienced users.

Require that checklists be turned in if necessary for quality assurance.

Avoid using checklists instead of supervision to ensure that tasks are performed correctly because checklists can easily be filled out before or after the task. If supervision is required, then provide a supervisor.

Include the unique system response to be expected when an employee completes each step of a checklist.

Provide enough white space on the checklist so that the employee can record the system response and document expected as well as unexpected responses.

Ensure that checklists are only developed for critical tasks. Overuse of checklists will reduce their effectiveness on critical tasks.

Clearly identify (such as with a sidebar or bold italics print or shading) the steps/information that have changed, and ensure that all employees are trained in or informed of the changes.

Examples

A mate failed to complete one step of a procedure. The procedure required a check at the completion of each step. Because it did not require unique responses for the steps, the mate completed the procedure and then checked off all the steps at one time.

A checklist was designed so that the desirable answer to most questions (23 out of 26) was yes. As a result, the three remaining questions were often answered incorrectly.

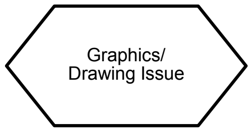
An engineer incorrectly completed a step of a procedure. The engineer was experienced and performed the action as he always had. The new procedure (which had been correctly updated) was not marked to indicate that the step had recently been revised, and the engineer did not realize that a change had been made.

Standards References

ISM Sec 7

ISO 9001: 2000: Sec 7.5.1

OHSAS 4.4.6



Graphics/Drawing Issue

Intermediate Cause

Typical Issues

Was an error made because graphics or drawings were of poor quality? Were the graphics or drawings unclear, confusing or misleading? Were graphics, including data sheets, legible? Would a graphic (diagram, picture, chart, etc.) have made a significant reduction in the likelihood of this error were it provided?

Typical Recommendations

For hard-copy graphics that have been reproduced, ensure that the copy is easy to read (e.g., not too dark, too light or splotchy).

Include color coding on graphics when possible for easy use.

Ensure that the graphics accurately depict actual process operations and/or equipment configuration.

Do not overwhelm the user with too many graphics on one screen or one sheet of paper. Information should not appear crowded.

The text should support the graphics.

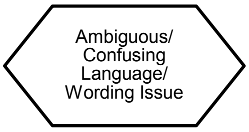
Flowcharts can be very effective graphics for tasks that require decision making and branching.

Examples

A new cargo officer did not open a critical valve when lining up the cargo system for discharge. The drawing the cargo officer used had several systems illustrated on it and was overloaded with information within a small space. The cargo officer missed the valve that was depicted in an area of the drawing that was very crowded.

A mechanic replaced the wrong seal on a large piece of equipment. The seal that he was to remove was shaded on the drawing, but he could not determine which seal was shaded because the copy was of poor quality.

An electrician incorrectly terminated a wire. The wire terminations were shown on the installation diagram. The procedure copy he was using was not legible because it was made from a copy of a copy of a copy of the original.



Ambiguous/Confusing Language/Wording Issue

Intermediate Cause

Typical Issues

Were the instructions in the procedure unclear? Could they be interpreted in more than one way? Was the language, wording or grammar unclear/complex?

Typical Recommendations

Have procedures validated by a team of subject matter experts (workers) and by walkthroughs in the field.

To find difficult steps, have the newest employee walk through the procedure without coaching.

Allow technical editors to review procedures to ensure that ambiguous terms have been avoided.

Perform a hazard review or risk assessment of critical procedures to determine other accident scenarios related to errors in procedures and to determine if sufficient safeguards are provided against employees not following the written procedures and other identified risks.

Examples

A document control procedure required that no uncontrolled documents were to be used. By definition, uncontrolled documents included photocopies of controlled documents. The procedure also stated that a photocopy of a controlled document could be made by personnel for use at a location where it was needed. As a result, personnel were confused about whether photocopies should be controlled.

An instruction called for cutting XYZ rods into 10-foot-long pieces. The intent was to have pieces 10 feet long. The person cutting the pieces cut 10 pieces, each a foot long.

A procedure indicated that the set-point should be increased until it set off the alarm. The term "set off" (which means to turn on [actuate the alarm]) was confusing to personnel.

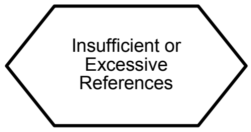
Standards References

ISM Sec 5.1.3

ISO 9001: 2000: Sec 7

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.4, 4.5.1



Insufficient or Excessive References

Intermediate Cause

Typical Issues

Did the procedure refer to an excessive number of additional procedures? Did the procedure contain numerous steps of the type "Calculate limits per procedure XYZ"? Was the procedure difficult to follow because of excessive branching to other procedures? Did the procedure contain numerous steps of the type "If X, then go to procedure ABC. If Y, then go to procedure EFG"? Did the procedure contain numerous references to other parts of the procedure? Did it contain steps of the type "If the material is acceptable, go to Step 13.3. If the material is unacceptable, go to Step 12.4. If the test cannot be run, redo Step 4 and contact your supervisor"?

Typical Recommendations

List all information that an employee must have in order to perform a specific task in the procedure designated for this task. If the same information is required to perform different tasks, repeat the information in each procedure.

Do not branch (reference) to more than one other procedure (module) from a procedure.

Procedures intended for step-by-step use away from the engine control room need to contain all required tasks. Personnel are unlikely to return to the file/manual to get any referenced procedure.

Perform a hazard review or risk assessment of critical procedures to determine other accident scenarios related to errors in procedures and to determine if sufficient safeguards are provided against employees not following the written procedures and other identified risks.

Use a flowchart to determine the correct procedure steps to be implemented. Avoid too many jumps within a procedure.

Example

A crew member exceeded an operating limit. The primary procedure did not contain the limits but referred to four other procedures to find the limits. When checking his results against the limits, he looked at the wrong limit in one of the referenced procedures.

Standards References

ISO 9001: 2000: Sec 7

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.4, 4.5.1

Too Much/Little Detail

Intermediate Cause

Typical Issues

Do the procedures provide too little detail to ensure proper performance of the task by the most inexperienced person? Do the procedures have more detail than necessary to ensure proper performance of the task?

Typical Recommendation

Consider using an outline format with high-level steps for experienced users and detailed steps for inexperienced users.

Examples

The instructions for a computer software program just stated "Change the loading preferences to user-defined values." No further directions were provided on how this could be done.

An engineer developed a procedure in paragraph format. About half of the information in the procedure was design information that the engineers did not need.

A procedure for the shutdown of the cooling water system included specific steps on how to close manually operated valves. This information was not needed in the procedure because it was a skill that did not require any task-specific knowledge.

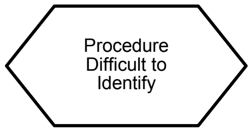
The procedure indicated that the level alarm should be set for 70%. However, it did not indicate if this was 70% of the tank level or 70% of the span of the level sensor.

Standards References

ISO 9001: 2000: Sec 7

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.4, 4.5.1



Procedure Difficult to Identify

Intermediate Cause

Typical Issues

Is it difficult to identify the correct procedure to use? Do many procedures have similar names? Are the procedures for different units and vessels clearly distinguishable from one another?

Typical Recommendations

Include a header at the top of each procedure page that includes the procedure number, page number, procedure revision, unit number and vessel name.

Use different colored paper for each department's procedures.

Provide clear, descriptive names for each procedure.

Examples

An engineer used the wrong procedure to start up Compressor 3A. There were two procedures labeled "Startup of Compressor 3" (for Compressors 3A and 3B). The procedure he used was for Compressor 3B.

A mechanic incorrectly calibrated a pressure transmitter. A page from a similar procedure was inadvertently substituted into his calibration procedure. Individual procedure pages did not contain procedure titles or procedure numbers, so the substituted page was difficult to distinguish from the others.

Standards References

ISO 9001: 2000: Sec 7

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.4, 4.5.1

Wrong/Incomplete

Wrong/Incomplete

Cause Type

Typical Issues

Was the procedure incorrect? Did the procedure fail to address a situation that occurred during performance of the task? Is the procedure consistent with the installed equipment?

Typical Recommendations

Ensure that procedures are technically reviewed.

Perform a walkthrough of procedures.

Examples

The vessel's stores crane located on the main deck at the vessel's house was not included in the vessel's maintenance plan. The engine department thought maintenance of the ship's stores crane was the responsibility of the deck department and the deck department thought it was the responsibility of the vessel's engine department.

The chief officer directed a gas freeing operation of the ship's cargo tanks in accordance with procedure GF-N-1. The scope of the procedure included tank inertion followed by a fresh air purge. The chief officer did not check the flammable gas content of the exhaust gas prior to the changeover from inert gas purging to fresh air purge. Although most chief officers performed the check, the procedure did not identify the key safety-related step of testing the exhaust gas from the tanks to ensure that flammable gas concentrations had dropped below required levels before beginning the introduction of fresh air.

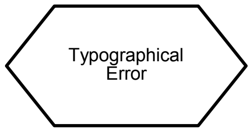
A mechanic made a mistake calibrating a piece of equipment because the procedure specified the wrong limits.

Standards References

ISO 9001: 2000: Sec 7

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.4, 4.5.1



Typographical Error

Intermediate Cause

Typical Issue

Was a typographical error in the procedure responsible for the event?

Typical Recommendations

Use a word processor to electronically spell-check the procedure immediately after it has been typed.

Allow a technical editor to review procedures for typographical errors.

Allow employees to review procedures for accuracy.

Solicit feedback from employees.

Examples

A crew member made a mistake because the procedure contained the wrong limit. The maximum temperature was supposed to be 38°C, but the procedure said 48°C. The mistake was made during typing and not caught by the validators.

An engineer overfilled a tank because of a procedure error. The procedure should have stated “Hold the valve open for 3-4 seconds”. The typist inadvertently removed the hyphen (when the spell-checker in the word processing software flagged this potential misspelling) and the procedure then read, “Hold the valve open for 34 seconds”.

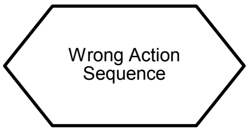
The procedure indicated that valve XC131AC01 should be opened, but the procedure should have indicated XC121AC01 instead.

Standards References

ISO 9001: 2000: Sec 7

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.4, 4.5.1



Wrong Action Sequence

Intermediate Cause

Typical Issue

Were the instructions/steps in the procedure out of sequence?

Typical Recommendations

Have procedures validated by a team of subject matter experts (workers) and by walkthroughs in the field.

Perform a hazard review or risk assessment of critical procedures to determine other accident scenarios related to errors in procedures and to determine if sufficient safeguards are provided against employees not following the written procedures and other identified risks.

Example

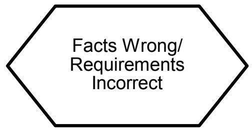
An engineer made a mistake because the steps were out of sequence in a procedure. Step 5 directed the engineer to transfer material from Tank A to Tank B. Step 7 directed the engineer to verify that the high level alarm on Tank B was functioning prior to beginning the transfer.

Standards References

ISO 9001: 2000: Sec 7

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.4, 4.5.1



Facts Wrong/Requirements incorrect

Intermediate Cause

Typical Issues

Was specific information in the procedure incorrect? Did the procedure contain current requirements? Did the procedure reflect the current status of equipment?

Typical Recommendations

Have procedures validated by a team of subject matter experts (workers) and by walkthroughs in the field.

Perform a hazard review or risk assessment of critical procedures to determine other accident scenarios related to errors in procedures and to determine if sufficient safeguards are provided against employees not following the written procedures and other identified risks.

Examples

A safety limit was violated because the procedure did not contain the current limits. The limits had been changed, but the procedure had not been revised.

The procedure indicated that valve XC131AC01 should be opened; however, the procedure should have indicated that the valve should be throttled, not fully opened.

The procedure stated that the data should be sent to the central office on Form 42-001, Rev. 2. However, the data should have been sent on Form 16-ASP-01.

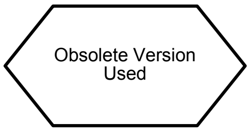
The procedure indicated that the temperature should be recorded in degrees F, but it should have been recorded in degrees C.

Standards References

ISO 9001: 2000: Sec 7

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.4, 4.5.1



Obsolete Version Used

Intermediate Cause

Typical Issues

Was an older version of the procedure used? Was specific information in the procedure incorrect? Did the procedure contain current requirements? Did the procedure reflect the current status of equipment?

Note: May require dual coding under "Obsolete Documents Being Used (Document [Drawing] Control Issue)".

Typical Recommendations

Ensure that only current copies of procedures are available.

Seek out and destroy old versions of the procedures.

Consider incorporating information added by seafarers to their "personal" copies of procedures.

Create electronic reminders requiring periodic seek-out-and-destroy missions of obsolete documents to be timed with master's review of the management system (MS). If procedures are updated three times per year, then check for obsolete documents three times per year, mid-way between each MS update.

Examples

A safety limit was violated because the procedure did not contain the current limits. The limits had been changed, but the master procedure had not been revised.

The cargo officer liked to use his marked-up version of the cargo operations procedure because it contained the system operating limits, which were contained in a different procedure. The cargo officer always checked his personal version for updates, but he missed adding a recent change. As a result, he shut down the cargo operations when he performed the procedure incorrectly.

A mechanic did not like to print out procedures from the computer system, so he made his own copies of the procedures he often used. However, he failed to keep track of numerous procedure changes. As a result, many of his "personal" procedures were out of date.

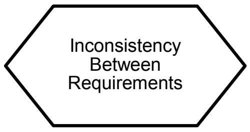
Standards References

ISM Code 11.2.3

ISO 9001: 2000: Sec 4.2

ISO 14001: 2000: Sec 4.4.5

OHSAS 4.4, 4.5.1



Inconsistency Between Requirements

Intermediate Cause

Typical Issues

Did different procedures related to the same task contain different requirements? Were there conflicting or inconsistent requirements stated in different steps of the same procedure? Were requirements stated in different units?

Typical Recommendations

Have procedures validated by a team of subject matter experts (workers) and by walkthroughs in the field.

Perform a hazard review or risk assessment of critical procedures to determine other accident scenarios related to errors in procedures and to determine if sufficient safeguards are provided against employees not following the written procedures and other identified risks.

Provide accurate cross-referencing within procedures. Create Excel spreadsheets that provide an overview or summary of all cross-referencing with the MS. Make it available to all persons responsible for reviewing and approving procedures, either by hard copy, e-mail or company intranet.

Examples

An engineer exceeded the environmental discharge limits. A caution in the procedure stated the flow rate limit in liters per hour. The procedure step stated the limit in gallons per minute. The engineer set the flow rate based on the gallons-per-minute limit, which was less restrictive in this case.

The procedure said to send the completed form to the DPA (designated person ashore), but the form itself had a note on the bottom that said to send it to the operations manager.

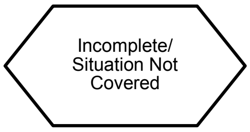
A caution stated that the cover of the detector should not be opened until power was disconnected (after Step 12). But Step 9 said, “After removing the cover, push the red button to discharge the capacitor”.

Standards References

ISO 9001: 2000: Sec 7

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.4, 4.5.1



Incomplete/Situation Not Covered

Intermediate Cause

Typical Issues

Were details of the procedure incomplete? Was sufficient information presented? Did the procedure address all situations likely to occur during the completion of the procedure? Was a critical step missing?

Note: This node addresses specific issues that have not been included in a procedure. If procedures in general do not have a sufficient level of detail, consider coding under "Too Much/Little Detail (Misleading/Confusing)".

Typical Recommendations

Ensure that all modes of operation, all maintenance activities and all special activities have written procedures.

Perform a hazard review or risk assessment of critical procedures to determine other accident scenarios related to errors in procedures and to determine if sufficient safeguards are provided against employees not following the written procedures and other identified risks.

Examples

The chief officer directed a gas freeing operation of the ship's cargo tanks in accordance with procedure GF-N-1. The scope of the procedure included tank inertion followed by a fresh air purge. The chief officer did not check the flammable gas content of the exhaust gas prior to the changeover from inert gas purging to fresh air purge. Although most chief officers performed the check, the procedure did not identify the key safety-related step of testing the exhaust gas from the tanks to ensure that flammable gas concentrations had dropped below required levels before beginning the introduction of fresh air.

A mechanic did not correctly replace a pump. The instruction stated to "replace the pump." Numerous actions were required to replace the pump, including an electrical lockout, which was incorrectly performed.

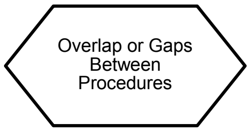
Standards References

ISM Code 11.2.3

ISO 9001: 2000: Sec 4.2

ISO 14001: 2000: Sec 4.4.5

OHSAS 4.4, 4.5.1



Overlap or Gaps Between Procedures

Intermediate Cause

Typical Issues

Are there gaps between procedures that are used in sequence? Do multiple procedures cover the same task?

Typical Recommendations

Develop a procedure development plan to allocate tasks between procedures.

Review procedures to determine overlaps between them.

Perform a walkthrough of the procedures to identify overlap or gaps between them.

Examples

The chief officer directed an inerting operation of the ship's cargo tanks in accordance with procedure GF-N-1. He then began a fresh air purge of the cargo tanks in preparation for entry in accordance with GF-N-2. Neither of the procedures identified the key safety-related step of testing the exhaust gas from the tanks to ensure that flammable gas concentrations had dropped below required levels before beginning the introduction of fresh air.

The vessel's stores crane located on the main deck at the vessel's house was not included in the vessel's maintenance plan. The engine department thought maintenance of the vessel's stores crane was the responsibility of the deck department and the deck department thought it was the responsibility of the vessel's engine department.

An engineer started up the control air system using the startup procedure. He then checked the normal operations procedure and it also contained a section on starting up the system.

Human Factors

Cause Category

Typical Issues

Were the capabilities and limitations of humans considered in the design, development, production and control of systems? Is the layout of the workplace adequate? Is the work environment excessively noisy, hot or cold? Does the task impose an excessive physical or mental workload? Can the system tolerate faults?

Typical Recommendations

Locate related controls and indications together.

Provide employees with adequate personal protective clothing such as hearing protection, gloves and safety glasses. Ensure that they are available in different sizes to ensure a comfortable fit.

Reduce the complexity of control systems.

Provide feedback to personnel so that they can tell if actions are performed correctly.

Examples

A deck officer, assigned the responsibility of monitoring a computer screen for an entire 8-hour shift, failed to detect an important signal.

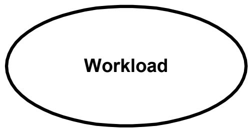
An engineer failed to control the discharge flow rate in a process because the flow rate meter could not be seen from the location where the flow was controlled.

A crew member inadvertently switched on the wrong pump because all three pumps switches looked the same and were not labeled.

An AB was supposed to open cartons of materials. It was difficult to obtain utility knives from the stores locker (the locker was always kept locked by the first officer), so the AB often used a screwdriver to open the packages. As a result, some of the items were scratched by the tip of the screwdriver.

Standards References

SEMP 2.3.5, 6.1, 8.1



Workload

Cause Type

Typical Issues

Were too many tasks required for the number of available staff? Was the error caused by a situation or system being complex and requiring a decision based on specific knowledge for a successful outcome? Were system controls so complex that they contributed to user error? Did the system impose unrealistic monitoring or mental processing requirements?

Typical Recommendations

Provide tools to make decision making easier and to reduce the chances of human error.

Reduce the complexity of control systems.

Do not place workers in situations requiring extended, uneventful vigilance.

Examples

Two maintenance tasks were in progress at the same time. The watch engineer had to perform some steps for each of these tasks. He was to transfer the contents of Tank A to Tank B to support one of the maintenance tasks. While he was involved with another task, Tank B overflowed.

The first officer, who was usually assisted by the watch officer, was temporarily left alone in the cargo control room to monitor and control both the ballasting operation and cargo discharge operation. While correcting a minor vessel list to port, a cargo pump tripped, catching the first officer’s attention. While investigating the pump trip and preparing for a pump restart, the vessel quickly took on substantial starboard list. The vessel was tender and the ballast overcorrection caused by the first officer’s lapse in attention caused the list.

Standards Reference

TMSA 3B: 1.2

Sustained High Workload/Fatigue

Intermediate Cause

Typical Issues

Was the problem attributable to a lack of attention caused by continuous long hours of work? Did lack of sufficient rest contribute to the event? Was the problem attributable to a high pressure work environment? Did fatigue from sustained excessive work performance requirements contribute to the problem?

Are personnel working steadily more the 75% of any given hour? Are rest periods available, and is there sufficient time for people to take those rest periods? Are watchstanding officers and crew provided the minimum rest required by Chapter A-VIII/1 of the STCW Code? "Are working hours and rest periods tracked? Are crew members reporting fatigue? Are crew members showing signs of fatigue (sleepy, forgetful, short tempered, etc.)? Do crew members get at least 7 to 8 hours of continuous sleep every 24 hours? Are there heavy physical demands on the job? Are there procedures for fatigue assessment control? Are there methods in place to test for fatigue or general fitness for duty? Are sufficient personnel available to complete all tasks in a timely manner? Do task requirements interfere with adequate sleep?

Typical Recommendations

Develop adequate rest requirements, which should correspond to hours worked.

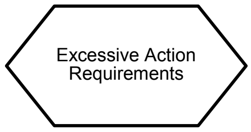
Review statutory rest requirements, ensure that they are incorporated into company requirements and provide a method of tracking.

Example

The vessel arrived in port during the first officer's watch. Among other things, the first officer was required to supervise cargo operations, sign for deck stores, provide newly joining crew members with familiarization information, accompany a class Surveyor on a ballast tank inspection and undergo a portion of an ISM Code audit. Cargo operations ended just before the beginning of the first officer's sea watch. The first officer assumed the watch, and the vessel departed the terminal. Soon after departing the port, the first officer became confused about the identification of a buoy and gave a wrong helm command, resulting in the vessel grounding.

Standards Reference

STCW Code Chapter A-VIII/1



Excessive Action Requirements

Intermediate Cause

Typical Issues

Were the system or equipment controls so complex that they contributed to or caused the event? Could the system have been designed with simpler controls so that the chance of error was reduced?

Typical Recommendations

Automate the system so that an employee is not required to constantly manipulate controls.

Reduce the complexity of the control system demands on personnel.

Make the system more stable to reduce the number of control adjustments required.

Example

The thermal expansion valve on the dehydrator cooling coils was too large for the application and caused large fluctuations in refrigeration compressor suction pressure during the startup and ramp-up (or loading) of the inert gas plant. As a result, the compressor would load up and unload in response to the large Freon flow fluctuations to the evaporator coil. This often caused the refrigeration plant to trip, causing a cascade trip of the inert gas plant. Starting of the inert gas plant often required an engineer to run back and forth between the inert gas generator control panel and refrigeration compressor to make adjustments to steady out the plant. Plant startup, which was designed to be automatic, often took 30 to 45 minutes to accomplish while the plant cycled through several shutdowns. The Freon compressor often required maintenance due to liquid return, slugging, loading and unloading caused by the large flow changes through the oversized thermal expansion valve.

Unrealistic Monitoring Requirements

Intermediate Cause

Typical Issues

Were personnel required to monitor more than three variables at once, causing overload or failure to notice important information? Could the error be attributed to loss of alertness because of the excessive length of a monitoring task?

Typical Recommendations

Automate the system so that an employee is not required to monitor several variables simultaneously. However, provide enough employee interaction with the system to keep personnel alert.

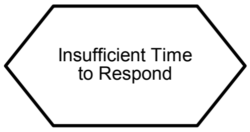
Do not place workers in situations requiring extended, uneventful vigilance.

Ensure that staffing levels are adequate.

Examples

The first officer, who was usually assisted by the watch officer, was temporarily left alone in the cargo control room to monitor and control both the ballasting operation and cargo discharge operation. While correcting a minor vessel list to port, a cargo pump tripped, catching the first officer’s attention. While investigating the pump trip and preparing for a pump restart, the vessel quickly took on substantial starboard list. The vessel was tender, and the ballast overcorrection caused by the first officer’s lapse in attention caused the list.

In restricted visibility, the cadet was given the responsibility for monitoring the radar screen for blips during an entire four-hour watch. As a result of a decrease in vigilance, the cadet failed to identify an important signal.



Insufficient Time to Respond

Intermediate Cause

Typical Issues

Were operations being conducted too quickly to allow sufficient time to respond to a problem? Did the actions required to respond to a problem require too much time to execute? Were events transpiring too fast to allow sufficient time to respond? Did someone create a hazardous situation that would not allow enough time to respond if something went wrong?

Does design of the workspace allow sufficient time to respond to a signal or condition? Are there too many intervening tasks that must be performed to prohibit responding in appropriate time? Is an appropriate amount of response time provided? Are there tasks that are nearly beyond human capability that should or could be better performed by machines?

Typical Recommendation

Analyze the hazards associated with operations to determine what measures would be required in the event of an emergency or operational upset, and ensure that the operation is conducted at a speed that allows enough time to respond to potential events.

Examples

A vessel was approaching the terminal platform too quickly. When the master recognized that the vessel was approaching too quickly, he placed the engines in full astern and passed by the platform by a ship length before coming to a stop.

Cargo loading was coming to a close. The first officer had adjusted the tank fill valves so that all tanks were filling evenly and would be coming to full at approximately the same time. There were four loading pumps filling the vessel. Instead of rating down by shutting down cargo pumps as the tanks approached full and staggering the topping off of each tank, the first officer allowed the loading pumps to run at full rate close to the end. When the first officer called for loading pumps to be cut off, the terminal engineers could not shut the loading pumps down quickly enough. The first officer initiated an emergency shutdown, which did not close down the valves fast enough to prevent one of the tanks from overflowing.

High Transient Workload

Intermediate Cause

Typical Issues

Does an operation or process require the operating personnel at some point to perform multiple steps or duties within a restricted time frame? Did an overlooked step during a very busy operation contribute to the problem?

Are there specific tasks or operational evolutions that are at or exceed the threshold for human work production? Are sufficient personnel available to complete all tasks in a timely manner? Are high workload periods more than 30 minutes in duration? Are sufficient rest intervals provided between high workload periods? Can high workload periods be predicted so that additional personnel can be assigned to perform tasks during those intervals?

Typical Recommendations

Analyze mechanized processes to determine the need for control systems that can respond to high transient conditions where personnel cannot.

Provide checklists to ensure that critical steps are not overlooked during high activity operations.

Review manpower requirements for transient activities to determine if extra personnel should be provided.

Example

In preparation for arrival at a load port, a number of checks are required to ensure that the cargo system, associated equipment, alarms and safety devices are functional. Notation is also made of any exceptions so that operating personnel are aware of any system limitations. Vessel personnel performed these by memory and forgot to check the automatic operation of the tank valves. One of the tank valves was not responding properly in a remote actuation mode, but operating personnel were not aware of the problem. When rating down at the close of cargo loading, the tank valve failed to close properly by remote activation.

Situational Awareness

Cause Type

Typical Issues

Is the crew aware of threats and hazards to operations? Have plans been devised to address all threats and contingencies? Does everyone have a clear understanding of all relevant aspects of the immediate situation and expectations for the near future? Is all the required information at hand to form a realistic assessment? Is required information accurate and timely?

Typical Recommendations

Ensure that adequate and relevant information is provided in a timely manner to the user as a basis for decision making.

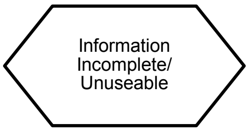
Ensure that information from various sources relevant to operational decisions is readily accessible at locations where decisions are made or actions are taken.

Equipment or systems that are critical to safe vessel operation should be equipped with failure alarms.

Examples

Grounding occurred when communication between bridge navigating personnel and the pilot was interrupted and position-fixing methods were not being employed to determine the ship's position.

Alarms cannot be heard in the lower engine room above the noise of the main engine when it is in operation. No visible indicator is provided. Therefore, alarms are not communicated to personnel working in the lower engine room when the main engine is in operation.



Information Incomplete/Unusable

Intermediate Cause

Typical Issues

Is information reliable, accurate and complete? Is information timely? Is similar information from different sources consistent? Is information presented in a useful format, without the need for manipulation? Is the information at hand relevant for assessing the current situation? Can the completeness of the information be validated?

Typical Recommendations

Ensure that sources of information are reliable and accurate.

Ensure that adequate and relevant information is provided in a timely manner to the user as a basis for decision making.

Provide information in a useful format.

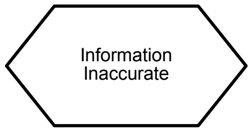
Review information provided to decision makers to ensure that it provides a complete basis (picture) upon which to make decisions.

Structure instrument panels to put related gauges or information readouts close together.

Examples

Navigation personnel were aware of a current in the bay. The small-scale chart in use was not appropriate for coastal navigation, and the radar's automatic radar plotting aid (ARPA) was not being used. The officer of the watch did not succeed in fully assessing the situation. The vessel drifted toward the shoal without the drift speed being taken into account.

Grounding occurred when communication between bridge navigating personnel and the pilot was interrupted and position-fixing methods were not being employed to determine the ship's position.



Information Inaccurate

Intermediate Cause

Typical Issues

Is information reliable, accurate and complete? Is information timely and relevant to the situation at hand (does the information have a “shelf life”)? Is similar information from different sources consistent? Can the accuracy of the information be confirmed?

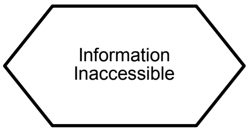
Typical Recommendations

Ensure that there is a valid basis for confidence in the reliability and accuracy of the information, such as a systematic maintenance and calibration program.

Provide information in a timely manner that ensures its relevance.

Example

A vessel ran aground when, on scanty and erroneous information, a critical course alteration was delayed. Contributing factors were the speed of the vessel under the prevailing circumstances and the lack of a recent fix to positively determine both the vessel’s position and her progress along the intended track. These factors, along with the lack of a complete, predetermined passage plan, contributed to the grounding.



Information Inaccessible

Intermediate Cause

Typical Issues

Is information sufficiently available at required locations in time for ship's personnel to make relevant and informed decisions? What are the time considerations and constraints in acquiring information? Does information need to be collected from different sources (locations) and integrated at a single location? Is needed information communicated among the crew?

Typical Recommendations

Ensure that information from various sources relevant to operational decisions is readily accessible at locations where decisions are made or actions are taken.

Ensure that information is accessible within a time frame that preserves the relevance of the information.

Use radio communication to transmit relevant information that must be verified by sight but is required quickly.

Examples

Detailed documentation on the design of the vessel's electrical distribution system was not available onboard. As a result, personnel could not easily identify the source of the problem, and extensive troubleshooting was needed to restore power to one of the vessel's computer systems.

While the vessel was in port, a question arose concerning resupply of the vessel. The stores manager was not onboard and could not be reached. The first officer had to make decisions about what to load without critical information. As a result, the vessel failed to have critical items onboard when it left port.

The container vessel's loading/stowage plan was provided to the vessel on a disk to be read on the chief officer's computer. The chief officer's computer was experiencing difficulties. The stowage plan could not be read because only the chief officer's computer was equipped with the necessary software. As a result, two containers of incompatible hazardous materials were stowed next to one another (with a significant number of containers stowed above them) before the problem was discovered.

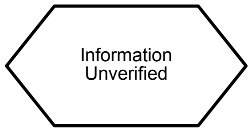
Standards References

ISM Sec 11.2.1

ISO 9001: 2000: Sec 4.2

ISO 14001: 2000: Sec 4.4.5

OHSAS 4.3.4, 4.4.4, 4.4.5



Information Unverified

Intermediate Cause

Typical Issues

Are there multiple and redundant sources of critical information? Is there an adequate update rate for sensed information (e.g., depth under keel)? Are there procedures or other means to test and verify information? Are there alternate means to acquire and verify information? Are components and devices needed to verify information available where the situation assessment is performed?

Typical Recommendations

Provide redundant sources of critical information.

Does analysis of complementary information confirm (verify) the accuracy and relevance of critical information?

Examples

The vessel had arrived in port and was in transit to the loading terminal. A pilot was aboard directing the vessel's maneuver, and a radar map of the port was being used to track vessel position. The vessel was equipped with two GPS units. One unit was linked to the radar. The other was associated with the GMDSS. The deck officer on watch was not taking hard fixes and plotting them on the chart. The GMDSS GPS readout started to indicate a different position than the one indicated on the radar. The master and deck officer assumed the error to be in the GMDSS GPS unit rather than the one associated with the radar. The pilot did not know that there was a disparity between the units and relied on the position shown by the radar. As a result, the vessel ran aground.

Two temperature indicators displayed different oil temperatures. The engineer assumed that the one gauge had failed high and ignored the indication. In fact, the other gauge had failed as-is. As a result, the diesel engine sustained severe damage from overheating.

Alarm/Signal Issue

Intermediate Cause

Typical Issues

Are critical device failures alarmed? Are alarms sufficiently detectable in terms of hearing audible signals and reading alarm tiles or computer displays? Are alarms arranged and formatted to directly support situation assessment? Are alarms prioritized in terms of criticality to safety and immediacy of required crew response? Are there adequate controls for alarms, including acknowledgment and reset? For computer-displayed alarms, are alarm lists presented in the order in which the initiating condition occurred? Is there alarm overload in the workplace?

Typical Recommendations

Equipment or systems that are critical to safe vessel operation should be equipped with failure alarms.

Make alarms for critical systems and equipment audible, visible and easy to read within a display that allows someone to easily assess the situation.

Alarm recording systems should record alarms in order of occurrence.

Place flashing lights in locations where an audible alarm cannot be heard over the surrounding noise.

Examples

The vessel's bilge pump operated automatically by means of level switches. The bilge well high level switch, which turned on the bilge pump, was set at almost the same level as the bilge high level alarm, so that if the vessel was experiencing a minor roll of any sort, the bilge high level alarm would often go off almost simultaneously with the bilge pump startup. The alarm became an annoyance, so the engineer used a toothpick to hold down the alarm acknowledge button in order to silence the bilge high level alarm. A leak opened in a salt water service line and began to fill the bilges faster than the bilge pump could pump out. As a result, the engineer was not alerted of the condition until his next round when he discovered that the water was halfway to the lower engine room deck plates, was sloshing and splashing to the deck plates on either side of the lower engine room and was dangerously close to wetting several pump motors.

Alarms cannot be heard in the lower engine room above the noise of the main engine when it is in operation. No visible indicator is provided. Therefore, alarms are not communicated to personnel working in the lower engine room when the main engine is in operation.

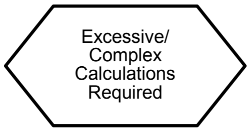
Standards References

ISM Sec 10.3

ISO 9001: 2000: Sec 7

ISO 14001: 2000: Sec 4.5.1

OHSAS 4.4, 4.5.1



Excessive/Complex Calculations Required

Intermediate Cause

Typical Issues

Are complex calculations required to render information, validate that information or test its accuracy? Can complex calculation and operation of data be automated to promote data to information? Can calculations be based on incomplete data?

Typical Recommendations

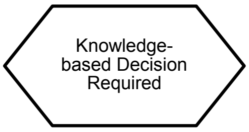
Provide the vessel with proven computerized solutions for performing complex and critical calculations.

Where possible, have key sensor outputs fed to computerized systems that perform critical calculations automatically for use by the crew members.

Examples

A vessel's stability and stresses were calculated manually using loading information and the ship's trim and stability book. While on the loaded voyage, the vessel began to take on a list in a storm. A check of the ballast tank soundings indicated that water was filling a ballast tank on the port side. An attempt to pump out the ballast tank proved ineffective in controlling the ingress of water. In a panic, rather than running through the calculations necessary to determine vessel stresses and stability, the chief officer chose to fill the starboard ballast tank opposite the damaged and flooded ballast tank on the port side. The uninformed step was a mistake and exceeded the vessel's stress limitations, causing the ship to break. A computerized system could have quickly provided the much needed information.

To determine the flow rate from a tank, the engineer was required to measure the tank level at two different times and divide the difference in the levels by the amount of time between the readings; and then also convert to liters/hour when the tank was calibrated in barrels. A flow meter could have been installed in the line instead.



Knowledge-Based Decision Required

Intermediate Cause

Typical Issues

Do personnel have to recall infrequently used information to adequately perform the task? Is it reasonable for a person to remember the information? Do personnel have to make decisions based on specific knowledge about the system for a successful outcome? Could better guidance eliminate the error?

Typical Recommendations

Use unusual situations where decisions must be made with incomplete information as an opportunity for experienced personnel to train less skilled personnel.

Train personnel to use the information they are provided to narrow down the conceivable scenarios/possibilities that the information could represent.

Provide tools (such as decision trees, job risk assessment or flowcharts) to aid in decision making and to reduce the potential for error.

Provide adequate staffing with the required knowledge and experience base to reach knowledge-based decisions.

Provide guidelines and objectives to aid in decision making.

Examples

The third officer, recently licensed, was in charge of the 12-4 bridge watch. A vessel was picked up on radar and became visible to the helmsman and the third officer. As the range between the vessels decreased, the third officer, considering the circumstances to be simple enough, decided not to wake the master and call him to the bridge as instructed in the master's night orders. As the situation evolved, the vessels found themselves on near-collision headings. The third officer attempted to communicate with the other vessel without success. As the possibility of collision became imminent, the approaching vessel altered course to port at the same time the third mate ordered the helmsman to turn to starboard. A collision resulted.

Failure of an auger in the unloading system occurred. Because there was no procedure and no one else onboard had any experience with the system, the engineer attempted to correct the failure without success. After a few hours of trial and many errors, he successfully returned the equipment to service.

Work Environment

Work Environment

Cause Type

Typical Issues

Did stresses (or stress factors) in the work environment, such as poor housekeeping, extreme heat or cold, inadequate lighting or excessive noise, contribute to the error? Was the problem caused by difficulties associated with protective clothing? Were there other stresses (or stress factors) present in the work area that may have contributed to the problem (e.g., vibration, movement, constriction, confined space, high jeopardy or risk)? Were the right tools available to do the job?

Typical Recommendations

Remove unused equipment and piping.

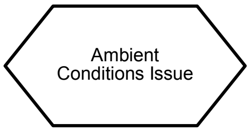
Provide employees with adequate personal protective clothing such as hearing protection, gloves and safety glasses. Ensure that they are available in different sizes to ensure a comfortable fit.

Ensure that the right tools are available to do the job.

Examples

An engineer wearing a hard hat hit his head very hard against a pipe passing overhead, which almost caused him to fall over backward. The lid of the hard hat obscured his upward vision; therefore, he did not see the pipe before he collided with it.

A step was missed during performance of a job. The crew member hurried through the job because it required him to wear a respirator and work in a confined space. None of the available respirators fit comfortably.



Ambient Conditions Issue

Intermediate Cause

Typical Issues

Was the event caused by excessive exposure of personnel to a hot or cold environment? Was poor ventilation (i.e., poor air quality or inadequate air velocity) a contributor to the event? Was the effect of rain, snow, etc., a factor?

Was the event caused because illumination levels were not sufficient for task performance? Did the level of illumination vary greatly over a given work station? Was the error caused by failure to provide supplemental lighting for personnel performing specialized visual tasks in areas in which fixed illumination was not adequate? Was there shadowing of labels, instructions or other written information? Was there a problem with glare or reflection? If the event occurred during an emergency situation, such as loss of power, was emergency lighting inadequate?

Was the event caused by diminished human performance resulting from excessive noise? Were personnel unable to hear auditory signals or alarms because of excessive background noise? Did auditory distraction, irritation or fatigue of personnel result from excessive noise?

Typical Recommendations

Ensure that indoor work areas are adequately ventilated and heated/cooled.

Allow personnel to take frequent breaks if they are required to work in an uncontrolled, uncomfortable climate for extended periods of time.

Solicit comments from employees regarding work station lighting. Address any comments received.

Provide nonglare screens for computer monitors.

Conduct an emergency drill at night and use emergency lighting. Solicit employee feedback to determine whether or not the lighting is adequate for emergency operations/evacuation.

Install additional equipment to diminish workplace noise when possible (e.g., mufflers or sound enclosures).

Post danger signs in areas in which noise is in excess of 85 dB to alert employees to wear hearing protection in those areas.

Ensure that emergency alarms and the emergency public address system can be heard throughout the process area.

Examples

While descending the very long ladder of the forward pump room, the second mate experienced dizziness. The ventilation fans were not in operation, the air was stagnant and it was very hot and humid in the space.

The cargo engineer slipped and injured himself while performing a round in the gas compressor room. The pipes in the gas compressor room were typically covered with ice, and water dripped onto the deck plates constantly when the vessel was in a warm climate.

Cool temperatures and poor lighting contributed to watchstanders becoming drowsy while on watch in the cargo control room during the night. On several occasions level alarms sounded for situations that watchstanders should have clearly anticipated and attended to well before the alarm. On one occasion a spill occurred when the vessel was loading at a high rate and the watchstander did not respond in time.

A serious incident occurred when glare caused by improper overhead lighting prevented an engineer from detecting that an important annunciator tile was illuminated.

Protective Clothing/Equipment Issue

Intermediate Cause

Typical Issues

Did protective clothing or equipment (e.g., plastic suit, gloves, respirator) contribute to the difficulty? Did protective clothing or equipment significantly diminish any of the senses (i.e., sight, touch, smell, hearing or taste) necessary to perform the task? Were personnel required to wear protective clothing or equipment for an uncomfortable length of time? Were personnel required to dress in and out of protective clothing an excessive number of times?

Typical Recommendations

Ensure that protective clothing is available in different sizes so that all employees can be properly fitted.

If several consecutive tasks require that protective clothing be worn for a long time, investigate the possibility of using more comfortable protective clothing (e.g., looser or tighter fit) or protective clothing made of more comfortable material (e.g., “breathable” fabric).

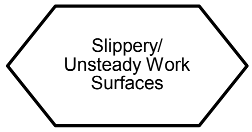
If protective clothing diminishes senses required to complete the task, investigate altering the clothing, if possible, so that personnel can perform their duties effectively.

Examples

An engineer wearing a hard hat hit his head very hard against a pipe passing overhead, which almost caused him to fall backward. The lid of the hard hat obscured his upward vision; therefore, he did not see the pipe before he collided with it.

An able-bodied seaman (AB) was applying an anticorrosive treatment to some freshly scaled metal. She was wearing protective goggles and rubber gloves for protection. The goggles did not fit comfortably, so she adjusted them without removing her gloves. The gloves had some anticorrosive on them, which rubbed onto her skin and caused a chemical burn.

During a fire drill the engine mechanic was required to put on firefighting gear, including a suit and fresh-air breathing apparatus. The firefighting suit was much too large. After putting on the equipment, the mechanic was directed to the site of the mock fire. The clumsiness of the oversized suit, compounded by the visibility limitations of the fresh-air mask, caused the mechanic to trip and fall as he was passing through a main deck watertight door.



Slippery/Unsteady Work Surfaces

Intermediate Cause

Typical Issues

Was the accident caused by a slippery deck surface? Did movement of the vessel cause or contribute to the accident? Did a slippery deck, combined with vessel movement, initiate the accident?

Are standing surfaces subject to the weather? Are standing surfaces subject to spills of oils, soaps or other slippery material? Is skid or slip proofing provided on standing and walking surfaces? Is the standing surface subject to motions such as ship roll? Are overhead or lateral handrails provided for potentially slippery surfaces?

Typical Recommendations

Continually remind personnel during safety meetings, safety training and shipboard familiarization to be alert regarding the surface they are walking on.

Continually remind personnel to always keep at least one hand free to steady themselves if needed.

Keep deck surfaces clean at all times.

Examples

An AB slipped on the focsle deck and injured himself. The focsle deck is an area frequently covered by take-out saltwater spray and, in some places, by grease originating from the mooring equipment.

Using both hands, the cook was carrying a box of food stuffs from the freezer to the galley as the ship was rolling. An unexpected large roll occurred, causing the cook to stumble in an attempt to maintain balance. The cook dropped the box, fell against the galley sink and bruised his hip.

Housekeeping Issue

Intermediate Cause

Typical Issues

Did poor housekeeping conditions contribute to the event? Was the error caused by a cluttered work environment? Was an unsafe situation created by a sloppy workplace?

Typical Recommendations

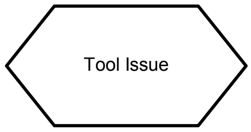
Ensure that work areas are maintained in a clean, organized manner.

Remove unused equipment and piping.

Example

A mechanic received a puncture wound to his hand when he reached into a toolbox and came into contact with an open pen knife. The toolbox was full of old rags and crumpled paper; therefore, the mechanic was unable to detect the hazard.

An engineer needed to check the operating records from a couple of months ago. The records were recorded in logbooks. The logbooks were not clearly labeled and were haphazardly thrown into a box. As a result, the engineer had to open each logbook to determine the period the contents covered. It took 25 minutes to locate the correct logbook.



Tool Issue

Intermediate Cause

Typical Issues

Were the proper tools supplied to do the job correctly? Were the tools in good condition?

Typical Recommendations

Provide the proper tools to do the job correctly.

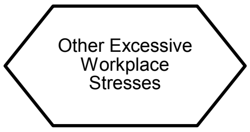
Ensure that worn tools are repaired or replaced.

Examples

An engine mechanic was assigned the task of tightening a large high pressure steam flange that had just begun leaking. A slugging wrench of the correct size was not immediately accessible because the second assistant engineer kept the wrenches locked up. Rather than seek out the second engineer, the mechanic retrieved two standard spanner wrenches and a mallet from the machine shop. With the assistance of the engine utility, the mechanic proceeded to beat one of the wrenches as each bolt was tightened. The wrench eventually broke in two, sending a piece flying across the engine room while just missing the engine utility. The mechanic lost his balance, fell against a valve wheel and hit his head.

An engine crew member was assigned the task of checking batteries in smoke alarms. He was not allowed to use a voltmeter to check the condition of the 9-volt batteries (only electricians could use voltmeters). So, he stuck the batteries on his tongue to see if they were still good.

An AB was using a hammer with a worn handle. When he was pulling out a nail, the handle broke and he injured his elbow.



Other Excessive Workplace Stresses

Intermediate Cause

Typical Issues

Was the error a result of environmental stresses other than poor housekeeping, inadequate climate control, poor lighting, noisy work area or problems with protective clothing? Was the worker rushed to get the job done? Was there pressure to get the job done to allow the system to be restarted? Did he/she perceive that he/she was at risk?

Typical Recommendation

When possible, reduce certain physiological and psychological stresses such as:

- Pain or discomfort caused by seating, etc.
- Hunger or thirst
- Vibration
- Movement constriction
- Disruption of circadian rhythm (normal sleeping cycle)
- High-risk job
- Perceived threat (e.g., of failure or job loss)
- Monotonous, degrading or meaningless work
- Self-imposed pressure to perform

Examples

Maintenance was being performed on the vessel’s main engine when the scheduled sailing time was moved up by three hours. The change in schedule caused the job to be rushed. A mechanic injured his elbow when the wrench he was using slipped off a nut he was in a hurry to tighten.

An ordinary seaman, having just learned of a distressing family situation during a phone call home, was distracted and not paying attention as he walked down the deck. He did not see a small pool of hydraulic oil near one of the winches and slipped, resulting in an injury.

Working in a confined space contributed to an event because personnel rushed through the job to get out of the higher-risk environment.

Workplace Layout

Cause Type

Typical Issues

Did inadequate controls or displays contribute to the error? Was poor integration of controls and displays a factor? Did differences in equipment in different areas contribute to the problem? Did poor arrangement or placement of equipment contribute to the event? Was there a failure to appropriately and clearly label all controls, displays and other equipment?

Typical Recommendations

Ensure that personnel are provided with sufficient information to control the process.

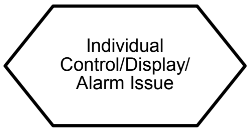
Locate related controls and indicators together.

Follow expected norms in labeling and layout of controls and indicators (e.g., left to right, top to bottom, consistent color coding).

Examples

A skin valve located on the sea chest was difficult to access, so it was left in the open position. The line that the valve secured sprung a leak. It took some time and considerable effort to locate and close the valve. In the meantime, a substantial amount of water accumulated in the engine room bilges.

The controller for an automatic valve was located on the front side of a vertical panel. The flow indication for the line was on the back side of the panel. A mirror was installed so that the engineer could see the flow indication while adjusting the valve position. However, the reversed image in the mirror caused problems in setting the correct valve position.



Individual Control/Display/Alarm Issue

Intermediate Cause

Typical Issues

Did inadequate equipment controls or control systems (e.g., push buttons, rotary controls, J-handles, key-operated controls, thumbwheels, switches, joy sticks) contribute to the occurrence? Did the control fail to provide an adequate range of control for the function it performs? Was the control inadequately protected from accidental activation? Were similar controls indistinguishable from one another? Did one switch control a number of parameters or have different functions under different conditions?

Did inadequate displays or display systems (e.g., gauges, meters, light indicators, graphic recorders, counters, video display terminals) contribute to the occurrence? Did the display fail to provide all information about system status and parameter values needed to meet task requirements? Did the configuration of the display make information difficult to see or to interpret? Was it necessary for the user to convert information presented by the display prior to using it? Did unnecessary or redundant information contribute to the error?

Note: Arrangement of controls is addressed by "Control/Display/Alarm Integration/Arrangement Issue". The location of controls is addressed by "Awkward/Inconvenient/Inaccessible Location of Control/Display/Alarm".

Typical Recommendations

Configure controls such that it would be difficult to accidentally activate them.

Ensure that similar controls have distinguishable features.

Ensure that the device/display allows the necessary range of control (e.g., a 0-100 GPM control dial would be inappropriate if the flow sometimes required settings as high as 110 GPM).

Ensure that sensitivity of controls allows personnel to quickly and accurately make process changes.

Ensure that displays provide enough information about the process so that the crew member can adequately control it.

Configure displays so that they are easy to read and interpret.

Provide direct display of the necessary parameters so that personnel do not have to convert the information for it to be usable.

Display only the information that is necessary/helpful to safely and efficiently control the process.

Avoid the use of dual purpose controls. Provide one control for each parameter being controlled.

Examples

The operator of the ship's stores crane inadvertently dropped the load being raised. The keys on the keypad he was using to operate the crane were very small and close together. The operator's fingers, even though they were average size, were too large to accurately press one button without inadvertently pressing the adjacent keys.

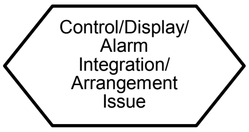
During an emergency, an engineer made the event worse by increasing flow instead of stopping flow. All valve controllers on the cargo control panel were rotated counterclockwise to reduce flow except for the one involved in this event. It was rotated clockwise to reduce flow.

Someone made an error in reading a meter because of the unusual scale progression. Instead of a scale with major markings divided by units of five (i.e., 5, 10, 15, 20), the scale was divided into units of six (i.e., 6, 12, 18, 24).

A digital display was used to monitor the flow rate of a system. The system responded slowly to control changes. This required the engineer to write down values at various times to create a time log. A chart recorder would have been a more appropriate type of display.

Standards References

SEMP 2.3.5, 8.1



Control/Display/Alarm Integration/Arrangement Issue

Intermediate Cause

Typical Issues

Was there a failure to arrange related controls and displays of the readouts of these controls close to each other? Was a display arranged so that it was obscured during manipulation of the related control? Were control/display relationships unclear to the user? Was the response of a display to control movements inconsistent, unpredictable or incompatible with populational stereotypes or with the user's expectations? Was there difficulty with multiple displays being operated by a single control? Is there a clear relationship between the controls and the displays? Were controls located near the displays they affected? Can the personnel read the display while adjusting the control? Are control/display arrangements consistent with populational stereotypes?

Typical Recommendations

Configure the control panel so that it is easy to locate related controls and displays.

Locate displays so that the related control can be manipulated while watching the display.

Ensure that the control and its displays are directly related to one another (i.e., if pressure is displayed, the corresponding control should directly affect pressure as opposed to another parameter, like temperature).

Ensure that each display responds consistently with populational stereotypes when the control is manipulated (e.g., the display shows a quantitative increase when a control is turned clockwise).

Ensure that one display is provided for every control.

Ensure that there is clear mapping between the controls and displays.

Examples

The temperature control had numbers on the dial that ranged from 0 to 100. The temperature indication also ranged from 0 to 100°C. However, setting the dial to 75 did not result in a temperature of 75°C.

An engineer set the flow rate improperly. The procedure specified the flow rate in gallons per minute. The display indicated tons per hour.

The crew member incorrectly started Pump D instead of Pump B. The pump controls are all identical and arranged in reverse alphabetical order from left to right like this: E D C B A. This violates a stereotype that controls will be in alphabetical order from left to right.

The controls for three pumps were arranged differently than the pumps themselves.

There were three sections of lights in the room (front, middle and back). However, the light switches were not in the same arrangement. The light switch for the back lights was located closest to the front of the room.

Awkward/Inconvenient/Inaccessible Location of Control/ Display/Alarm

Intermediate Cause

Typical Issues

Were there problems related to the location of controls or displays? Were they out of the normal work area?

Typical Recommendations

Locate controls in convenient locations to encourage their proper use.

Locate displays in convenient locations to encourage their use.

Locate displays so that they can be read by the average person.

Locate controls so that they can be easily operated by the average person.

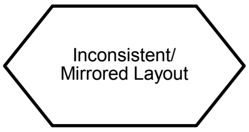
Locate controls so that they are not accidentally bumped.

Examples

A large control handle on a control panel stuck out beyond the edge of the panel when the pump was running. Someone walking past the panel accidentally bumped the switch and shut down the pump.

The speed control for a pump was located three levels below the normal operating area. As a result, engineers ignored out-of-tolerance conditions because they did not want to go up and down the three ladders.

The only open space on a control panel was near the floor. As a result, a new chart recorder was installed six inches above the floor. To read the display, the engineers had to get down on their hands and knees. Sometimes, the engineers just looked at the display while standing and guessed at the readings.



Inconsistent/Mirrored Layout

Intermediate Cause

Typical Issue

Did differences in the arrangement of controls, displays or other equipment between different processes or areas contribute to the event?

Typical Recommendations

Ensure that color codes have the same meaning on all control boards aboard the vessel.

Ensure that identical units have identical control board configurations.

Label similar components in sequential order: ABC not ACB.

Examples

Two computer systems with monitors, located in the cargo control room, were programmed using different color schemes. On the first system, the color red indicated an open valve and green indicated a closed valve. On the second system, green indicated normal and red indicated an abnormal condition. Because of the inconsistency in color coding between the two systems, a newly assigned chief officer allowed a tank to overflow when he was temporarily confused about the second monitor. His mindset after having viewed the first monitor was that green indicated lack of flow.

Someone inadvertently started the wrong pump. The cooling water pumps are arranged alphabetically (A-D) from left to right. However, the control panel has the controls arranged as follows:

A C

B D

The ballast control panel and mimic display were oriented with the controls and displays for the forward tanks toward the bow of the vessel and the after tanks toward the stern. The cargo control panel, on the other hand, was oriented such that the controls and displays for the forward tanks were depicted on the after end of the display and after tanks were depicted on the forward end of the display. In other words, the ballast panel was consistent with vessel orientation while the cargo panel opposed vessel orientation. In preparation for loading, the newly assigned chief officer opened the offshore manifold valves instead of the manifold valves connected to the loading arms.

Awkward/Inconvenient/Inaccessible Equipment Location

Intermediate Cause

Typical Issues

Is equipment (tools, work surfaces, supplies) that personnel need to perform their jobs conveniently located? Is it accessible by workers when needed?

Note: This node addresses equipment other than controls/displays/alarms.

Typical Recommendations

Ask workers about problems they have encountered in locating needed tools.

Locate tools and supplies so that workers will have access to them when needed.

Review workstations to ensure that proper ergonomics are being implemented.

Examples

A skin valve located on the sea chest was difficult to access, so it was left in the open position. The line that the valve secured sprung a leak. It took some time and considerable effort to locate and close the valve. In the meantime, a substantial amount of water accumulated in the engine room bilges.

An engineer needed to make a copy of a procedure to use in the startup of a system. His printer was out of paper. The paper supply was locked up in the ship's office. As a result, he spent 45 minutes gathering enough paper by taking it from other printers.

All tools were returned to the vessel's machine shop at the close of each work day. As a result, personnel spent 30 minutes at the beginning of each day obtaining the tools they needed for the day and 20 minutes returning them at the end of each day.

Standards Reference

TMSA 5A: 4.3

Poor/Illegible Labeling of Equipment or Space

Intermediate Cause

Typical Issues

Was there a failure to appropriately and clearly label all controls, displays or other equipment items that had to be located, identified or manipulated by the user during performance of a task? Did labeling fail to clearly identify equipment? Did labeling incorrectly identify equipment? Were labels hard to read, incorrect or misleading?

Typical Recommendations

Ensure that all controls and displays are labeled correctly.

Ensure that labels are made using an easy-to-read font and are color-coded if necessary.

Locate all labels close to the related control/display.

Maintain labels as necessary (clean, ensure reliable adhesive, etc.).

Ensure that equipment locations or locations of materials are properly labeled.

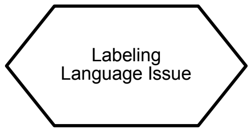
Ensure that bins in the stores locker are properly labeled.

Examples

An engineer selected the wrong valve from a 20-valve manifold because more than half of the valves in the group were unlabeled. The adhesive used to attach labels to the valves was not reliable in the hot, humid environment in which the valves were located; therefore, many of the labels had fallen into the bilge. She tried to judge which was the correct valve using the labels that remained attached.

Someone opened the wrong valve, causing a transfer error. The label was positioned between two valves, forcing the person to choose between them.

A row of bins in the stores locker contained different types of bolts. The labels for the bins had part numbers on them, but no equipment descriptions. As a result, some items were incorrectly restocked after being returned to the stores locker.



Labeling Language Issue

Intermediate Cause

Typical Issues

Are labels understood by officers and crew members? Are labeling conventions understood by personnel?

Are labels and placards consistently applied? Do labels and placards follow standards guidance and formats? Are messages limited to a specific language list? Are messages presented in a language understood by the user population of that vessel?

Typical Recommendations

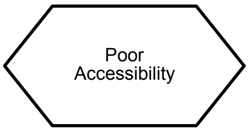
Ensure that all pertinent labels are understood by officers and crew members.

Ensure that conventions used for labeling are clearly understood.

Examples

A vessel recently purchased by the company was operated under U.S. flag for a number of years after delivery. Most of the labels used throughout the vessel were not understood by the Chinese officers and crew who were assigned to the vessel upon handover to the company.

A vessel recently purchased by the company was operated under U.S. flag for a number of years after delivery. The exit signs were all in red letters. The European officers and crew assigned to the vessel at handover were accustomed to green exit signs. The signs caused some confusion during a minor incident requiring evacuation of a space.



Poor Accessibility

Intermediate Cause

Typical Issues

Are all items in the work space accessible to personnel? Are personnel required to step around or over piping or other obstacles to gain access to an area or to equipment? Are the means of access adequate for the tasks to be completed (e.g., is a stair, ladder or ramp provided where changes at a height of more than 12 inches [200 mm] are required)? Are unobstructed emergency egress paths available? Is adequate space provided for personnel to complete their operational or maintenance tasks? Have adequate clearances been provided to move equipment into or out of a space? Has adequate clearance been provided to allow tools to be used in their full range of motion? Is the necessary physical access (e.g., room for a hand, arm, head, two arms, etc.) to equipment provided?

Note: This node addresses equipment other than controls/displays/alarms.

Typical Recommendations

Provide a permanent access feature to accommodate personnel during maintenance.

Provide sufficient room around equipment to allow personnel to remove it and replace it as needed.

Provide an access opening sufficient to allow personnel to perform maintenance tasks on equipment while it is in place.

Provide a stair to the workplace when daily access is required.

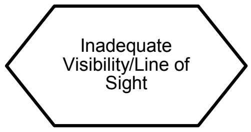
Provide a secondary means of escape from the work space.

Provide a ramp to allow movement of goods in and out of a work space.

Examples

No permanent means of access was provided to a relief valve on top of a tank. As a result, an injury occurred when a worker fell in the process of gaining access to the top of the tank.

Access to the main engine lube oil filters required personnel to remove a section of walkway grating. After the filters were changed, the grating was not replaced. A crew member was injured when he fell into the hole.



Inadequate Visibility/Line of Sight

Intermediate Cause

Typical Issues

Are views to visual targets partially or completely obstructed? Are visual targets needed by personnel (such as bridge watchstanders) visible from nominal working positions (such as consoles and workstations)? When operating controls, do personnel have to bend, crane or lean to see associated displays? Are displays oriented approximately perpendicular to a viewer's line of sight? Are displays and other visual targets sufficiently illuminated? Are the atmospherics free of obscuring material such as air-suspended dust or gases? Are there moveable or portable devices that can be positioned such that they obscure visibility (e.g., fork lifts, robotic devices, carts)?

Typical Recommendations

Provide unobstructed views to visual targets.

Make visual targets needed by crew members (such as bridge watchstanders) visible from nominal working positions (such as consoles and workstations).

Position displays associated with operating controls such that people do not have to bend, crane or lean to see them.

Arrange displays so that they are oriented approximately perpendicular to a viewer's line of sight.

Sufficiently illuminate displays and other visual targets so that they can be easily read in the expected environments.

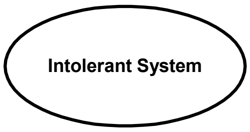
Maintain atmospherics that are free of obscuring material such as air-suspended dust or gases.

Where moveable or portable devices are used that may obscure visibility, designate use or placement positions for them that do not obscure visibility for long periods of time.

Examples

A collision occurred between a high-speed ferry and a freight ferry during thick fog. While the fog severely limited visibility, the high-speed craft did not alter speed or course, and the adjustments made by the ferry were not sufficient. Misinterpretation of radar information onboard the high-speed craft also contributed to the collision.

A watchkeeper onboard a tanker and another onboard a cargo vessel were distracted when one vessel was overtaking the other and a collision occurred. The collision was attributed to insufficient lookout.



Intolerant System

Cause Type

Typical Issues

Were personnel unable to detect errors (by way of alarms or instrument readings) during or after the occurrence? Was the system designed such that personnel were unable to recover from errors before a failure occurred?

Typical Recommendations

Ensure that important safety-related equipment is adequately equipped with error-detection systems.

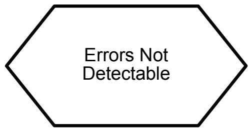
Provide feedback to personnel so that they can tell if procedure steps are performed correctly.

Design tasks and equipment to allow time to detect and correct errors for safety-critical tasks and equipment.

Examples

An engineer was simultaneously filling two fuel oil settling tanks. While attending to one of the settling tanks, he allowed the other one to overflow because no level alarms were provided to let him know that the tank was reaching its capacity.

A crew member thought he closed a valve on the feed line to a tank. However, the valve stem was binding and the valve was half-open. No position indicator was provided for the valve and no flow indication was provided for the line.



Errors Not Detectable

Intermediate Cause

Typical Issues

Were personnel unable to detect errors (by way of alarms or instrument readings) during or after the occurrence? Did a serious error go unnoticed because no means were provided to monitor system status?

Note: Consider dual coding with "Control/Display/Alarm Integration/Arrangement Issue (Workplace Layout)".

Typical Recommendations

Ensure that important safety-related equipment is adequately equipped with error detection systems.

Ensure that systems important to reliability and quality are equipped with error detection systems.

Examples

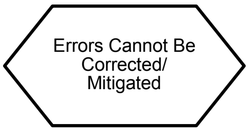
Fuel oil samples were taken and sent to a lab for analysis each time the vessel took on bunkers. Lab results typically took up to a week to be transmitted to the vessel. The company practice was to carry the minimum amount of fuel oil aboard to safely make the passage. Because of this practice, bunker fuels were often put into use prior to receiving laboratory results. Due to system constraints, this often included mixing newly obtained bunkers with those already aboard the vessel. As a result, incompatible fuels were mixed, which caused damage to the main engines.

An engineer intending to stop flow to a tank accidentally turned the wrong valves. No level alarm was provided on the tank to indicate that overflow was imminent; therefore, the tank overflowed.

The alarm limits for cooling water flow were set very close to the normal values. The alarm went off frequently. The engineers learned to ignore the alarm because it was part of normal operations. As a result, when cooling water flow stopped because of a failed pump, the engineers did not respond.

Bolts were stored in bins that were only labeled with the part numbers; no part descriptions were included. Small parts like these were not individually labeled with part numbers. As a result, there was no means of checking that the materials in the bin were the ones that were supposed to be there.

A crew member attempted to open a block valve underneath a relief valve. The gate separated from the stem, so even though the valve appeared open (based on stem position), the gate was still closed and obstructed the pressure relief valve inlet.



Errors Cannot Be Corrected/Mitigated

Intermediate Cause

Typical Issue

Was the system designed such that personnel were unable to recover from errors before a failure occurred?

Typical Recommendations

Design safety-related equipment so that the detected errors can be corrected before system failure occurs.

Design tasks and related procedures to allow employees time to detect and correct errors for safety-critical tasks.

Example

A low tank level alarm occurred, indicating insufficient level for the pump drawing suction from the tank. By the time someone responded to the alarm, the pump was already damaged.

Training/Personnel Qualifications

Training/Personnel Qualifications

Cause Category

Typical Issues

Was training provided on this task? Was the training sufficient to perform the task? Did the training correspond to the actual work environment? Were training records adequate?

Typical Recommendations

Provide training in the hazards of the process and job tasks.

Provide refresher training in appropriate areas.

Solicit comments from the trainees after they have been on the job for three months or other specific time frame to identify gaps in the training program.

Ensure that instructors are properly qualified.

Provide training on tasks critical to the environment, reliability and quality.

Examples

The company required that all deck personnel be trained in the operation of the constant tension mooring winches prior to being assigned to operate them. The third officer assumed that the gray-haired AB who had just signed on knew how to operate the winch. During cargo loading operations, the third mate directed the AB to take the slack out of a mooring line. As a result of his unfamiliarity with the winch, the AB placed too much tension on the line and it parted.

Engineers were not trained on how to parallel generators. An engineer newly assigned to the vessel, and unfamiliar with the vessel's automatic load sharing, was directed to start the number two generator and bring it online with the number one generator. The engineer started the number two generator, brought it up to speed and closed the breaker in accordance with generally accepted practice. The engineer did not know that he was to place both generators in manual control until the load had been evenly distributed between them. As a result, the automatic load sharing attempted to balance the large disparity in load between the generators too quickly, and this caused the number two generator to trip back offline.

Standards References

ISM Code 6.1.1, 6.2, 6.3, 6.4, 6.5

STCW All

ISO 9001: 2000: Sec 6.2.1 and 6.2.2

ISO 14001: 2000: Sec 4.4.2

TMSA 1A: 2.3, 2A: 1.1, 2.2, 4.1, 4.4, 3B: 1.3, 2.1, 3.4, 4.3, 5A: 3.2, 3.3, 6A: 3.2, 4.2, 7A: 2.2, 3.2, 8B: 1.1, 2.1, 4.1, 9B: 2.3, 3.3

SEMP 1.2.1 f, 1.2.4, 3.5, 3.6, 5.3, 6.3, all of Sec 7, 8.5.b, 9.1.e

OHSAS 4.4.2

No Training

No Training

Cause Type

Typical Issues

Had training on the task been developed? Had training been conducted? Did the individual(s) involved in the event receive training? Had the training requirements been identified? Was a decision made to not train on the task?

Typical Recommendations

Provide training in the hazards of the process and job tasks.

Provide refresher training in appropriate areas.

Provide a written description of the training requirements associated with a specific job title.

Provide training on tasks critical to the environment, reliability and quality.

Examples

Engineers were not trained on how to parallel generators. An engineer newly assigned to the vessel, and unfamiliar with the vessel's automatic load sharing, was directed to start the number two generator and bring it online with the number one generator. The engineer started the number two generator, brought it up to speed and closed the breaker in accordance with generally accepted practice. The engineer did not know that he was to place both generators in manual control until the load had been evenly distributed between them. As a result, the automatic load sharing attempted to balance the large disparity in load between the generators too quickly, and this caused the number two generator to trip back offline.

ABs were not provided training in rigging bosun's chairs. It was assumed to be a skill they would gain through experience. As a result, a new AB assigned to paint aloft rigged the chair incorrectly. After he lifted himself a few feet from the deck, the knot holding the chair slipped and he fell to the deck and was injured.

Standards References

ISM Code 6.3 and 6.5

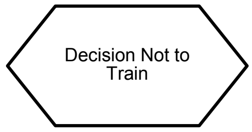
STCW All

ISO 9001: 2000: Sec 6.2.1 and 6.2.2

ISO 14001: 2000: Sec 4.4.2

TMSA 2A: 2.2, 3.1, 3B: 3.3, 8B: 3.2

OHSAS 4.4.2



Decision Not to Train

Intermediate Cause

Typical Issues

Was the decision made to not provide specific training on a task? Were some employees not required to receive training? Was experience considered a substitute for training?

Typical Recommendations

Provide training in the hazards of the process and job tasks associated with normal operations, nonroutine operations and emergency operations.

Provide training for maintenance tasks such as inspection, testing, calibration, planned maintenance, repair, replacement and installation.

Provide refresher training annually for all employees in their assigned duties.

Examples

ABs were not provided training in rigging bosun's chairs. It was assumed to be a skill they would gain through experience. As a result, a new AB assigned to paint aloft rigged the chair incorrectly. After he lifted himself a few feet from the deck, the knot holding the chair slipped and he fell to the deck and was injured.

The company required that all deck personnel be trained in the operation of the constant tension mooring winches prior to being assigned to operate them. The third officer assumed that the gray-haired AB who had just signed on knew how to operate the winch. During cargo loading operations, the third mate directed the AB to take the slack out of a mooring line. Because of his unfamiliarity with the winch, the AB placed too much tension on the line and it parted.

Standards References

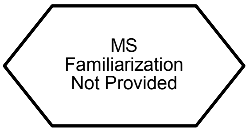
ISM Code 6.3 and 6.5

SCTW All

ISO 9001: 2000: Sec 6.2.1 and 6.2.2

ISO 14001: 2000: Sec 4.4.2

OHSAS 4.4.2



MS (Management System) Familiarization Not Provided

Intermediate Cause

Typical Issues

Were officers and crew members given proper familiarization with the management system (MS)? Did the problem result from an officer or crew member not knowing an MS requirement? Would familiarity with the SMS have helped prevent the event? Were personnel familiar with the operation of safety-related equipment?

Typical Recommendations

Ensure that officers and crew members joining the vessel are familiarized with the MS as soon as possible after joining the vessel. Test officers and crew members on basic MS requirements and the location of MS information to ensure a working familiarity with the system.

Ensure that personnel are given proper familiarization with their duties. The MS should require that essential instructions are documented and provided to new personnel prior to sailing.

Examples

A small fire broke out in the accommodations three days out of port. When the emergency alarm sounded, a number of new crew members who had signed on in the previous port to relieve those disembarking were confused about where the emergency squads were to meet. Two crew members assigned to wear fire protection suits and fresh-air breathing apparatus were unfamiliar with the suits and had not put on a fresh-air breathing apparatus in years. In the meantime, the small fire became much larger and damaged a significant portion of the accommodations.

The MS required that an MS familiarization booklet be provided to crew members upon joining the vessel. The vessel ran short of the booklets, and not all crew members were provided with the booklet upon joining. Among other things, the booklet prohibited the disposal of plastics overboard. A member of the crew who did not receive the booklet threw a plastic bag full of rubbish overboard in clear view of a pleasure craft, which reported the incident to local port state authorities.

The MS required that all personnel must wear hearing protection when in the engine spaces. The MS familiarization procedure included a review of safety equipment and its use aboard the vessel, including spaces where special equipment must be worn. MS familiarization had not been provided, and a number of personnel entered the engine spaces without wearing hearing protection.

Standards Reference

ISM Code 6.3

Training Requirements Not Fulfilled

Intermediate Cause

Typical Issues

Was required training provided? Did the nonfulfillment of training requirements contribute to the event?

Typical Recommendations

Review training records of joining crew members against SMS requirements to determine what training/retraining needs exist and plan shipboard training to fulfill those needs.

Establish an organized program of training, including drills, to address likely emergency situations and ensure that training is provided to officers and crew members on a schedule that ensures that an adequate number of personnel are prepared to respond at any time to a variety of emergencies.

Examples

The company required that all deck personnel be trained in the operation of the constant tension mooring winches prior to being assigned to operate them. The third officer assumed that the gray-haired AB who had just signed on knew how to operate the winch. During cargo loading operations, the third mate directed the AB to take the slack out of a mooring line. As a result of his unfamiliarity with the winch, the AB placed too much tension on the line and it parted.

The company established an organized program of safety training to be carried out in a four-month cycle. The training included the viewing of videos followed by an actual drill or walkthrough to familiarize personnel with the ship's actual equipment and arrangements. The chief officer often ended the training with the video and did not follow through with the drill or walkthrough. When a fire broke out in the engine room, personnel were not familiar with the operation of the ship's ventilation dampers and their locations and the operation of the CO_2 fire extinguishing system. As a result, a couple of dampers were left open so that after the engine room was evacuated and CO_2 was subsequently released into the space, the fire was restarted by the natural air draft flowing through the open dampers.

Standards References

ISM Code 6.5 and 8.2

ISO 9001: 2000: Sec 6.2.2

ISO 14001: 2000: Sec 4.4.2

OHSAS 4.4.2

Training Need Not Identified

Intermediate Cause

Typical Issues

Did an overlooked training need of an officer or crew member contribute to the event? Did an event serve to identify a training need that was previously overlooked?

Typical Recommendations

Develop a checklist as a guideline for conducting interviews and reviewing the training records of joining officers and crew members to determine training/retraining needs.

Review events to determine additional training needs.

Example

The vessel was equipped with automatic load sharing, which required some special steps to be taken when paralleling generators. The need to train newly assigned engineers on how to parallel the vessel's generators was not identified. An engineer newly assigned to the vessel, and unfamiliar with the vessel's automatic load sharing, was directed to start the number two generator and bring it online with the number one generator. The engineer started the number two generator, brought it up to speed and closed the breaker in accordance with generally accepted practice. The engineer did not know that he was to place both generators in manual control until the load had been evenly distributed between them. As a result, the automatic load sharing attempted to balance the large disparity in load between the generators too quickly, and this caused the number two generator to trip back offline.

Standards References

ISM Code 6.5

ISO 9001: 2000: Sec 6.2.2

ISO 14001: 2000: Sec 4.4.2

TMSA 3B: 2.3

OHSAS 4.4.2

Training Records
System Issue

Training Records System Issue

Cause Type

Typical Issues

Was the training record system complete and up to date? Did it accurately reflect the employee's training? Were the records used to determine worker selection and task assignments?

Typical Recommendations

Document the training that an individual is required to receive prior to qualification and to maintain qualification.

Ensure that individuals are assigned responsibilities for maintaining training records.

Examples

Requirements for serving as chief officer aboard a container vessel required successful completion of training in the stowage of containers containing hazardous materials. Training records for the newly assigned chief officer indicated that the officer had received the required hazardous materials stowage training. A round of the deck by the ship's master after putting to sea indicated that two containers containing incompatible classes of materials were stowed one above the other. The master brought this to the chief officer's attention, and during this discussion discovered that the chief officer had not received the required training.

A seafarer who recently upgraded his qualifications was not considered for a new opening corresponding to his newly obtained qualifications because personnel records did not indicate the upgrade.

Standards References

ISM Code 6.5

ISO 9001: 2000: Sec 6.2.2

ISO 14001: 2000: Sec 4.4.2

TMSA 2A: 2.3, 3B: 2.2

SEMP 13.3.c

OHSAS 4.4.2

Training Records Incorrect

Intermediate Cause

Typical Issues

Did the records show training that the employee had not received? Did the records correctly indicate the employee's qualifications?

Typical Recommendations

Document the required training that an employee is required to complete to be promoted.

Document required retraining that an employee is required to complete on a periodic basis.

Document all in-house, on-the-job and outside training that an employee completes. Include dates of completion, test scores, instructor comments, certifications, etc. Include a description of how competency is ascertained.

Example

Requirements for serving as chief officer aboard a container vessel required successful completion of training in the stowage of containers containing hazardous materials. Training records for the newly assigned chief officer indicated that the officer had received the required hazardous materials stowage training. A round of the deck by the ship's master after putting to sea indicated that two containers containing incompatible classes of materials were stowed one above the other. The master brought this to the chief officer's attention, and during this discussion discovered that the chief officer had not received the required training.

Standards References

ISO 9001: 2000: Sec 6.2.2

OHSAS 4.4.2

Training Certificate/Endorsement Expired/Invalid

Intermediate Cause

Typical Issues

Did the training records show the employee's current status or job qualification? Had the qualification expired but not been reflected in the training records? Did the records include up-to-date copies/records of pertinent certificates and/or endorsements?

Typical Recommendations

Review current certificates and endorsements of officers and crew members reporting to work against personnel records to identify any inconsistencies.

Require permanent employees to provide copies of any certificate renewals, additional qualifications or upgrades to the personnel department.

Establish a training records management system that assigns certain individuals the responsibility for:

- Notifying records management personnel of employee training completion dates
- Recording training completion dates
- Forwarding materials to records management personnel that verify employee understanding of the training
- Alerting employees and supervisors about upcoming training requirements
- Scheduling employees and instructors for specific training modules
- Recording onboard training in training record books

Example

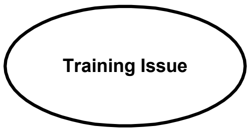
A seafarer who recently upgraded his qualifications was not considered for a new opening corresponding to his newly obtained qualifications because personnel records did not indicate the upgrade.

Standards References

ISM Code 6.2

ISO 9001: 2000: Sec 6.2.2

OHSAS 4.4.2



Training Issue

Cause Type

Typical Issues

Were job/task analyses adequate? Were the program design and objectives complete? Did the training organization have adequate instructors and facilities? Is refresher training performed? Does testing adequately measure the employee's ability to perform the task (competence)? Does training include normal and abnormal/emergency working conditions?

Typical Recommendations

Perform job/task analyses for routine jobs/tasks.

Solicit comments from the trainees after they have been on the job for three months to identify gaps in the training program.

Ensure that on-the-job training consists of "doing" rather than just "watching" (competence).

Provide refresher training for nonroutine tasks.

Ensure that instructors are properly qualified.

Examples

In the event of an oil spill, ship's officers were supposed to contact local authorities, the spill response organization and pertinent company officers. During an actual event, while the vessel's master and chief engineer were ashore, the emergency contact numbers and procedures could not be found. No training had ever been provided regarding the location and use of the emergency response plan and the contact of pertinent authorities and company personnel.

A deck officer made a mistake while using the flammable gas detection meter. The task analysis identified that training was required on the use of the meter, but the training/learning objectives did not include it; therefore, training did not stress this skill and the deck officer used the meter incorrectly.

An AB failed to place a remotely controlled valve into local control and close it in response to an urgent request from the cargo control room. Qualification to stand a cargo watch included a discussion of how remotely controlled valves could be operated locally in the event of a control failure. A prior walkthrough evaluation should have been performed to determine whether the AB was qualified to stand a cargo watch.

Standards References

ISM Code 6.2, 6.5

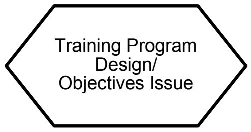
STCW Code A-I/6 and applicable sections following A-I/6

ISO 9001: 2000: Sec 6.2.2

TMSA 2A: 2.2, 3.1, 4.3, 4.4, 3B: 2.4, 3.3, 5A: 4.3, 8B: 3.2, 9B: 4.3

SEMP 7.2.2.d.f

OHSAS 4.4.2



Training Program Design/Objectives Issue

Intermediate Cause

Typical Issues

Did the objectives satisfy the needs identified in the task analysis? Did the objectives cover all the requirements necessary to successfully complete the task? Were the objectives written at the correct cognitive level?

Was the training program designed to equip the trainees to perform the task? Did it contain the correct amounts of classroom and on-the-job instruction?

Typical Recommendations

Provide employees with classroom and on-the-job training. After completion of the training, have the trainee physically demonstrate competence in all tasks (without receiving direction) to ensure that the employee has received an adequate amount of training.

After completion of a training module, have trainees evaluate the program design. Solicit comments to improve the program design.

Establish an overall training management system that assigns certain individuals the responsibility for:

- Analyzing training needs for each job title
- Establishing training criteria for each job title
- Designing curricula to meet training needs
- Continually assessing and improving the training program

Using the job/task analysis, define and document training objectives so that employees will be equipped with sufficient skills to perform their assignments successfully.

Ensure that trainees understand the training objectives at the start of each new training module.

Ensure that the objectives are written at the correct cognitive level. For example, the objective should be written as “Use ARPA to safely navigate in traffic” rather than “Explain how ARPA is used to safely navigate”. The trainee’s job is to perform the task, not merely to explain how to do it. Knowing and doing are on two different cognitive levels.

Examples

A deck officer made a mistake when using the flammable gas detection meter. His formal training had contained instruction about using the flammable gas detection meter, but on-the-job or hands-on use of the flammable gas detection meter had not been required.

A deck officer made a mistake while using the flammable gas detection meter. The task analysis identified that training was required on the use of the meter, but the training/learning objectives did not include it; therefore, training did not stress this skill and the deck officer used the meter incorrectly.

Someone opened the wrong valve during an emergency. In training, she had read the emergency procedure but had never performed the procedure on the vessel or on a simulator; nor had she performed a walkthrough.

A crew member made a mistake weighing material because he used the scale incorrectly. The task analysis identified that training was required on the use of the scale, but the training objectives did not include it; therefore, training did not stress this skill.

An engineer overfilled a tank. The training objectives for this system required the engineer to list the components in the system, but did not include an objective to explain the function and operation of the control system.

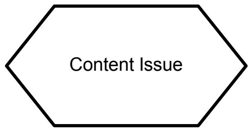
Standards References

ISM Code 6.5

STCW Code A-I/6 and applicable sections following A-I/6

ISO 9001: 2000: Sec 6.2.2

OHSAS 4.4.2



Content Issue

Intermediate Cause

Typical Issues

Did the lesson content address all the training objectives? Did the lessons contain all of the information necessary to perform the job? Was the lesson material consistent with the current system configuration and procedures?

Note: This node addresses the content of lessons led by training personnel or formal training away from the job (such as classroom, laboratory or simulator training). Problems with the content of on-the-job training are addressed under the "On-the-job Training Issue" node.

Typical Recommendations

Ensure that the lesson content for each training module addresses all the necessary topics to guarantee a complete understanding of the required tasks.

Include workshops or demonstration techniques as part of the lesson content to provide a tangible and practical means of communication.

Examples

A deck officer incorrectly used the flammable gas detection meter. The lesson plan did not address training on the flammable gas detection meter, although it was listed in the objectives.

An engineer made a mistake performing a control transfer from the local control station panel to the remote station in the control room. The remote station had been installed several months before, but the control transfer procedure and operation of the new controller had not been added to engineer's familiarization training.

A new first officer made a mistake on the tank inerting procedure. The fill lines in the cargo tanks had been extended to within a meter of the bottom of the tank at the last shipyard period. The change in the inerting procedure resulting from this change had not been incorporated into training for new first officers.

The officer of the watch made a mistake using the ARPA. The system had been upgraded several months ago. The training he received on the system the previous month had not incorporated the new features of the upgrade.

A chief engineer incorrectly entered a requisition into the computer. During training, the instructor had shown her the wrong way to perform the task.

Standards References

ISM Code 6.5

STCW Code A-I/6 and applicable sections following A-I/6

ISO 9001: 2000: Sec 6.2.2

OHSAS 4.4.2

On-The-Job Training Issue

Intermediate Cause

Typical Issues

Did the on-the-job training provide opportunities to learn the skills necessary to perform the job? Was there sufficient on-the-job training? Did the on-the-job training cover unique and unusual situations or equipment to avoid surprising the crew later on?

Note: The STCW Code refers to this type of training as in-service training.

Typical Recommendations

Ensure that on-the-job training consists of actually “doing” rather than only “watching” (demonstrates competence).

Ensure that in-service training is conducted by appropriately qualified persons.

Match trainees with qualified personnel who can explain not only how to perform certain tasks, but also why certain tasks are performed.

Ensure that on-the-job training covers unique and unusual situations or equipment.

Examples

A deck officer incorrectly used the flammable gas detection meter. He had received classroom and lab instruction on the use of the flammable gas detection meter, but had no on-the-job experience in the use of the equipment.

A deck officer incorrectly used the flammable gas detection meter. He had received classroom and lab instruction on the use of the flammable gas detection meter, but the meter used in the lab was an earlier model and operated somewhat differently than the one used on the job. No on-the-job training was provided.

An oil tanker operator required that all engineers, prior to promotion to second assistant engineer, must undergo on-the-job training in the operation of the vessel’s environmental equipment, including the operation and maintenance of the oily water separator and oil content meter. An engineer who had successfully completed training and qualification was transferred to another one of the company’s tankers where he was responsible for the operation of the oily water separator. The engineer had significant difficulty operating the oily water separator because the one he was trained on was of a different type.

Standards References

ISM Code 6.5

STCW Code A-I/6 and applicable sections following A-I/6

ISO 9001: 2000: Sec 6.2.2

OHSAS 4.4.2

Qualification Testing Issue

Intermediate Cause

Typical Issues

Did the testing cover all of the knowledge and skills necessary to do the job? Did the testing adequately reflect the trainee's ability to perform the job? Was on-the-job demonstration part of qualification and was the demonstration thorough enough?

Typical Recommendations

Verify that the trainee fully understood the training in some tangible manner (such as a classroom exam, physical demonstration without direction, oral exam, working with an experienced employee who is able to evaluate the trainee's performance).

Ensure that all areas of the lesson content are verified for understanding (including both complex task skills and rudimentary skills).

Examples

A deck officer made a mistake while using the flammable gas detection meter. She had received instruction on the use of the flammable gas detection meter, but had not been tested on her ability to use the equipment. Therefore, she used it incorrectly.

An AB failed to place a remotely controlled valve into local control and close it in response to an urgent request from the cargo control room. Qualification to stand a cargo watch included a discussion of how remotely controlled valves could be operated locally in the event of a control failure. A prior walkthrough evaluation should have been performed to determine whether the AB was qualified to stand a cargo watch.

A crew member failed to close a valve in an emergency because he could not find it. Qualification testing consisted of a discussion of the procedure. A walkthrough evaluation should have been performed.

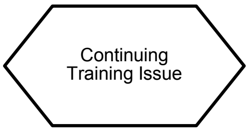
Standards References

ISM Code 6.5

STCW Code A-I/6 and applicable sections following A-I/6

ISO 9001: 2000: Sec 6.2.2

OHSAS 4.4.2



Continuing Training Issue

Intermediate Cause

Typical Issues

Was continuing training performed to keep employees equipped to perform non-routine tasks? Was the frequency of continuing training adequate?

Was training provided when the work methods for this task were changed? Was training provided on changes to the procedure for the task? Was training provided on new equipment used to perform the task?

Note: Problems with refresher training on abnormal and emergency operations should also be coded under “Emergency Preparedness Training Issue”.

Typical Recommendations

Provide all employees with refresher training for routine and non-routine tasks associated with their job assignments at least annually.

Consult employees regarding the frequency of training. Should the training be conducted more or less often? Should refresher training content be revised?

Provide additional training for new procedures, procedure modifications and process modifications involving new equipment.

Ensure that the new work method training includes instructions that relate to non-routine tasks (changes to startup, shutdown, emergency operations, etc.).

Verify understanding of the new work method in the same manner as initial training (classroom exams, physical demonstration, etc.).

Examples

A deck officer incorrectly used the flammable gas detection meter. The model on which she had been trained had been replaced by a newer model. No training had been provided on the newer model.

An engineer had trouble reading a graph with a logarithmic scale. The graph had been recently added to the procedure. The training department had not been notified of the change and did not identify the need to provide training on this topic.

A member of the emergency squad had trouble getting the foam system actuated. He received training on the system when he was hired five years earlier, but had not received any refresher training since then.

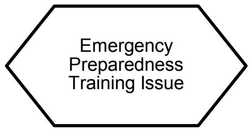
Standards References

ISM Code 6.5

TMSA 2A: 3.1

ISO 9001: 2000: Sec 6.2.2

OHSAS 4.4.2



Emergency Preparedness Training Issue

Intermediate Cause

Typical Issues

Was training provided on emergency events? Did it include all the necessary elements? Was the frequency of the training adequate?

Typical Recommendations

Include emergency response as part of the initial training as well as part of the continuing training. At a minimum, the lesson content should include emergency procedures and emergency evacuation and response.

Provide refresher training for these events FREQUENTLY to give employees confidence in dealing with these stressful activities.

Establish a frequency for providing emergency training and consult employees regarding the frequency.

Ensure that the training mimics the anticipated emergencies as closely as practical (e.g., ensure that employees are wearing the personal protective equipment prescribed for the event when walking through the tasks).

Examples

In the event of an oil spill, ship's officers were supposed to contact local authorities, the spill response organization and pertinent company officers. During an actual event, while the vessel's master and chief engineer were ashore, the emergency contact numbers and procedures could not be found. No training had ever been provided regarding the location and use of the emergency response plan and the contact of pertinent authorities and company personnel.

The vessel lost bridge control of the steering, requiring the immediate transfer of control to the steering flat using the trick wheel. The ship's personnel struggled to figure out how to line up the valves and place the steering gear into local manual control. An emergency steering gear drill had not been performed in more than 18 months.

An engineer opened the wrong valve during an emergency cooling water loss. He had received classroom training on the procedure, but had not performed a walkthrough or performed the procedure in the engine room.

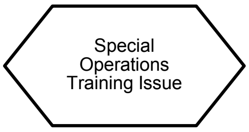
A member of the fire team had trouble getting the foam system actuated. He received training on the system when he was hired five years earlier, but had not received any refresher training since then.

Standards References

ISM Code 8.2

TMSA 9B: 2.2, 11A: 2.2

SEMP 10.4



Special Operations Training Issue

Intermediate Cause

Typical Issues

Was training provided on special or non-routine operations? Did it include all the necessary elements? Was frequency of the training adequate?

Typical Recommendations

Include special/non-routine job tasks as part of the initial training as well as part of the continuing training. At a minimum, the lesson content should include startup/shutdown procedures.

Provide refresher training frequently enough to give employees confidence in dealing with these activities.

Consult employees regarding the frequency of training.

Examples

A crew member passed out shortly after entering a confined space that had been aerated and certified safe for entry the previous day. Ship's personnel responsible for the previous work in the space had shut off the ventilation air being supplied to the space at the end of the previous day's work. The ventilation blower had been restarted, but no test of the air quality had been performed prior to reentry. Procedures and training for enclosed space entry required that forced ventilation be maintained during the period of time the space would be open for work and that air quality be rechecked every morning before reentry into a space could be performed. Training had not been performed in over a year.

The gas carrier required gas freeing in preparation for entering dry-dock. The gas freeing operation took 18 hours longer than anticipated. The first officer had received only conceptual training in regard to gas freeing operations. The particulars of performing gas freeing onboard the vessel itself had to be carefully determined from the ship's piping diagrams and training materials.

Standards References

ISM Code 6.5

ISO 9001: 2000: Sec 6.2.2

OHSAS 4.4.2

Qualifications Issue

Qualifications Issue

Cause Type

Typical Issues

Do officers and crew members joining the vessel possess documentation indicating that they are properly qualified for their assigned job? Are certificates and endorsements valid (not expired)? Are certificates and documents recognized by the vessel's flag if originally issued by another flag? Is there reason to believe that a document may be forged?

Typical Recommendation

Review joining officers'/crew members' certificates/endorsements prior to sending them to join the vessel and ensure that the certificates/endorsements fulfill requirements, are valid and have not expired.

Examples

The second officer joining the vessel had an STCW certificate issued by the Liberian Administration that qualified him to serve as a second officer aboard a Liberian-flag vessel. The vessel, however, was Panamanian flag and the second officer did not possess an endorsement from the Panama Administration that recognized the Liberian-issued certificate.

The relieving chief officer was suitably qualified for the job with the exception of the tonnage limitation on her certificate.

An officer's observed on-the-job skills were not consistent with the knowledge and competency required to possess the qualification represented by his certificates.

Standards References

ISM Code 6.2

TMSA 2A: 1.3, 1.4

SEMP 7.2.2

No License/Certificate

Intermediate Cause

Typical Issue

The officer/crew member does not have a valid STCW certificate, endorsement or endorsement attesting recognition of a certificate for the function or level at which the officer or crew member is serving.

Typical Recommendation

Review joining officers'/crew members' certificates/endorsements prior to sending them to join the vessel and ensure that they possess appropriate and valid certificates/endorsements.

Examples

The second officer joining the vessel had an STCW certificate issued by the Liberian Administration that qualified him to serve as a second officer aboard a Liberian-flag vessel. The vessel, however, was Panamanian flag and the second officer did not possess an endorsement from the Panama Administration that recognized the Liberian-issued certificate.

The AB's "Personal Survival" and "Basic Fire Fighting" training certificates exceeded the five-year validity period prior to him joining the vessel. The AB could not sign on.

Standards Reference

ISM Code 6.2

Expired License/Certificate

Intermediate Cause

Typical Issue

The officer's/crew member's STCW certificate, endorsement or endorsement attesting recognition of a certificate has expired and is no longer valid.

Typical Recommendation

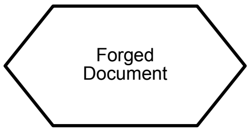
Review joining officers'/crew members' certificates/endorsements prior to sending them to join the vessel and ensure that the certificates/endorsements are valid and have not expired or will not expire over the duration of attendance.

Example

The chief officer reported to the vessel with an expired certificate.

Standards Reference

ISM Code 6.2



Forged Document

Intermediate Cause

Typical Issues

An officer's/crew member's certificate or endorsement is forged. The authenticity/validity of an officer's/crew member's certificate is suspect.

Typical Recommendations

When in doubt about whether a certificate is forged, contact the Administration that issued the certificate or on whose behalf the certificate was issued in order to validate authenticity.

Maintain example copies of authentic certificates for cross-reference in the event that a forgery is suspected.

Provide a procedure for screening certificates that includes information on how to identify a forgery.

Examples

An officer's observed on-the-job skills are not consistent with the knowledge and competency required to possess the qualification represented by his certificates.

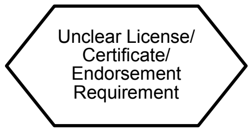
The typeface used to fill in a couple of lower entries within the function/level block of the certificate are close to the entries above, but slightly different.

The ink shade of some characters appears slightly different than the ink shade of others.

The certificate looks in part remarkably like a good photocopy of a certificate.

Standards Reference

ISM Code 6.2



Unclear License/Certificate/Endorsement Requirement

Intermediate Cause

Typical Issues

Did an unclear request for a qualified officer or crew member omit some qualification that was usually taken for granted along with the request? Was a key qualification for the particular vessel type omitted when requesting a qualified officer or crew member? Did the joining officer's qualifications match the requirements with the exception of a limitation listed on the certificate that made the individual unsuitable for the job?

Typical Recommendation

The procedure for requesting officers and crew members should require that all suitable qualifications are listed. Limitations that may affect the suitability of an otherwise qualified person should be indicated as not acceptable when requesting replacement personnel.

Examples

The relieving chief officer was suitably qualified for the job with the exception of the tonnage limitation on her certificate.

The relieving chief officer was suitably qualified for the job except the vessel also required her to have a GMDSS certificate to fulfill the minimum safe manning certificate requirements. The request for the officer did not specify that GMDSS certification was also required.

Standards Reference

ISM Code 6.2

Responsibility/Authority

Cause Category

Typical Issues

Did the lack of definition of responsibility and authority contribute to the event? Was responsibility for the operations unclear? Was the event the result of conflicting authority? Did confusion exist over who was responsible for the activity? Did an activity exist for which no one took responsibility?

Typical Recommendations

Review operations where responsibility and authority are assigned to more than one person, and ensure that the descriptions are specific enough to eliminate confusion.

Provide sufficient detail within descriptions of responsibility and authority to fully clarify what is encompassed.

Include accountability in job performance criteria (for job performance appraisals).

Examples

An oil spill occurred in port. The master of the vessel considered it his responsibility to take measures to contain the spill, contact authorities and the response organization and coordinate cleanup because the vessel emergency response plan assigned him ultimate responsibility for pollution prevention and control in the event of a spill. The vessel superintendent who was aboard considered it his responsibility because he was the highest ranking company official aboard the vessel and the vessel response plan indicated that the highest ranking company official aboard the vessel would be responsible for coordinating cleanup efforts and liaising with local port officials in the event of a spill.

During an extended shipyard period, daily rounds of the vessel were not performed by the vessel's deck and engine department heads. The written company policy required that rounds of the vessel were to be performed by company personnel on a daily basis while the vessel was in shipyard. However, this responsibility was not specifically assigned to an individual by title. The first officer and chief engineer understood this to mean that the ship's superintendent would be responsible for the rounds while in shipyard. The ship's superintendent understood this to mean that vessel's officers would continue their daily rounds while the vessel was in shipyard. As a result, rounds were not made.

Standards References

ISM Code 3.2, 4.5, 6.1.1, 6.2, 3.2, 5.1, 5.2

ISO 9001: 2000: Sec 5.5.2

ISO 14001: 2000; Sec 4.4.1

TMSA 1B: 3.3, 5A: 1.2, 6A: 1.2, 4A: 4.1

SEMP 5.2.a, 10.2

OHSAS 4.4.1

Responsibility/Authority Not Defined

Intermediate Cause

Typical Issues

Did the lack of definition of responsibility and authority contribute to the event? Did an activity exist for which no one took responsibility?

Typical Recommendations

Develop measures to ensure that responsibility and authority over various functions and operations are clearly understood.

Include accountability in job performance criteria (for job performance appraisals).

Example

An oil spill occurred in port. A vessel superintendent was aboard and was unsure of his responsibility in regard to the event. It had never been defined.

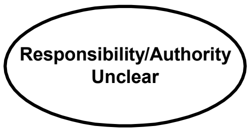
Standards References

ISM Code 3.2, 5.1, 5.2

ISO 9001: 2000: Sec 5.5.2

ISO 14001: 2000; Sec 4.4.1

OHSAS 4.4.1



Responsibility/Authority Unclear

Cause Type

Typical Issues

Was responsibility for the operations unclear? Was the event the result of conflicting authority? Did confusion exist over who was responsible for the activity?

Typical Recommendations

Review operations where responsibility and authority are assigned to more than one person, and ensure that the descriptions are specific enough not to cause confusion and clear enough not to be ambiguous.

Provide enough detail within descriptions of responsibility and authority to fully clarify what is encompassed.

Include accountability in job performance criteria (for job performance appraisals).

Example

An oil spill occurred in port. The master of the vessel took measures to stop the spill, notify local authorities and call the spill response organization. The vessel superintendent was aboard but unsure of his role. His responsibility within the vessel response plan was stated as simply to represent the company interests and coordinate activities. It was unclear what the specifics of this assigned responsibility and authority entailed. The master was also somewhat confused regarding the vessel superintendent's role, so he took charge of everything the vessel's superintendent wasn't sure of.

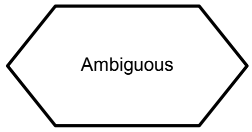
Standards References

ISM Code 3.2, 5.1, 5.2

ISO 9001: 2000: Sec 5.5.2

ISO 14001: 2000; Sec 4.4.1

OHSAS 4.4.1



Ambiguous

Intermediate Cause

Typical Issues

Was responsibility for the operations unclear? Could responsibility or authority for the operation be understood in more than one way? Was a lack of specificity in responsibility and authority a contributing factor to the event or its mitigation?

Typical Recommendations

Review operations where responsibility and authority are assigned to more than one person and ensure that the descriptions are clearly delineated.

Review operations where responsibility and authority are assigned to more than one person and ensure that the descriptions are specific enough to eliminate confusion.

Examples

An oil spill occurred in port. The master of the vessel was unclear if it was her responsibility to respond to the spill. The procedures indicated that the highest ranking company official was to take responsibility for the spill response. Because a vessel superintendent was aboard, it was unclear who was responsible for spill response.

During an extended shipyard period, daily rounds of the vessel were not performed by the vessel's deck and engine department heads. The written company policy required that rounds of the vessel were to be performed by company personnel on a daily basis while the vessel was in shipyard. However, this responsibility was not specifically assigned to an individual by title. The first officer and chief engineer understood this to mean that the ship's superintendent would be responsible for the rounds while in shipyard. The ship's superintendent understood this to mean that vessel's officers would continue their daily rounds while the vessel was in shipyard. As a result, rounds were not made.

An oil spill occurred in port. While the master of the vessel considered it his responsibility to take measures to stop and contain the spill and contact local authorities, he did not consider it his responsibility to call the response organization because the ship's superintendent was aboard and was part of that. The vessel's superintendent did not consider it his responsibility to call the response organization or coordinate the cleanup. As a result, there was a lapse in response time while the ship's master and the superintendent argued about who was in charge of what.

Standards References

ISM Code 3.2, 5.1, 5.2

ISO 9001: 2000: Sec 5.5.2

ISO 14001: 2000: Sec 4.4.1

OHSAS 4.4.1

Conflicting/Overlapping

Intermediate Cause

Typical Issues

Did more than one person believe himself or herself to be the party in charge or the person responsible for the operation? Was the event the result of conflicting authority?

Typical Recommendations

Review documented responsibility and authority to determine any conflict that may exist.

Develop a means of quickly resolving responsibility and authority conflicts if they arise.

Examples

An oil spill occurred in port. The master of the vessel considered it his responsibility to take measures to contain the spill, contact authorities and the response organization and coordinate cleanup because the vessel emergency response plan assigned him ultimate responsibility for pollution prevention and control in the event of a spill. The vessel superintendent who was aboard considered it his responsibility because he was the highest ranking company official aboard the vessel and the vessel response plan indicated that the highest ranking company official aboard the vessel would be responsible for coordinating cleanup efforts and liaising with local port officials in the event of a spill.

An oil spill occurred in port. The master of the vessel and the vessel superintendent onboard at the time of the spill were unsure about who was supposed to be responsible for the response. In one part of the procedure, it specified that the vessel master was responsible. In another part of the procedure, it specifically stated that the highest ranking company official was to take responsibility for the spill response. Because the master of the vessel and a vessel superintendent were both onboard at the time, it was unclear whose responsibility it was to respond to the spill.

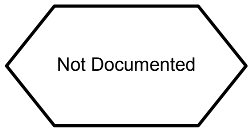
Standards References

ISM Code 3.2, 5.1, 5.2

ISO 9001: 2000: Sec 5.5.2

ISO 14001: 2000; Sec 4.4.1

OHSAS 4.4.1



Not Documented

Intermediate Cause

Typical Issue

Did the lack of documented responsibility and authority contribute to the incident?

Typical Recommendations

Document responsibility and authority where there may be any chance for misunderstanding.

Consider the various functions and operations within the organization and ensure that responsibility and authority for those that are vital and have significant impact on accomplishing management's objectives are documented.

Example

The responsibility and authority of some shore management personnel were not documented within the company's management system. As a result, new shipboard officers only became familiar with who was responsible for what by word of mouth. This sometimes resulted in confusion about who to contact in regard to various shipboard issues.

Standards References

ISM Code 3.2, 5.1, 5.2

ISO 9001: 2000: Sec 5.5.2

ISO 14001: 2000; Sec 4.4.1

OHSAS 4.4.1

Operations/Job Supervision

Cause Category

Typical Issues

Did immediate supervision fail to provide adequate preparation, job plans or walkthroughs for a job? Were potential problems identified before the work began? Were appropriate personnel selected and scheduled for the task? Did immediate supervision fail to provide adequate support, coverage or oversight during job performance? Did supervisors correct improper performance? Did personnel work together as a coordinated team?

Typical Recommendations

Update the tracking system daily, weekly or monthly, as appropriate, by adding new action items and/or documenting the current status of all action items.

Adopt a standard job plan format.

Distribute duties equally among similarly skilled/trained personnel.

For non-routine jobs or jobs that require specific safety precautions, encourage supervisors to oversee the job and provide job support as necessary.

Encourage supervisors to provide more supervision to less experienced workers.

Ensure that supervisors correct improper performance.

Examples

The bosun instructed several crew members to paint the focsle deck. The bosun did not go with the crew members to the focsle, explain the job, point out any special considerations or provide any specific instructions. As a result, the crew members did not scale the rust spots on the deck and prepare them with primer. The crew members painted right over the rust without taking proper preparatory measures.

As part of the gas freeing operation, a piping realignment was necessary that required an elbow piece to be swung in the cargo piping. The bosun and several crew members were instructed to swing the elbow piece. The first officer, however, only pointed at the elbow piece. He did not indicate what the final configuration should look like. As a result, when the elbow piece was swung, it joined the wrong two runs of pipe and had to be unbolted again and joined in the correct configuration.

Standards References

ISM Code: Sec 7

ISO 9001: 2000: Sec 7.5.1

STCW A–VIII/2 or 3

TMSA 3A: 1.1

SEMP 8.3

SOLAS Ch V: Reg 15

OHSAS 4.4.6

Preparation

Preparation

Cause Type

Typical Issues

Did immediate supervision fail to provide adequate preparation, job plans or walkthroughs for a job? Were potential interruptions or special circumstances identified before the work began? Were appropriate personnel selected and scheduled for the task?

Typical Recommendations

Ensure that supervisors understand their role in providing a job plan for subordinates.

Adopt a standard job plan format.

Distribute duties equally among similarly skilled/trained personnel.

Verify that the employee has the credentials to complete the task before assignment.

Examples

The bosun instructed several crew members to paint the focsle deck. The bosun did not go with the crew members to the focsle, explain the job, point out any special considerations or provide any specific instructions. As a result, the crew members did not scale the rust spots on the deck and prepare them with primer. The crew members painted right over the rust without taking proper preparatory measures.

As part of the gas freeing operation, a piping realignment was necessary that required an elbow piece to be swung in the cargo piping. The bosun and several crew members were instructed to swing the elbow piece. The first officer, however, only pointed at the elbow piece. He did not indicate what the final configuration should look like. As a result, when the elbow piece was swung, it joined the wrong two runs of pipe and had to be unbolted again and joined in the correct configuration.

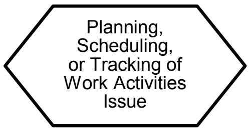
Two engine mechanics were assigned to perform a repair. Normally, an engineer was assigned the lead for performing a repair and then worked with a mechanic. In this case an older mechanic was assigned the lead for the repair even though he was not qualified.

Standards References

ISM Code: Sec 7

ISO 9001: 2000: Sec 7.5.1

OHSAS 4.4.6



Planning, Scheduling or Tracking of Work Activities Issue

Intermediate Cause

Typical Issues

Was the work scheduling system adequate? Was the work properly planned? Was the work schedule used for implementing work? Was the work scheduled based on safety and reliability impact?

Did the lack of a complete passage plan contribute to the event? Did immediate supervision provide an incorrect, incomplete or otherwise inadequate job plan for performance of the work?

Note: This node addresses the scheduling of work activities only, not the scheduling of personnel to accomplish the work. Problems with scheduling of personnel are addressed under "Scheduling/Rotation Issue (Operations/Job Supervision, Preparation)".

Typical Recommendations

Update the tracking system daily, weekly or monthly, as appropriate, by adding new action items and/or documenting the current status of all action items.

Conduct periodic, unannounced audits to verify that those action items documented as "complete" are actually complete.

Limit access to the tracking/scheduling system to authorized personnel (e.g., use a password for an electronic system, lock system documentation in a filing cabinet and distribute keys only to authorized personnel).

Prioritize action items and assign realistic dates for completion.

Develop and use "indicators" to help detect problems in ongoing use of management systems (e.g., how long does it take to respond to a request for change to a standard operating procedure?).

Establish a procedure that requires passage planning to be performed berth-to-berth, including the identification of all potential hazards that may be encountered en route.

Establish a procedure for planning special operations, including the identification of hazards, identification of safety measures and provision of adequate resources throughout the operations.

Establish an administrative procedure that requires all supervisors (including contract supervisors) to provide their subordinates with a job plan that includes instructions necessary for completing non-routine job tasks.

Establish a job plan format to ensure that all necessary information is included in the job plan.

Examples

A tank overflowed during filling because the automatic shutoff valve failed to close. An earlier inspection found that the level switch for the valve was defective, but the equipment deficiency had not been resolved.

A scheduling system was developed by the chief engineer; however, because there were too many panic repairs, the schedule was never followed. No one actually used the scheduling system to determine the priorities of the work that was performed.

A vessel ran aground when, on scanty and erroneous information, a critical course alteration was delayed. Contributing factors were the speed of the vessel under the prevailing circumstances and the lack of a recent fix to positively determine both the vessel's position and her progress along the intended track. These factors and the lack of a complete, predetermined passage plan also contributed to the grounding.

The vessel ran aground as the pilot hesitated to board due to high winds and waves. Voyage planning had failed to adequately identify the hazard posed by a shoal in close proximity to the point where pilots typically board arriving vessels. The vessel slowed during the pilot's indecision and lost weigh and steerage, allowing it to be blown by the wind onto the shoal.

The gas freeing operation had not been planned ahead of time and was conducted a step at a time in accordance with the procedures manual. Resources for swinging blind flanges, changing piping arrangements, realignment valves, etc., were not planned for. Safety considerations were not planned for. Personnel callouts were not planned and coordinated in regard to other shipboard activities. As a result, the operation took longer than it should have and delayed the work to be performed in the shipyard.

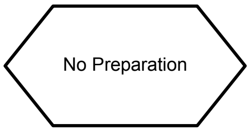
Standards References

ISM Code: Sec 7

ISO 9001: 2000: Sec 7.5.1

STCW A–VIII/2

OHSAS 4.4.6



No Preparation

Intermediate Cause

Typical Issue

Did immediate supervision fail to provide any preparation (e.g., instructions, job plan, walkthrough) for the task performed?

Typical Recommendations

Ensure that supervisors understand that it is their responsibility to provide subordinates with instructions and/or a job plan and to conduct walkthroughs, when appropriate (to show workers the location of equipment, to discuss the proper sequence of steps, etc.).

Provide supervisors with written job descriptions so that the above responsibilities are clearly communicated and documented.

Provide coaching to supervisors whose job preparation skills are less than adequate.

Examples

A job required the coordinated effort of the engine department with support from members of the deck department. The engine department was the lead group on the job. The second engineer failed to arrange the support required from the deck department with the first officer.

The bosun instructed several crew members to paint the focsle deck. The bosun did not go with the crew members to the focsle, explain the job, point out any special considerations or provide any specific instructions. As a result, the crew members did not scale the rust spots on the deck and prepare them with primer. The crew members painted right over the rust without taking proper preparatory measures.

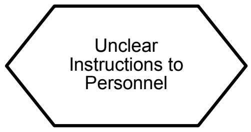
Standards References

ISM Code: Sec 7

ISO 9001: 2000: Sec 7.5.1

STCW A–VIII/2

OHSAS 4.4.6



Unclear Instructions to Personnel

Intermediate Cause

Typical Issue

Did immediate supervision provide incorrect, incomplete or otherwise inadequate job instructions before the beginning of work?

Typical Recommendations

Encourage a culture that is feedback oriented (i.e., repeating instructions back to the supervisor to ensure understanding).

Train supervisors on how to give instructions and how to verify that instructions are understood.

Examples

The bosun instructed several crew members to paint the focsle deck. The bosun went with the crew members to the focsle and explained the job. He stated that the deck should be washed down, the rust spots scaled and the deck swept before painting. He failed to tell the crew members to prime the scaled rust spots before applying the paint. As a result, the crew members did not prime the rust spots and the deck blistered again within several weeks.

As part of the gas freeing operation, a piping realignment was necessary that required an elbow piece to be swung in the cargo piping. The bosun and several crew members were instructed to swing the elbow piece. The first officer, however, only pointed at the elbow piece. He did not indicate what the final configuration should look like. As a result, when the elbow piece was swung, it joined the wrong two runs of pipe and had to be unbolted again and joined in the correct configuration.

Standards References

ISM Code: Sec 7

ISO 9001: 2000: Sec 7.5.1

STCW A–VIII/3

OHSAS 4.4.6

Ineffective Walkthrough

Intermediate Cause

Typical Issue

Did immediate supervision fail to perform an adequate walkthrough (show workers the location of equipment, discuss operation of the equipment and the proper sequence of steps, etc.) with the workers before they started the job?

Typical Recommendations

Encourage supervisors to show workers the location of equipment involved in the job task.

Encourage supervisors to discuss operation of the equipment and the sequence of steps involved in non-routine job tasks.

Examples

As part of the gas freeing operation, a piping realignment was necessary that required an elbow piece to be swung in the cargo piping. The first officer took the bosun and several crew members to the location of the elbow piece and walked through the process of swinging the elbow. He indicated the direction in which the elbow would be swung and marked with chalk the two pipes that were to be joined. He pointed out a socket welded to the deck into which a small portable davit would be mounted with a simple fall arrangement. He also took the team to where the new gaskets were located and where wrenches would be found, but neglected to indicate where the davit was located. The team could not find the small davit, so proceeded by rigging other arrangements over and around surrounding piping. As the elbow was freed from the bolts, the rigging slipped and dropped the elbow to the deck, bending the flange.

The bosun assigned several crew members to paint the focsle deck. The bosun went with the crew members to the focsle and walked through the job as he provided instructions. He took the crew members to the paint locker and pointed out the materials and tools to be used. He failed to walk through the process of mixing the epoxy-based paint that would be applied to the deck. As a result, the crew members mixed too much paint and the paint set up before most of it could be applied.

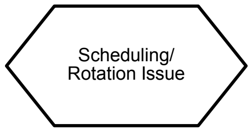
Standards References

ISM Code: Sec 7

ISO 9001: 2000: Sec 7.5.1

STCW A–VIII/3

OHSAS 4.4.6



Scheduling/Rotation Issue

Intermediate Issue

Typical Issues

Was scheduling of workers inadequate? Did immediate supervision arrange to have enough personnel available to effectively carry out the task? Were too many concurrent tasks assigned to workers? Were duties not well distributed among personnel?

Note: This node addresses the scheduling of personnel only, not the scheduling of work activities. Problems with scheduling of work activities are addressed under the "Planning, Scheduling or Tracking of Work Activities Issue (Human Resource Issue)" root cause node.

Typical Recommendations

Provide supervisors with an adequate number of employees to effectively and safely complete the tasks assigned.

Distribute duties equally among similarly skilled/trained personnel.

Consider the amount of time and concentration to perform each task. Assign individuals fewer responsibilities for tasks that require more time and concentration.

Examples

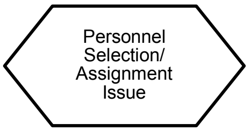
Engine room personnel scheduled to remain aboard the vessel in port were not sufficient to take on bunkers, perform receipt inspection of received goods, perform scheduled engine repairs and supervise vendors. As a result, engine repairs took longer than planned and the vessel sailing was delayed.

A job requiring the coordinated effort of the engine department with support from members of the deck department was delayed. The job required three members of the deck department to safely perform. Because of other job requirements, only two of the three were available when the job was scheduled to begin.

Four mechanics, a wiper and a cadet were assigned to install a new compressor motor. There was only enough work to keep two of the mechanics and one other person busy. The wiper and cadet spent about half the time watching the mechanics work.

Standards Reference

TMSA 2A: 4.3



Personnel Selection/Assignment Issue

Intermediate Cause

Typical Issues

Did immediate supervision fail to select capable workers to perform the job? Did workers assigned to the task have inadequate credentials? Were sufficient numbers of trained or experienced workers assigned to the task?

Note: This node addresses the assignment of existing or qualified workers to job tasks. For example, the selection of a laborer from a preapproved pool of individuals would be covered by this node. It does NOT address the hiring or preselection processes. Employee hiring is addressed by "Employee Screening/Hiring Issue (Human Resource Issue)".

Typical Recommendations

Before assigning any employee to a task, verify that the employee has the credentials to successfully complete the task.

Ensure that the individual assigned to a task matches the experience level required to effectively and safely perform the task.

Provide supervisors with the means to quickly determine if workers are qualified for a task.

Example

Two engine mechanics were assigned to perform a repair. Normally, an engineer was assigned the lead for performing a repair and worked together with a mechanic. In this case, an older mechanic was assigned the lead for the repair even though he was not qualified.

Standards References

ISM Code: Sec 6.3

ISO 9001: 2000: Sec 6.2.1

ISO 14001: 2000: Sec 4.4.2

STCW A–VIII/3

TMSA 3A: 1.1, 4B: 3.4, 5A: 1.2

OHSAS 4.4.2

Supervision During Work

Supervision During Work

Cause Type

Typical Issues

Did immediate supervision fail to provide adequate support, coverage, oversight or supervision during job performance?

Note: The investigator must judge what level of supervision was necessary based on the importance of the job in relation to safety, prevention of pollution, security and operation. It is not possible or practical to provide supervision on every job.

Typical Recommendations

For non-routine jobs or jobs that require specific safety or pollution prevention precautions, encourage supervisors to oversee the job and provide job support as necessary.

Encourage supervisors to provide more supervision to less experienced workers.

Examples

The bosun assigned an ordinary seaman (OS) to “scale and prime” the rust spots on the focsle in preparation for painting. He handed the OS the tools and primer but gave no instructions on how to perform the job, nor any oversight. Because the OS did not understand the particular hazards associated with the use of the primer, he did not wear goggles and rubber gloves when applying the primer. The wind over the focsle deck caused some of the primer to be blown into the OS’s eyes, causing a chemical burn.

A crew member standing a cargo watch late at night was requested to close the fill valve to the number two starboard cargo tank. The crew member closed the fill valve to the number two port cargo tank. The crew member had worked all day long in the sun prior to the vessel’s arrival and was visibly fatigued. Recognizing this, the mate on watch still allowed the crew member to stand the cargo watch rather than call a more well-rested crew member to stand the watch. As a result, the high level alarm on the number two port starboard cargo tank sounded and a shutdown was initiated to prevent a possible spill.

Standards References

ISM Code: Sec 5

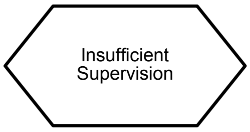
ISO 9001: 2000: Sec 5.5.2

ISO 14001: 2000: Sec 4.4.1

STCW A–VIII/3

SEMP 7.5

OHSAS 4.4.1



Insufficient Supervision

Intermediate Cause

Typical Issues

Did immediate supervision provide inadequate support, coverage or oversight during performance of the job? Was an inadequate level of supervision provided for the job? Was contact with workers too infrequent? Did direct supervision's involvement in the task interfere with the supervisory overview role?

Typical Recommendations

For non-routine job tasks or for tasks that require specific safety or pollution prevention precautions, encourage supervisors to remain at the job site to provide coverage for the entire job or at least frequently visit the job to provide direction as necessary.

Encourage supervisors to give their supervisory role priority over their job-task support role.

Ensure that supervisors understand their responsibilities to provide more supervision to less experienced workers.

Examples

The bosun assigned an OS to "scale and prime" the rust spots on the focsle in preparation for painting. He handed the OS the tools and primer but gave no instructions on how to perform the job, nor any oversight. Because the OS did not understand the particular hazards associated with the use of the primer, he did not wear goggles and rubber gloves when applying the primer. The wind over the focsle deck caused some of the primer to be blown into the OS's eyes, causing a chemical burn.

During the installation of a new computerized control system, the immediate supervisor of the responsible crew became so interested in installing the central control unit that he picked up a screwdriver and became involved in the work. As a result, he ignored those members of the crew who were installing the auxiliary unit. Some important checks were missed on the auxiliary unit; therefore, it failed upon startup.

Standards References

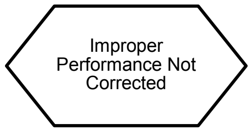
ISM Code: Sec 5

ISO 9001: 2000: Sec 5.5.2

ISO 14001: 2000: Sec 4.4.1

STCW A–VIII/3

OHSAS 4.4.1



Improper Performance Not Corrected

Intermediate Cause

Typical Issues

Do supervisors correct improper performance when they observe it or know about it? Do they let improper performance slip “just this once”?

Typical Recommendation

Correct the behavior when improper performance is observed or is known by supervision. If supervision knows a task is being performed incorrectly and does not correct it, workers will continue to perform the task incorrectly.

Enforce existing rules and requirements. If the rule is important enough to exist, it should be enforced. If it’s not important enough to enforce, eliminate the requirement.

Examples

The second engineer noticed a crew member in the machine shop who was not wearing safety goggles. The second engineer was just passing through the area and did not say anything to the crew member.

Engineers were supposed to perform plant rounds at least once per watch and generate work requests for any equipment that was inoperable or needed repairs. Often the engineers skipped the rounds. The chief engineer and second engineer knew what was occurring and did nothing to correct the situation.

Standards References

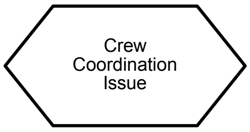
ISM Code: Sec 9

ISO 9001: 2000: Sec 8.3

ISO 14001: 1996: Sec 4.5.2

STCW A–VIII/3

OHSAS 4.4.7



Crew Coordination Issue

Intermediate Cause

Typical Issues

Did a supervisor's failure to properly coordinate the efforts of several crew members contribute to the event? Did the operation require the coordination of multiple crew members to accomplish?

Note: This node focuses upon problems associated with coordination of crew members' activities by a supervisor. Problems associated with crew members working together as a team to accomplish a task is covered by "Ineffective Teamwork (Supervision During Work)" under operation/job supervisor.

Typical Recommendation

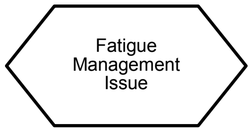
Conduct a review of operations prior to execution to understand how various crew members' activities are to be coordinated.

Example

The engine department and the deck department were involved in vessel cargo tank inerting operations. The first officer was in charge. The first officer requested the engine room to start inert gas generation and to let him know when gas was produced within specifications. The engine department informed the first officer when gas reached specifications. The first officer directed the ship's bosun to open the inert gas valve on deck but was distracted and did not request the engine room to route the inert gas into the inert gas header. As a result, the good inert gas was vented to atmosphere for almost an hour before the engine room called the first officer about the delay.

Standards Reference

STCW A–VIII/3



Fatigue Management Issue

Intermediate Cause

Typical Issues

Did a failure of a supervisor to recognize that personnel participating in the operation were becoming fatigued contribute to the event? Did supervisors allow or cause personnel to work while fatigued and did that contribute to the event?

Note: This node addresses the responsibility of supervisors to identify fatigue and respond appropriately to ensure that fatigued personnel are given adequate opportunity to rest and recover. Dual coding may be appropriate under "Sustained High Workload/Fatigue (Workload) under Human Factors" that addresses the effects of specific tasks that can cause fatigue and degradation of individual performance (e.g., strenuous physical work in a hot, humid environment).

Typical Recommendations

Provide training to officers in the recognition of human fatigue.

Require that supervisors ensure that personnel workloads are managed to prevent fatigue.

Require that fatigued crew members be relieved of their duties until rested enough to return to work.

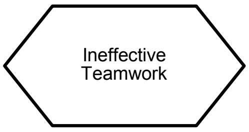
Examples

Personnel involved in gas freeing the vessel prior to entry into shipyard had been up all night. Meetings were scheduled first thing in the morning, and tank entry was scheduled for the afternoon, allowing little time for sleep. The first officer was tired and slipped on a ladder rung while entering a tank.

A crew member standing a cargo watch late at night was requested to close the fill valve to the number two starboard cargo tank. The crew member closed the fill valve to the number two port cargo tank. The crew member had worked all day long in the sun prior to the vessel's arrival and was visibly fatigued. Recognizing this, the mate on watch still allowed the crew member to stand the cargo watch rather than call a more well-rested crew member to stand the watch. As a result, the high level alarm on the number two port starboard cargo tank sounded and a shutdown was initiated to prevent a possible spill.

Standards Reference

STCW A–VIII/3



Ineffective Teamwork

Intermediate Cause

Typical Issues

Was there a lack of coordination between workers possibly due to lack of supervision? Was a plan developed to assign responsibilities to different team members? Were there overlaps or gaps in the work that was assigned to different groups or team members? Was there a lack of communication between work groups?

Note: This node is focused on problems associated with crew members' ineffectiveness working together as a team to accomplish a task. Problems associated with coordination of crew members' activities by a supervisor is covered by "Crew Coordination Issue (Supervision During Work)" under operation/job supervision.

Typical Recommendations

On tasks that require coordination of work, ensure that tasks are assigned to team members and that an adequate means of communication is provided between workers .

For work that requires coordination of multiple work groups (i.e., deck department and engine department), ensure that there are clear methods and means for exchanging information between work groups.

Coordinate tasks between different work groups. Develop a work plan prior to beginning the work.

Example

The engine department and the deck department were coordinating vessel cargo tank inerting operations. The engine department was requested by the deck department to start inert gas generation and to open the valve forward when the inert gas being produced was within specifications. The engine department did not inform the deck department when the valve was opened. As a result, the good inert gas was vented to atmosphere for almost an hour before the deck department called to ask when the inert gas plant was anticipated to be online.

Standards Reference

STCW A–VIII/3

Communications

Cause Category

Note: "Communication" is defined as the act of exchanging information. This node addresses many modes of communication (e.g., face-to-face, telephone, radio, short written messages, log entries, informal notes, e-mail correspondence). It does not address the more formal methods of communication involving written procedures, specifications, documents, policies, standards, etc.

Typical Issues

Was the problem caused by a failure to communicate? Did a method or system exist for communicating between the groups or individuals? Was an error caused by misunderstood communication between personnel? Was there incorrect, incomplete or otherwise inadequate communication between workers during a watch or between workers during a watch change? Was there a problem communicating with contractors or customers?

Typical Recommendations

Require that helm orders are repeated back to the person with the conn.

Provide a backup means of communication for when the primary system is inoperable.

Establish standard terminology for equipment and operations.

Use the repeat-back method of communication.

Examples

Prior to cargo operations, a telephone line was established as the only means of communication between the shore terminal operators and the vessel. When the time came to rate down, the connection was no longer working. Not having a secondary means of communication, the operation had to be stopped by initiating an emergency shutdown.

A crew member was instructed to turn a valve handle to the left, which was supposed to mean counterclockwise, to open the valve more. The crew member turned the valve handle clockwise, closing the valve.

The helmsman did not repeat back orders given by the pilot prior to executing them. Neither the pilot nor ship's officers on the bridge corrected the helmsman's behavior as he executed orders promptly and in accordance with the pilot's commands. In a close-quarters situation, the pilot gave a starboard helm order and the helmsman executed an equivalent port helm order, creating a situation that eventually resulted in a collision.

Standards References

ISO 9001: 2000: Sec 5.5.3

ISO 14001: 2000: Sec 4.4.3

TMSA 8A: 1.1

SEMP 1.2.4, 3.6

OHSAS 4.4.3

No Communications or Untimely

No Communications or Untimely

Cause Type

Typical Issues

Was the problem caused by a failure to communicate? Did a method or system exist for communicating between the departments or individuals? Did the communication take place too late? Did obstacles hinder or delay communication?

Define and agree upon with the charterer/customer the means of communication to be used. Establish a checklist that ensures that the pilot is provided all pertinent information regarding the vessel and that communication procedures are established prior to the pilot assuming the conn.

Note: Each individual involved in the occurrence should be questioned regarding messages he or she feels should have been received or transmitted. Determine what means of communication were used (i.e., the techniques). Persons on all sides of a communication link should be questioned regarding known or suspected problems.

Typical Recommendations

Provide a backup means of communication for when the primary system is inoperable.

Establish formal means of communication when required.

Examples

A remote-controlled cargo tank valve could not be closed from the cargo control room. The first officer attempted to contact the AB on cargo watch via the two-way radio. There was interference on the radio from another vessel in the port using the same channel. As a result, the AB could not be contacted to manually close the valve locally. The first officer had to shut down cargo loading to keep from overflowing the tank.

Since the beginning of the charter agreement, the vessel had received its sailing orders via the company. The sailing orders consistently had the vessel loading and discharging at the same load and discharge ports. The charterer typically phoned the voyage requirements to the company and the company relayed the message by e-mail communication. On a Friday evening, the charterer, having failed to make contact with the company, attempted to contact the vessel with a last-minute change to the sailing orders and was unsuccessful. The vessel sailed for the same port as usual and, as a result, when the rerouting instructions finally came from the company, the vessel would be delayed by a day.

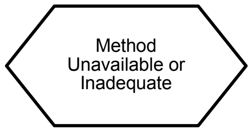
Standards References

ISO 9001: 2000: Sec 5.5.3

ISO 14001: 1996: Sec 4.4.3

TMSA 1A: 2.3, 7A: 3.1, 9B: 4.1, 4.2

OHSAS 4.4.3



Method Unavailable or Inadequate

Intermediate Cause

Typical Issues

Did a method or system exist for communicating the necessary message or information? Was the communication system out of service or otherwise unavailable at the time of the incident?

Typical Recommendations

Ensure that some method of communication is in working order at all times.

When the primary method of communication is unavailable, provide some temporary means of communication (e.g., two-way radios).

Example

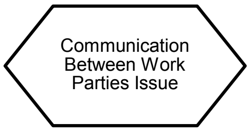
A remote-controlled cargo tank valve could not be closed from the cargo control room. The first officer attempted to contact the AB on cargo watch via the two-way radio. There was interference on the radio from another vessel in the port using the same channel. As a result, the AB could not be contacted to manually close the valve locally. The first officer had to shut down cargo loading to keep from overflowing the tank.

Standards References

ISO 9001: 2000: Sec 5.5.3

ISO 14001: 2000: Sec 4.4.3

OHSAS 4.4.3



Communication Between Work Parties Issue

Intermediate Cause

Typical Issues

Did lack of communication between departments contribute to the problem? Did methods exist for communicating between departments?

Typical Recommendation

Establish a procedure that requires departments to review work plans and discuss the day's activities with each other and determine what cooperation is needed and if any conflicts exist, especially conflicts on permit-to-work items with other permits and normal operations.

Example

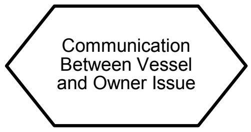
The service air to the deck was cut off by the engine department because the service air compressor was shut down for maintenance. The deck department had been alerted that the air would be cut off but understood it to be control air. As a result, the deck crew was in the process of scaling and spray painting when the cutoff occurred. The work on deck was abruptly brought to a halt, and the paint being sprayed, which had a limited pot life, went to waste.

Standards References

ISO 9001: 2000: Sec 5.5.3

ISO 14001: 2000: Sec 4.4.3

OHSAS 4.4.3



Communication Between Vessel and Owner Issue

Intermediate Cause

Typical Issues

Did lack of communication between shore management and the vessel contribute to the incident? Had the owner effectively communicated policies to the vessel officers and crew? Were the concerns of vessel personnel communicated to shore management and given proper attention?

Typical Recommendations

Provide a forum where owner’s policies are explained and discussed with vessel personnel.

Provide a means through which vessel personnel can provide suggestions and feedback to shore management.

Post pertinent owner’s directives or communications in public spaces where they can be read.

Designate various means of communication between vessel management and the vessel that are appropriate for the importance and urgency of the communication.

Examples

The company’s environmental policy had not been adequately communicated and emphasized to vessel personnel. Because of this, the vessel took a rather cavalier approach to environmental issues, thinking that the company really didn’t care that much about it. The oil content meter began to frequently indicate high levels of oil in the treated bilge water being discharged to the sea. The engineers could not determine for sure if the meter was malfunctioning or providing a true reading. They preferred to believe that the oil content meter was providing false indications and so set up a false signal to the control circuitry to keep the overboard discharge solenoid from the oily water separator open. As a result, water with oil content in excess of 15 ppm was discharged into the sea. The vessel was caught by port state control authorities and subsequently prosecuted, resulting in a heavy fine to the company.

At a safety meeting, vessel personnel expressed a need for renewal of the ship’s personal safety equipment because much of the equipment aboard was becoming worn and required replacement. For example, goggles were scratched and clouded, obscuring the wearer’s vision. The master sent numerous e-mails to management requesting new personnel safety equipment. However, he did not highlight the urgency or the situation nor did he communicate the need to the appropriate personnel. The request did not result in new equipment being supplied. As a result, when crew members could no longer see well enough through the goggles to accomplish their task, they removed them. Several eye injuries ensued, one of them serious.

Standards References

ISO 9001: 2000: Sec 5.5.3

ISO 14001: 2000: Sec 4.4.3

OHSAS 4.4.3

Communication with Other Vessels

Intermediate Cause

Typical Issue

Did a lack of communication with another vessel or other vessels in the area contribute to the event?

Typical Recommendation

Establish communication with other vessels with whom there may be any possibility of a close quarters encounter as soon as possible to establish their intentions.

Example

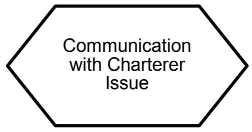
The vessel collided with another vessel when both held course and speed in a situation where they both thought they were the "stand-on" vessel. The vessel did not make an attempt to contact the other in an attempt to establish each other's intentions and avoid the situation.

Standards References

ISO 9001: 2000: Sec 5.5.3

ISO 14001: 2000: Sec 4.4.3

OHSAS 4.4.3



Communication with Charterer Issue

Intermediate Cause

Typical Issues

Were there problems communicating with the charterer/customer? Are charterers/customers able to communicate their needs to the vessel or company? Does the company/vessel respond to communications from the charterer/customer?

Typical Recommendations

Track charterer/customer communications to ensure timely follow-up.

Provide convenient means for customers to contact the company.

Define and agree upon with the charterer/customer the means of communication to be used.

Examples

Since the beginning of the charter agreement, the vessel had received its sailing orders via the company. The sailing orders consistently had the vessel loading and discharging at the same load and discharge ports. The charterer typically phoned the voyage requirements to the company and the company relayed the message by e-mail communication. On a Friday evening, the charterer, having failed to make contact with the company, attempted to contact the vessel with a last-minute change to the sailing orders and was unsuccessful. The vessel sailed for the same port as usual and, as a result, when the rerouting instructions finally came from the company, the vessel would be delayed by a day.

While the supply boat was being readied to depart for the oil rig, the customer called with instructions to have the boat wait for a truck with equipment that had been delayed. The master was not on the bridge to receive the telephone call, and a means of leaving a message had not been established. The master took the vessel to sea as soon as the deck cargo was secured. A follow-up phone call was received from the customer two hours after leaving the dock. As a result, the truckload of supplies did not get delivered to the rig.

Standards References

ISO 9001: 2000: Sec 5.5.3

ISO 14001: 2000: Sec 4.4.3

OHSAS 4.4.3

Communication with Parties Ashore Issue

Intermediate Cause

Typical Issues

Did a breakdown or lack of communication with parties ashore contribute to the event? Did an interruption in the primary means of communication associated with critical in-port operations contribute to the incident?

Note: Communications with the owner or vessel charterer are addressed under separate nodes.

Typical Recommendations

Establish communication with parties ashore by means of accepted, established or agreed-upon methods and channels.

Prior to cargo operations, establish an agreed-upon primary and secondary means of communication between the vessel's cargo control room and the terminal control room.

Establish the means by which ship's business is communicated with concerned parties when in port.

Establish a means of emergency communications with concerned and pertinent shore-based organizations and parties.

Examples

Prior to cargo operations, a telephone line was established as the only means of communication between the shore terminal operators and the vessel. When the time came to rate down, the connection was no longer working. Not having a secondary means of communication, the operation had to be stopped by initiating a shutdown.

The first officer identified two containers with hazardous materials that were not supposed to be stowed next to each other which were actually planned for stowage in two adjacent locations. The first officer communicated the problem to the planning office by leaving a message with the office secretary. Later, upon conducting a round on deck, the first officer noted that the two containers had been towed next to each other in accordance with the original stowage plan.

Standards References

ISO 9001: 2000: Sec 5.5.3

ISO 14001: 1996: Sec 4.4.3

TMSA 1A: 2.3

OHSAS 4.4.3

Communication Misunderstood/Incorrect

Communication Misunderstood/Incorrect

Cause Type

Typical Issues

Was an error caused by misunderstood communications between personnel? Was there an error in verbal communication? Did someone misunderstand a hand signal? Was a sign misunderstood? Were oral instructions given when written instructions should have been provided?

Typical Recommendations

Establish standard terminology for equipment and operations.

Use the repeat-back method of communication.

Provide written instructions when necessary.

Minimize interference from noise.

Examples

A crew member was instructed to turn a valve handle to the left, which was supposed to mean counterclockwise to open the valve more. The crew member turned the valve handle clockwise, closing the valve.

An AB located in a noisy part of the vessel was given an instruction by walkie-talkie to open Valve B-2. He thought the verbal instruction was to open Valve D-2. No repeat-back or other type of verification was used. He opened D-2, resulting in a spill.

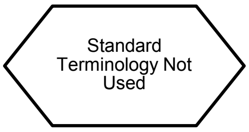
A second engineer told a third engineer to open Valve 2P instead of Valve 2S.

Standards References

ISO 9001: 2000: Sec 5.5.3

ISO 14001: 2000: Sec 4.4.3

OHSAS 4.4.3



Standard Terminology Not Used

Intermediate Cause

Typical Issues

Was standard or accepted terminology used? Could the communication be interpreted more than one way? Did one piece of equipment have two or more commonly used names? Could the terminology have applied to more than one item?

Typical Recommendations

Establish standard terminology for equipment, operations and maintenance operations.

Encourage all employees to stop using nonstandard terminology.

Avoid ambiguous terms and phrases in procedures, work instructions, logbooks, etc.

Example

A crew member was instructed to turn a valve handle to the left, which was supposed to mean counterclockwise to open the valve more. The crew member turned the valve handle clockwise, closing the valve.

Standards Reference

ISM Code 6.7

Language/Translation Issue

Intermediate Cause

Typical Issues

Did the use of an unfamiliar language contribute to the problem? Was a crew member assigned to the vessel who could not understand the working language used aboard? Did lack of or an inadequate translation of the MS contribute to the cause of an incident?

Typical Recommendations

Establish a screening procedure to ensure that officers and crew members assigned to company vessels have adequate understanding of the working language used aboard.

Make pertinent portions of the MS available in the working language used aboard the vessel.

Example

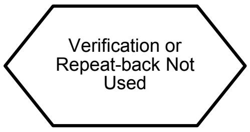
A crew member whose skills in the working language aboard were less than adequate was assigned to the vessel. He was assigned a cargo watch, and a crew member from his country of origin familiarized him with his duties and showed him how to locally operate remote valves in the event that automatic controls failed and how to use the walkie-talkie. While he was standing the watch, a leak began at the manifold. He was unable to adequately communicate the situation to the cargo control room, so an officer was dispatched to see what was going on. By the time the officer arrived, the leak had grown dramatically and was spilling over the sides of the containment.

Standards References

ISM Sec 6.6

ISO 9001: 2000: Sec 6.2.1

OHSAS 4.4.2



Verification or Repeat-back Not Used

Intermediate Cause

Typical Issue

Was a communication error caused by failure to repeat a message back to the sender for the purpose of verifying that the message was heard and understood correctly?

Typical Recommendations

Encourage personnel at all levels to use the repeat-back communication method to ensure thorough understanding of related job tasks.

If employees/workers forget to use the repeat-back method, instruct supervisors to request that the employee repeat back.

Example

An AB was given an instruction by walkie-talkie to open a valve. The instruction was to open Valve B-2. He thought the verbal instruction was to open Valve D-2. No repeat-back or other type of verification was used.

Standards Reference

ISM Code 6.7

Long Message

Intermediate Cause

Typical Issues

Was a message or instruction misunderstood because it was too long? Should the message have been written instead of spoken? Could the message have been shortened or broken up?

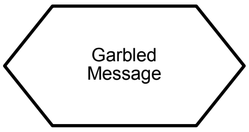
Typical Recommendations

Keep oral instructions short and rehearsed (especially if communicating in noisy areas).

If several lengthy details must be conveyed, consider providing them as written instructions rather than orally (i.e., generate a written procedure).

Example

An AB was verbally instructed to open Valves A-7, B-4, B-5, C-6, D-6, D-7, D-8 and F-1. He failed to open D-6. No written instructions were given.



Garbled Message

Intermediate Cause

Typical Issue

Did a broken-up or unintelligible message/communication contribute to the event?

Typical Recommendations

Plan ahead of time to change to a designated second frequency if onboard walkie-talkie communications become garbled by interference.

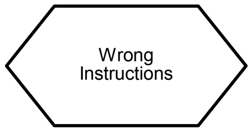
Carefully qualify any conclusions that may be reached from a garbled message before taking action using the potentially misinterpreted/misunderstood information. Where practicable, attempt an alternative channel or means of communication when communications are garbled.

Implement repeat-back methods of communication.

Examples

The vessel contacted another vessel with which it was on a course that would have the vessels passing in close proximity to one another. The communication was garbled but the watch officer understood that the other vessel would alter course to pass his vessel to port. In response he altered his course to starboard. At the same time the other vessel executed a turn to port, placing the two vessels on a collision course.

The order given to the AB to close a tank valve was garbled by interference from other walkie-talkie chatter in the harbor. He did not recognize the communication and did not respond at all.



Wrong Instructions

Intermediate Cause

Typical Issue

Was the communication errant or inaccurate?

Typical Recommendation

Consult the procedure, training, supervision, human factors engineering and/or personal performance branches of the map.

Example

A second engineer told a third engineer to open Valve 2P instead of Valve 2S.

Bridge Team Management

Cause Type

Typical Issues

Did an incorrectly executed helm order contribute to the event? Was critical information ignored? Was information communicated in such a manner to be understood differently than intended?

Typical Recommendations

Require that helm orders are repeated back to the person with the conn.

Establish a bridge procedure that requires a repeat-back acknowledgement of information provided by any member of the bridge team to the member with the conn.

Establish a bridge management procedure that requires, wherever practical, that the receiver of information visually confirm the information given.

Examples

Sound bridge resource management practices (i.e., the full and complete cooperation necessary for a safe approach) was not established between the vessel's navigating personnel and the pilot. Communication between navigating personnel and the pilot was interrupted, and position-fixing methods, such as radar parallel indexing, were not employed to determine the ship's position. As a result, the vessel ran aground.

The ship's master had a habit of barking at the third officer when he was on the bridge. He chastised the third officer for providing "obvious" information when the master had the conn. The third officer began making judgments about what was obvious information and what wasn't. As a result, while maneuvering toward the approaches of a harbor, he did not report a small vessel coming out of a crowded anchorage on the port side of the vessel, and a collision occurred.

The pilot and the master did not exchange port passage plans prior to the pilot taking the conn. The master relied on the pilot's expertise and knowledge of the harbor. The watch officer likewise trusted the pilot's knowledge and did not alert the pilot when the course line, ship's heading and speed appeared to be heading the ship to shallow water. As a result, the pilot was not alerted of the developing situation in time to avert grounding the vessel.

Standards References

ISM Sec 7

ISO 9001: 2000: Sec 7.5.1

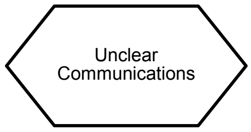
ISO 14001: 2000: Sec 4.4.6

STCW A-VIII/3

TMSA 5A: 1.1, 3.4

SOLAS Chapter V: Regulation 15

OHSAS 4.4.3



Unclear Communications

Intermediate Cause

Typical Issues

Did an incorrectly executed helm order contribute to the event? Did an unclear communication of the vessel's position contribute to the event?

Typical Recommendations

Require that helm orders are repeated back to the person with the conn.

Observe the execution of helm orders by watching the rudder angle indicator and compass repeater.

Example

The pilot spoke a different language than the officers and crew of the vessel. English was used as the communication language between them. The pilot gave an order to the helmsman to set a course of 10 degrees. The helmsman understood the order to mean 10 degrees port rudder angle. Rather than the expected starboard turn to bring the vessel to 10 degrees, the vessel began turning to port and into the path of oncoming traffic.

Standards References

ISO 14001: 2000: Sec 4.4.3

SOLAS Chapter V Regulation 15

STCW A-VIII/3

OHSAS 4.4.3

Information Not Communicated

Intermediate Cause

Typical Issues

Was critical information not communicated? Did bridge watch personnel neglect to state the obvious to the conn?

Typical Recommendation

Establish a bridge team management procedure that requires that all relevant information and observations be communicated to the person with the conn irrespective of whether the information appears to be obvious.

Examples

The ship's master had a habit of barking at the third officer when he was on the bridge. He chastised the third officer for providing "obvious" information when the master had the conn. The third officer began making judgments about what was obvious information and what wasn't. As a result, while maneuvering toward the approaches of a harbor, he did not report a small vessel coming out of a crowded anchorage on the port side of the vessel, and a collision occurred.

The vessel grounded because the vessel's position was not established by the pilot before a critical course alteration, and the vessel's speed was not adapted to the prevailing circumstances and visibility. A contributing factor was the lack of exchange of information between the bridge team and the pilot.

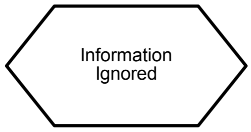
Sound bridge resource management practices (i.e., the full and complete cooperation necessary for a safe approach) were not established between the vessel's navigating personnel and the pilot. Communication between navigating personnel and the pilot was interrupted, and position-fixing methods, such as radar parallel indexing, were not employed to determine the ship's position. The vessel ran aground.

The vessel struck bottom because of a delayed decision on the best course of action after experiencing engine problems. Factors contributing to the occurrence were as follows: poor communication between the master and the pilot, which led to an inadequate appreciation of the existing situation; the inadequate sharing of information among the bridge team; and a poor appreciation of the vessel's maneuvering characteristics. No complete harbor-entry plan had been discussed nor decided upon. In addition, the master did not make a timely contribution to the vessel's safe navigation due to a lack of communication with the pilot whose intentions were not understood by the master until the vessel was approaching a critical position.

Standards References

SOLAS Chapter V: Regulation 15

STCW A–VIII/3



Information Ignored

Intermediate Cause

Typical Issues

Did ignoring information provided by others on the bridge contribute to the event? Was the master so occupied with a maneuver that he did not pay attention to information provided by a member of the bridge team?

Typical Recommendations

Establish a bridge procedure that requires a repeat-back acknowledgement of information provided by any member of the bridge team to the member with the conn.

Bridge team members should repeat information given if it is not acknowledged by the member of the team with the conn.

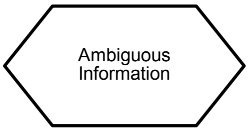
Example

The ship's master was self-confident and had a poor opinion of the third officer. He generally gave little note to input provided by the third officer while he had the conn. As a result, while the vessel was maneuvering toward the approaches of a harbor, the master did not pay attention to the third officer's caution about a small vessel coming out of a crowded anchorage to the port side of the vessel. By the time the master recognized the critical nature of the situation, it was too late to avoid the collision.

Standards References

SOLAS Chapter V: Regulation 15

STCW A-VIII/3



Ambiguous Information

Intermediate Cause

Typical Issues

Was information communicated in such a manner as to be understood differently than intended? Was information communicated in such a manner as to be understood two different ways?

Typical Recommendation

Establish a bridge management procedure that requires, wherever practical, that the receiver of information visually confirm the information given.

Examples

The ship's master was self-confident and had a poor opinion of the third officer. He generally gave little note to input provided by the third officer while he had the conn. As a result, while the vessel was maneuvering toward the approaches of a harbor, the master did not pay attention to the third officer's caution about a small vessel coming out of a crowded anchorage on the port side of the vessel. By the time the master recognized the critical nature of the situation, it was too late to avoid the collision.

As the vessel was maneuvering within the approaches of a harbor, the third officer alerted the master, who had the conn, that a small vessel was coming out of a crowded anchorage on the port side of the vessel. The master acknowledged the third officer and understood the comment to mean the vessel was entering the traffic lane from the anchorage located to port. The small vessel's heading actually had it cutting across the traffic lane and on a near-collision course. A near miss occurred when the third officer, recognizing that the master misunderstood the communication, alerted the master of the impending situation. Belated evasive action was then taken

Standards References

SOLAS Chapter V: Regulation 15

STCW A-VIII/3

Communication with Pilot

Intermediate Cause

Typical Issues

Did a lack of effective communication with the pilot contribute to the incident? Did inattention to establishing the means of communication with the pilot prior to the pilot taking the conn contribute to the event? Was a critical piece of information not passed on to the pilot before the pilot assumed the conn?

Typical Recommendations

Establish a checklist that ensures that the pilot is provided all pertinent information regarding the vessel, and that communication procedures are established prior to the pilot assuming the conn.

Ensure that the master and pilot exchange port passage plans and that the master understands the pilot's intentions prior to handing the conn to the pilot.

Require that the pilot communicate his intentions at each critical juncture in the passage.

Require repeat-back of pilots' commands.

Examples

The pilot and the master did not exchange port passage plans prior to the pilot taking the conn. The master relied on the pilot's expertise and knowledge of the harbor. The watch officer likewise trusted the pilot's knowledge and did not alert the pilot when the course line, ship's heading and speed appeared to be heading the ship to shallow water. As a result, the pilot was not alerted of the developing situation in time to avert grounding the vessel.

The helmsman did not repeat back orders given by the pilot prior to executing them. Neither the pilot nor the ship's officers on the bridge corrected the helmsman's behavior as he executed orders promptly and in accordance with the pilot's commands. In a close-quarters situation, the pilot gave a starboard helm order and the helmsman executed an equivalent port helm order, creating a situation that eventually evolved into a collision.

Standards References

SOLAS Chapter V: Regulation 15

STCW A-VIII/3

Duty/Watch Handover Issue

Cause Type

Typical Issue

Was there incorrect, incomplete or otherwise inadequate communication between workers during a watch or during a watch change?

Typical Recommendations

Ensure that the current status of operations, safety and pollution prevention considerations and problems encountered during the previous watch are discussed as part of the watch change process.

Provide a checklist of items that should be considered for discussion at each watch change.

Provide a means of communication among personnel working on the same watch (e.g., two-way radios).

Example

Cargo operations were well under way at the change of the watch. At the watch change, the AB going off duty neglected to tell the AB coming on that several tanks were nearing full and that the first officer had asked the AB to stand by the tank that was going to be topped off first. The oncoming AB made a round of the deck and was some distance from the first tank when the first officer called for the AB to manually close the fill valve. By the time the AB reached the tank and closed the valve, the tank was dangerously close to overflowing.

Standards References

ISO 9001: 2000: Sec 7.5.1

ISO 14001: 2000: Sec 4.4.6

SOLAS Chapter V: Regulation 15

STCW A-VIII/3

OHSAS 4.4.6

Communication within Watch Issue

Intermediate Cause

Typical Issues

Was there incorrect, incomplete or otherwise inadequate communication between personnel during a watch? Could a more effective means of communication have been used?

Note: Planning and coordination of jobs between individuals and work groups should be coded under "Ineffective Teamwork (Operations/Job Supervision; Supervision During Work)".

Typical Recommendations

Encourage personnel to alert others on their watch of changes that may affect others (tell others when you plan to take a break, tell others when you move from one location to another, etc.).

Encourage personnel to keep each other informed about changes in operation/equipment.

Example

Cargo operations were well under way when the AB was scheduled to go on break. When the OS relieved the AB for his break, several tanks were nearing full. The AB neglected to tell the OS that the first officer had asked the AB to stand by a tank that was close to being topped off. The oncoming OS made a round of the deck and was some distance from the tank when the first officer called for him to manually close the fill valve. By the time the OS reached the tank and closed the valve, the tank was dangerously close to overflowing.

Standards References

SOLAS Chapter V: Regulation 15

STCW A-VIII/3

Communication at Watch Handover Issue

Intermediate Cause

Typical Issue

Was there incorrect, incomplete or otherwise inadequate communication between personnel during a watch change?

Typical Recommendations

Use logbooks to communicate between shifts.

Provide guidance on the content of shift turnovers.

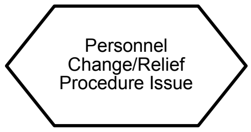
Example

Cargo operations were well under way at the change of the watch. At the watch change, the AB going off duty neglected to tell the AB coming on that several tanks were nearing full and that the first officer had asked the AB to standby the tank that was going to be topped off first. The oncoming AB made a round of the deck and was some distance from the first tank when the first officer called for the AB to manually close the fill valve. By the time the AB reached the tank and closed the valve, the tank was dangerously close to overflowing.

Standards References

SOLAS Chapter V: Regulation 15

STCW A-VIII/3



Personnel Change/Relief Procedure Issue

Intermediate Cause

Typical Issues

Did failure to pass on an important piece of information during vacation relief create or contribute to the problem?

Typical Recommendations

Establish a relieving procedure that requires that all significant work and events transpiring during the disembarking person's period of service aboard the vessel be recorded for review at relief.

The relieving procedure should require that the quantities of fuels, lubes and water be recorded.

All pending repair items and ordered parts should be included in the information passed on at relief.

Examples

The ship's master neglected to tell the relieving master that the bow thruster was only operable up to half power. The master did not tell the pilot ahead of time that an extra tug might be required when departing the terminal. The pilot was not provided the pertinent information when she boarded to take the vessel out from the berth.

The chief engineer failed to let the relieving chief know that the number one and number three cylinder liners and piston rings were in need of replacement and that liners and rings had been requisitioned. The relieving chief soon identified the problem and placed an emergency requisition for two more liners and two more sets of piston rings.

The first officer neglected to tell the relieving first officer that several of the remotely operated cargo valves were not functional remotely, thus requiring manual operation by crew members at the valve locations. As a result, when topping off at the end of loading operations, the first officer was surprised to see that the valves were not functioning from the control room.

Standards References

SOLAS Chapter V: Regulation 15

STCW A-VIII/3

Personnel Performance

Cause Category

Typical Issues

Did the worker's physical or mental well-being, attitude, mental capacity, attention span, rest, substance abuse, etc., adversely affect the performance of the task? Was the problem the result of the individual not being capable of performing the task or not wanting to do his or her job? Was a personal performance problem promptly detected? Was corrective action promptly taken?

Typical Recommendations

Ensure that there is a process in place to detect personal performance problems.

Provide a means for personnel to self-report problems.

Examples

An engineer failed to close a valve after completion of a transfer. The engineer was not paying attention to the level of the tank into which the oil was being transferred. The engineer had a history of not paying attention to his work. He had been involved in several other incidents during which he had left his job or was not performing his job requirements. Other engineers performed these same job requirements with no problems.

An engineer came to work drunk. The engineer was stumbling while walking to the engine control station. However, no one did anything to stop him from going to work.

Standards References

ISO 9001: 2000: Sec 7.5.1

TMSA 2A: 2.1, 4.2, 3A: 2.1, 2.2, 3.1, 3.2

OHSAS 4.4.6

Company Issue

Company Issue

Cause Type

Typical Issues

Did personal performance issues contribute to the event? Should the personal performance issues have been detected prior to the event? Were workers rewarded for improper performance?

Note: Consider dual coding under" Insufficient Supervision (Operations/Job Supervision, Supervision During Work)".

Typical Recommendations

Provide supervisors with training on the detection of personal problems.

Give supervisors the authority to remove workers from hazardous assignments when personal problems are detected.

Encourage coworkers to help identify personal performance problems.

Develop rewards that are consistent with company goals and objectives.

Ensure that metrics and other measurements for performance are consistent with facility goals and objectives.

Examples

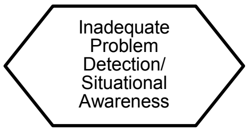
An AB came to work drunk. He was having trouble walking and talking. While going to get a part from the storage locker, he fell down some steps and injured himself and another seafarer.

Six months ago, an engine mechanic was hired who could not read. The second engineer had not detected the problem, even though this mechanic had trouble with all of his non-routine tasks (those that required him to use a procedure).

The vessel's first officers were to be considered for promotion based upon how far under budget they were able to maintain the vessel. As a result, first officer A typically used up the supplies, including paint, that remained onboard when he would return to work. He then ordered as little as possible or nothing at all during his time onboard. This left first officer B, upon relieving first officer A, with few or no supplies to work with, and required first officer B to place large orders for supplies in order to maintain the vessel in accordance with company standards. As a result, there were periods of time when sufficient supplies were not available to keep up with continual maintenance requirements, and the ship suffered considerable deterioration on deck.

Standards Reference

TMSA 2A: 1.2



Inadequate Problem Detection/Situational Awareness

Intermediate Cause

Typical Issues

Did personal performance issues contribute to the event? Should the personal performance issues have been detected prior to the event?

Note: Consider dual coding under "Insufficient Supervision (Operations/Job Supervision, Supervision During Work)".

Typical Recommendations

Provide supervisors with training on the detection of personal problems.

Give supervisors the authority to remove workers from hazardous assignments when personal problems are detected.

Encourage coworkers to help identify personal performance problems.

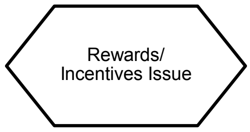
Examples

An AB came to work drunk. He was having trouble walking and talking. While going to get a part from the storage locker, he fell down some steps and injured himself and another seafarer.

Six months ago, an engine mechanic was hired who could not read. The second engineer had not detected the problem, even though this mechanic had trouble with all of his non-routine tasks (those that required him to use a procedure).

Standards Reference

ISM Code 3



Rewards/Incentives Issue

Intermediate Cause

Typical Issues

Were workers rewarded for improper performance? Were incentives consistent with the goals of the company? Did the reward system encourage workers to take short cuts or waste resources?

Typical Recommendations

Develop rewards that are consistent with company goals and objectives.

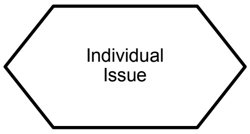
Ensure that metrics and other measurements for performance are consistent with facility goals and objectives.

Example

The vessel's first officers were to be considered for promotion based upon how far under budget they were able to maintain the vessel. As a result, first officer A typically used up the supplies, including paint, that remained onboard when he would return to work. He then ordered as little as possible or nothing at all during his time onboard. This left first officer B, upon relieving first officer A, with few or no supplies to work with, and required first officer B to place large orders for supplies in order to maintain the vessel in accordance with company standards. As a result, there were periods of time when sufficient supplies were not available to keep up with continual maintenance requirements, and the ship suffered considerable deterioration on deck.

Standards Reference

TMSA 2A: 4.1



Individual Issue

Intermediate Cause

Typical Issues

Did the worker's physical or mental well-being, attitude, mental capacity, attention span, rest, substance abuse, etc., adversely affect the performance of the task? Was the problem the result of the individual not being capable of performing the task or not wanting to do his or her job? Was a personal performance problem promptly detected? Was corrective action promptly taken?

Note: Code as "Individual Issue" only. The six causes beneath "Personal Performance; Individual Issue" are included to provide the investigator with an understanding of the types of problems that might be categorized as "Personal Performance; Individual Issue". However, the investigator should NOT include these items in the investigation report. Also, identifying an additional root cause analysis path through the Management Systems cause category is recommended for problems of this type. Human Resources cause types can often be used to detect and correct most (if not all) individual issues BEFORE a loss event occurs therefore, the failure or absence of the management systems should be coded as well.

Typical Recommendations

Ensure that there is a process in place to detect personal performance problems.

Provide a means for personnel to self-report problems.

Examples

An engineer failed to close a valve after completion of a transfer. The engineer was not paying attention to the level of the tank into which the oil was being transferred. The engineer had a history of not paying attention to his work. He had been involved in several other incidents during which he had left his job or was not performing his job requirements. Other engineers performed these same job requirements with no problems.

An engineer came to work drunk. The engineer was stumbling while walking to the engine control station. However, no one did anything to stop him from going to work.

Inadequate Sensory/Perceptual Abilities

Inadequate Sensory/Perceptual Abilities

Information Only. Code to Individual Issue under Personnel Performance.

Typical Issues

Was the problem a result of less than adequate vision (e.g., poor visual acuity, color blindness, tunnel vision)? Was the problem a result of some defect in hearing (e.g., hearing loss, tone deafness)? Was the problem a result of some sensory defect (e.g., poor sense of touch or smell)?

Note: Code as "Individual Issue" only. The six causes beneath "Personal Performance; Individual Issue" are included to provide the investigator with an understanding of the types of problems that might be categorized as "Personal Performance; Individual Issue". However, the investigator should NOT include these items in the investigation report. Also, identifying an additional root cause analysis path through the Management Systems cause category is recommended for problems of this type. Human Resources cause types can often be used to detect and correct most (if not all) individual issues BEFORE a loss event occurs therefore, the failure or absence of the management systems should be coded as well.

Typical Recommendations

Ensure that job requirements are complete, including required physical/perceptual capabilities.

Provide reasonable accommodations for coworkers with sensory/perceptual limits.

Note: A review of the human factors for the process is also appropriate to accommodate a wider spectrum of sensory capabilities. For example: Can the displays be redesigned so that lights that indicate "closed" conditions of valves are always in the same relative location on the panel? Can more chart recorders be installed with fewer points per chart?

Example

An engineer read the wrong temperature on a chart that recorded temperatures for several tanks. The chart was color-coded. The operator was partially color blind and confused the readings. He recorded a temperature that was in range when the actual temperature was out of range.

Note: Consider coding under "Employee Screening/Hiring Issue [Human Resource Issue under Management System (MS)]" because there should be management controls to ensure that employees possess the required job capabilities.

Standards Reference

ISM Code 6.2

Poor
Reasoning

Poor Reasoning

Information Only. Code to Individual Issue under Personnel Performance.

Typical Issues

Was the problem caused by inadequate intellectual capacity? Does the person frequently make wrong decisions? In general, does the person have difficulty processing information? Do other workers have difficulty performing these tasks or is it isolated to this one worker?

Note: Code as “Individual Issue” only. The six causes beneath “Personal Performance; Individual Issue” are included to provide the investigator with an understanding of the types of problems that might be categorized as “Personal Performance; Individual Issue”. However, the investigator should NOT include these items in the investigation report. Also, identifying an additional root cause analysis path through the Management Systems cause category is recommended for problems of this type. Human Resources cause types can often be used to detect and correct most (if not all) individual issues BEFORE a loss event occurs therefore, the failure or absence of the management systems should be coded as well.

Typical Recommendation

Review employee screening and hiring processes to ensure that the individuals who are hired have the required reasoning capabilities.

Examples

A bosun made a mistake in a calculation and added too much activator to the epoxy. The bosun had frequently made errors with calculations and appeared to have problems with numbers. Other bosuns did not have difficulty performing these tasks.

An AB missed several steps in a procedure. The AB was unable to clearly understand the procedures because they were written at a sixth-grade level and he could only read at a second-grade level.

Note: Consider coding under “Employee Screening/Hiring Issue [Human Resource Issue under Management Systems (MS)]” as well, since there should be management controls to ensure that employees possess the appropriate reading and mathematical skills.

Inadequate Motor/
Physical Capabilities

Inadequate Motor/Physical Capabilities

Information Only. Code to Individual Issue under Personnel Performance.

Typical Issues

Can the causal factor be attributed to trouble with inadequate coordination or inadequate strength? Was the problem a result of inadequate size or stature of the individual involved? Did other physical limitations (e.g., shaking, poor reaction time) contribute to the problem?

Note: Code as "Individual Issue" only. The six causes beneath "Personal Performance; Individual Issue" are included to provide the investigator with an understanding of the types of problems that might be categorized as "Personal Performance; Individual Issue". However, the investigator should NOT include these items in the investigation report. Also, identifying an additional root cause analysis path through the Management Systems cause category is recommended for problems of this type. Human Resources cause types can often be used to detect and correct most (if not all) individual issues BEFORE a loss event occurs therefore, the failure or absence of the management systems should be coded as well.

Note: A review of the human factors for the process is also appropriate. Is it reasonable for an "average" individual to perform this task? Can the individual be provided with a tool to assist in the task? Can the task be redesigned to reduce the physical requirements?

Typical Recommendations

Ensure that job requirements are complete, including required physical/perceptual capabilities.

Provide reasonable accommodations for workers with physical limitations.

Example

A tank overflowed because the engineer could not close the valve. The valve was large and difficult to close. The engineer did not have the strength to close the valve. By the time he obtained help in closing it, the tank had overflowed.

Note: Consider coding under "Employee Screening/Hiring Issue [Human Resource Issue under Management Systems (MS)]" because there should be management controls to ensure that employees possess the required job capabilities.

Standards Reference

ISM Code 6.2

Disregard for Company Procedures/Policies

Disregard for Company Procedures/Policies

Information Only. Code to Individual Issue under Personnel Performance.

Typical Issues

Was the problem a result of poor attitude on the part of an individual? Does the individual frequently violate company rules in an effort to hurt the performance of the vessel or the company?

Typical characteristics may include the following:

- Engages in horseplay
- Exhibits maliciousness
- Exhibits insubordination
- Enjoys seeing the organization fail
- Enjoys seeing others in the organization fail or get injured
- Exhibits no remorse

Note: Code as "Individual Issue" only. The six causes beneath "Personal Performance; Individual Issue" are included to provide the investigator with an understanding of the types of problems that might be categorized as "Personal Performance; Individual Issue". However, the investigator should NOT include these items in the investigation report. Also, identifying an additional root cause analysis path through the Management Systems cause category is recommended for problems of this type. Human Resources cause types can often be used to detect and correct most (if not all) individual issues BEFORE a loss event occurs therefore, the failure or absence of the management systems should be coded as well.

Typical Recommendations

Consider reviewing the employee's supervision.

Consider reviewing hiring practices to determine how/why this person was hired.

Example

An engineer failed to close a valve while filling a tank, resulting in an overflow from the tank. He often was away from his assigned work location engaging in horseplay and was not concerned about the consequences of the overflow.

Note: Consider coding under "Employee Screening/Hiring Issue [Human Resource Issue under Management System (MS)]" because there should be management controls to ensure that employees possess the required job capabilities. Also consider coding under "Insufficient Supervision (Operations/Job Supervision, Supervision During Work)" because supervision should detect this problem.

Inadequate Rest/
Sleep (Fatigue)

Inadequate Rest/Sleep (Fatigue)

Information Only. Code to Individual Issue under Personnel Performance.

Typical Issues

Was the worker involved in the incident asleep while on duty? Was the person too tired to perform the job?

Note: Code as "Individual Issue" only. The six causes beneath "Personal Performance; Individual Issue" are included to provide the investigator with an understanding of the types of problems that might be categorized as "Personal Performance; Individual Issue". However, the investigator should NOT include these items in the investigation report. Also, identifying an additional root cause analysis path through the Management Systems cause category is recommended for problems of this type. Human Resources cause types can often be used to detect and correct most (if not all) individual issues BEFORE a loss event occurs therefore, the failure or absence of the management systems should be coded as well.

Note: This node addresses problems associated with an individual's rest and sleep practices outside of normal work hours and outside the control of the organization. Problems with workers who are forced to work unreasonable amounts of overtime should be coded using the "Fatigue Management Issue (Operations/Job Supervision, Supervision During Work)" or "Sustained High Workload/Fatigue (Human Factors, Workload)" segments of the map.

Typical Recommendations

Review the work scheduling to ensure that the work schedule is appropriate.

Counseling for the individual may help, but the worker must want the counseling to succeed.

Example

During off-shift hours, one of the crew members stays up reading six to eight hours per day. As a result, the crew member does not get adequate sleep. The individual was told to get adequate rest, but he refused to change his behavior.

Personal
Medication
Use/Abuse

Personal Medication Use/Abuse

Information Only. Code to Individual Issue under Personnel Performance

Typical Issues

Is the individual experiencing personal problems that are affecting his or her job performance? Is the individual taking medications that affect his or her job performance?

Typical symptoms include:

- Chronic inattention
- Acute inattention
- Frequent daydreaming
- Easily distracted
- Poor vigilance
- Illness
- Impairment due to prescription drugs
- Poor psychological health
- Abuse of drugs/alcohol

Note: Code as "Individual Issue" only. The six causes beneath "Personal Performance; Individual Issue" are included to provide the investigator with an understanding of the types of problems that might be categorized as "Personal Performance; Individual Issue". However, the investigator should NOT include these items in the investigation report. Also, identifying an additional root cause analysis path through the Management Systems cause category is recommended for problems of this type. Human Resources cause types can often be used to detect and correct most (if not all) individual issues BEFORE a loss event occurs therefore, the failure or absence of the management systems should be coded as well.

Typical Recommendations

Establish an employee assistance program.

Inform and encourage workers to take advantage of employee assistance programs.

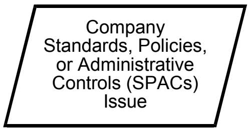
Example

An engineer was prescribed a medication that caused drowsiness. During a tank transfer, he lost track of time and the tank overflowed.

Enter here with each Immediate Cause from Page 1

After identifying an intermediate cause on of the ABS *Marine Root Cause Analysis Map*, continue on to bright green hexagon labeled "Enter here with each immediate cause" to identify root cause types and root causes. Intermediate causes are symbolized by a hexagon (hexagon shape).

Some of the branches of the map do not end in a hexagon. Examples include *Sabotage/Terrorism/War* (under the *External Factors* causal factor type) and the asterisked items under *Personal Performance*. Identification of root causes for these items is not anticipated because these issues are generally outside the control of the organization.



Company Standards, Policies or Administrative Controls (SPACS) Issue

Root Cause Type

Typical Issues

Was the error caused by the lack or inadequacy of SPACs? Were the SPACs inaccurate, confusing, incomplete, unclear, ambiguous, not strict enough or otherwise inadequate? Were the wrong actions rewarded?

Note: SPACs provide guidance on how an activity should be accomplished, whereas procedures provide a detailed, step-by-step method for performing a specific task. For example, there are SPACs that describe the policies governing scheduling of workers. There is also a procedure that provides a detailed, step-by-step process for performing the task, including the forms to complete and data to enter in the computer system.

Typical Recommendations

Provide written documentation of SPACs.

When errors are found, modify SPACs accordingly.

Ensure that policies regarding production, material control, procurement, security, etc., do not contradict safety and pollution prevention policies.

Examples

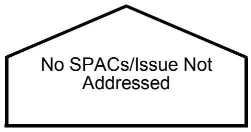
A man entered a cofferdam space without properly testing the atmosphere before entry. The procedure for confined space entry required testing of the atmosphere, but did not state the types of tests that should be performed. The confined space policy did not require a specific type of test to be performed. It left it up to the individual to decide how to test the atmosphere.

The policy for generating procedures did not require a field validation with end users of the procedure. As a result, many procedures contained errors that were considered obvious by field personnel.

Standards References

TMSA 1A: 1B: 1.2, 3A: 4.3, 9B: 3.1, 3.2, 10A: 1.4, 2.1, 2.2, 3.2, 4.1, 4.2, 4.3

SEMP 1.2.3, 1.4, 2.2.3



No SPACs/Issue Not Addressed

Root Cause

Typical Issues

Did a Standard, Policy or Administrative Control (SPAC) exist to control the particular type of work or situation involved in the incident? Was the work or situation significant or involved enough to warrant some type of SPAC to ensure adequate operational or job control?

Typical Recommendations

Compile a list of SPACs mandated by regulatory requirements (Class, SOLAS, MARPOL, etc.) and compare it to a current list of existing SPACs. Develop any missing SPACs.

Provide written documentation of SPACs.

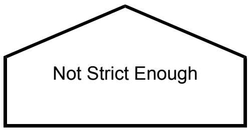
Define, document and communicate missing SPACs.

Examples

The company did not have a standard or policy that outlined the requirements for confined space entry.

The company did not have a standard or policy that limited overtime hours, even though regulations require a policy on this issue.

A deck officer bypassed an alarm on the navigational computer. The company did not have a policy on disabling alarms.



Not Strict Enough

Root Cause

Typical Issues

Were the existing Standards, Policies or Administrative Controls (SPACs) strict enough to provide adequate job quality or work control? Did vagueness allow violation of the intent, if not the letter, of the SPACs?

Typical Recommendations

Improve the level of detail of SPACs.

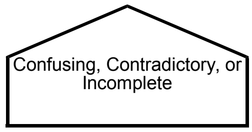
Improve the description of accountabilities in SPACs (for resolving ambiguities).

Examples

A man entered a cofferdam space without properly testing the atmosphere before entry. The confined space policy did not require a department head to certify the space before allowing anyone to enter. As a result, this requirement was not included in the confined space entry procedure. During entry into a confined space that was improperly prepared, a man entered the space thinking it was safe and passed out within several feet of the entrance.

The policy for generating procedures did not require a field validation with end users of the procedure. As a result, many procedures contained errors that were considered obvious by field personnel.

The policy for lockout/tagout indicates that equipment should be locked and tagged when work is to be performed on the equipment. However, it does not require lockout/tagout of equipment associated with controls and indications that are out of service.



Confusing, Contradictory or Incomplete

Root Cause

Typical Issues

Were the Standards, Policies or Administrative Controls (SPACs) confusing, hard to understand or interpret or ambiguous? Were the SPACs incomplete or not specific enough? Did contradictory requirements exist? Were some requirements violated or disregarded in order to follow others? Was a SPAC not followed because no practical way of implementing the SPAC existed? Would implementation have hindered production?

Typical Recommendations

Solicit comments and recommendations from operations/maintenance personnel regarding ambiguous or unclear language in the SPACs. Resolve comments.

Ensure that policies regarding operations, procurement, security, etc., never contradict a safety or pollution prevention policy.

Communicate to operators that safety should be given top priority.

Ensure that SPACs reflect management's decision to make safety and pollution prevention a top priority.

SPACs that require specific authorization signatures should state alternate sources of authorization in the event the primary authorizers are not available.

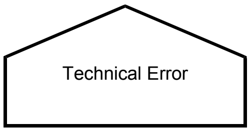
Provide the necessary tools/equipment features to allow/encourage personnel to follow the SPACs.

Examples

A company policy required assessment of changes made to the vessel. The policy contained examples of what were considered changes and examples of items that were not changes (replacements in kind). However, the policy contained a table that included many examples that were in both categories.

A company policy required the reporting of all injuries to the Personnel Department. However, a recent reorganization renamed the Personnel Department to Human Resources. As a result, the policy was inconsistent with the organizational structure.

A company policy required reliability-centered maintenance (RCM) analyses to be performed on vital equipment. However, the policy never defines what RCM stands for or any criteria by which to identify vital equipment.



Technical Error

Root Cause

Typical Issues

Did technical errors or incorrect facts exist in the Standards, Policies or Administrative Controls (SPACs)? Did the SPACs fail to consider all possible scenarios or conditions?

Typical Recommendations

Include SPACs in the scope/charter of hazard review teams.

When errors are found, modify SPACs accordingly.

Example

The policy for updating drawings did not specify any time requirements for updating the drawings. It did not require that the drawings be updated before startup of the equipment.

Company Standards, Policies, or Administrative Controls (SPACs) Not Used

Company Standards, Policies or Administrative Controls (SPACS) Not Used

Root Cause Type

Typical Issues

Were Standards, Policies or Administrative Controls (SPACs) or directives not used, adhered to or followed? Was communication or enforcement of SPACs inadequate? Were the SPACs recently revised or difficult to implement? Did the SPACs provide for adequate accountability?

Note: SPACs provide guidance on how an activity should be accomplished, whereas procedures provide a detailed, step-by-step method for performing a specific task. For example, there are SPACs that describe the policies governing scheduling of workers. There is also a procedure that provides a detailed, step-by-step process for performing the task, including the forms to complete and data to enter in the computer system.

Typical Recommendations

Ensure that all levels of affected employees are aware of SPACs changes.

Take appropriate actions concerning those employees who do not use the SPACs.

Apply lessons learned from one unit to other units.

Examples

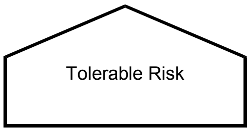
A mechanic bypassed an important step in calibrating a key safety instrument because he did not refer to the procedure as required. This was found to be an accepted practice aboard the vessel.

A requirement was in place to have the engineer check instruments in the engine room once per watch. The engineers never performed the checks. The second engineer was aware of the situation and never enforced the requirement.

During an extended dry-docking, daily rounds of the vessel were not performed by the vessel's deck and engine department heads. As a result, they did not discover that a storage locker had been broken into until a number of valuable items had been stolen, and that a hydraulic fluid leak had developed in the steering flat, covering a substantial portion of the deck. The vessel superintendent had not made it clear that the company's SPAC governing daily vessel rounds would remain in effect while in dry-dock.

Standards References

TMSA 1A: 2.1, 2.2, 3.1, 3.3, 4.1, 4.2, 4.3



Tolerable Risk

Root Cause

Typical Issues

Was it considered an acceptable risk to perform the task as observed? Was the loss associated with the incident considered acceptable?

Typical Recommendation

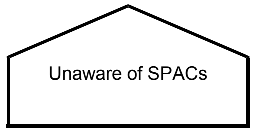
Review the organization's risk acceptance criteria to ensure that it is still appropriate.

Examples

The organization did not require the investigation of relief valve openings. Although failing to correct the causes of the openings led to an increased risk, the organization believed the risk was acceptable.

The organization did not require procedures for most operations. It only developed procedures that were required by outside organizations (regulatory bodies and certification organizations). Although development of some additional procedures would have reduced the risk of the operation, the organization believed that the risk was acceptable without them.

The organization knew that fires could be started because of hot work being performed on the vessel. The organization had developed policies and procedures on hot work. The organization ensured that the policies and procedures were followed. A fire occurred when hot work ignited some insulation on the inside of a duct near the work area. The procedure had been reasonably followed by the personnel performing the work. The policy does not require equipment in the area to be opened in order to identify potential hot work hazards. The organization decided not to change the policies or procedures because they believed the SPACs adequately controlled the risk.



Unaware of SPACs

Root Cause

Typical Issue

Were standards, directives or policies not communicated from management down through the organization?

Typical Recommendations

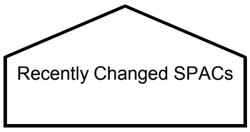
Include Standards, Policies or Administrative Controls (SPACs) content in initial and refresher formal training; determine employee's understanding.

Periodically stress the importance of using SPACs during shift change meetings, safety meetings, etc.

Ensure that SPACs documentation is readily available to all affected employees at all times for reference purposes.

Example

During an extended dry-docking, daily rounds of the vessel were not performed by the vessel's deck and engine department heads. As a result, they did not discover that a storage locker had been broken into until a number of valuable items had been stolen, and that a hydraulic fluid leak had developed in the steering flat, covering a substantial portion of the deck. The vessel superintendent had not identified which of the normal and which of the special dry-dock procedures would be in effect while the vessel was in dry dock. As a result, the personnel did not perform the daily rounds. Normal company policy is for the vessel superintendent to identify these requirements once the vessel reaches port. However, a new superintendent was assigned just as the vessel reached port, so the task was never completed.



Recently Changed SPACs

Root Cause

Typical Issues

Had standards or directives been recently changed? Did information concerning changes fail to reach all levels of the organization? Had some confusion been created by the changes?

Typical Recommendations

Ensure that all levels of affected employees are aware of Standards, Policies or Administrative Controls (SPACs) changes.

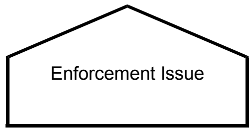
Verify that employees fully understand recent changes before expecting them to implement the changes.

Ensure that there is a process for communicating SPACs changes to the individuals who need to know about the changes.

Examples

A new policy on documentation requirements for calibration of pressure transmitters was provided to all of the ship superintendents, but the ship's engineers were not told of the change. As a result, the policy was not implemented as required.

A new policy was put in place to require personnel to enter the time charged against each work order into a computer system so the company could do a better job of tracking costs. No one was told of the requirement or taught how to enter the information in the computer.



Enforcement Issue

Root Cause

Typical Issues

In the past, has enforcement of the Standards, Policies or Administrative Controls (SPACs) been lax? Have failures to follow the SPAC in the past gone uncorrected or unpunished? Has noncompliance been accepted by management and supervision?

Note: Coding under "Rewards/Incentives Issue [Human Resource Issue under Management System (MS)]" or "Improper Performance Not Corrected (Operations/Job Supervision, Supervision During Work)" may be appropriate.

Typical Recommendations

Management should set an example by always following the letter of the SPACs.

Employees who do not use the SPACs should be corrected and/or disciplined.

Discipline needs to be fair, impartial, prestated, sure and swift.

Enforcement needs to be consistent.

Examples

A mechanic made a mistake installing a piece of equipment. He did not refer to a procedure when performing the test. Although policy is to always refer to the procedure, the policy had not been enforced. Mechanics often did not refer to the procedures, and their supervisors were aware of this.

Company policy required that tank levels be logged every hour during cargo transfer operations. However, they would typically take the readings only at the beginning of the watch. They used these readings to fill in the readings for the remainder of the watch. No one ever took issue with this practice until after an accident occurred.

Standards Reference

TMSA 1A: 1.2

Industry Standard Issue

Root Cause Type

Typical Issues

Was a novel design or concept applied for which there was no applicable prescriptive standard? Do applicable standards lack sufficient detail to be easily interpreted? Is insufficient detail provided to make interpretation of the standard easy? Is there disagreement with the criteria in an existing standard? Does the current standard fail to address a new technology or material? Was the wrong standard, code or guideline applied? Was the wrong version referenced?

Note: Determination of one of the root causes listed as subordinate to this node requires that a root cause associated with company Standards, Policies or Administrative Controls (SPACs) must also be determined.

Note: Determination of one of the root causes listed as subordinate to this node requires that the root cause be reported to pertinent standards organizations such as Flag Administrations, Class Societies, professional organizations like ANSI, API, IEE, British Standards, ISO, etc.

Typical Recommendations

Risk analysis should be performed in order to demonstrate equivalency with existing standards. Contact standards authorities and request clarification to determine the intent or basis for interpretation of the standard.

When a vessel changes service or trade routes, a review of existing regulations and vessel certificates should be performed to determine if additional requirements apply. Arrange for appropriate surveys to be conducted and certificates to be issued.

Examples

The vessel's engineering systems were controlled by computer systems. Alarms and shutdowns were also integrated into the computer software rather than conventional, mechanically actuated shutdowns and alarms. There was no existing standard by which software-actuated shutdowns and alarms might be assessed.

A vessel changed its trade routes and, although in compliance with international regulations, was detained for noncompliance with port state regulations.

Standards References

TMSA 10B: 3.2

SEMP 1.2.3, 1.5, 2.3.2, 2.3.3

Situation Not Addressed by Standard

Root Cause

Typical Issues

A novel design or concept was applied for which there was no applicable prescriptive standard.

Changes in practice or technology were not addressed by an industry standard.

An emerging technology was employed by the company for which no standard existed.

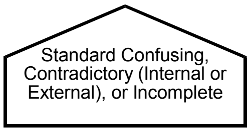
Typical Recommendation

Risk analysis should be performed in order to demonstrate equivalency with existing standards.

Examples

A new composite material for which no applicable standard existed was employed as part of the hull structure. A risk assessment was not performed from which to determine the best means of integrating the material with otherwise conventional vessel structural components.

The vessel's engineering systems were controlled by computer systems. Alarms and shutdowns were also integrated into the computer software rather than conventional, mechanically actuated shutdowns and alarms. There was no existing standard by which software-actuated shutdowns and alarms might be assessed.



Standard Confusing, Contradictory (Internal or External) or Incomplete

Root Cause

Typical Issues

Do two applicable standards contain conflicting requirements? Does current practice exceed the scope of existing standards? Do applicable standards lack sufficient detail to be easily interpreted? Is insufficient detail provided to make interpretation of the standard easy? Are there conflicting requirements within a standard?

Typical Recommendations

Review conflicting requirements and comply with the most stringent requirement.

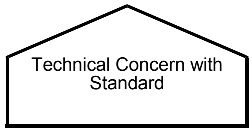
Contact standards authorities and request clarification to determine the intent or basis for interpretation of the standard.

Contact standards authorities and request formal ruling in application of the conflicting requirements.

Examples

Applicable international and flag state requirements conflict. The company chose to fulfill the less stringent of the conflicting requirements. As a result, the vessel was denied an important certificate.

The technological language used in a standard is confusing.



Technical Concern with Standard

Root Cause

Typical Issues

Is there a disagreement with the methodology recommended by an existing standard? Is there disagreement with the criteria in an existing standard? Does the current standard fail to address a new technology or material? Does a new technology or methodology indicate the need for changes in a standard?

Typical Recommendations

Provide an analysis to show equivalency with a current standard or that the current standard's criteria have been exceeded.

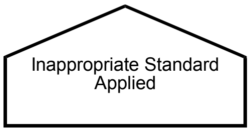
Request the appropriate standard's body/organization to establish new criteria.

Examples

A risk assessment indicated that the existing standard was not stringent enough.

A risk analysis indicated that the existing standard did not adequately address a safety-related concern.

A historical analysis of failures indicated that the existing standards did not provide an adequate measure of safety.



Inappropriate Standard Applied

Root Cause

Typical Issues

Was the wrong standard, code or guideline applied? Was the wrong version referenced? Did a change in vessel routing (new geographical area of operation) or service (cargo) have associated requirements that were not taken into account? Were international rules applied in place of more stringent flag regulations?

Typical Recommendations

When a vessel changes service or trade routes, a review of existing regulations and vessel certificates should be performed to determine if additional requirements apply. Arrange for appropriate surveys to be conducted and certificates to be issued.

Care should be taken to ensure that the applicable version/revision of a standard or regulation is applied to a vessel.

Examples

An OBO that had been serving as a bulk carrier for a number of years carried only certificates appropriate to the carriage of grain. The vessel was proposed for service carrying crude oil and neglected to undergo the appropriate surveys and obtain the appropriate certificates for carriage of oil. As a result, the vessel was detained at the discharge port.

A vessel changed its trade routes and, although in compliance with international regulations, was detained for noncompliance with port state regulations.

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APPENDIX 2 Fault Tree Details

1 Introduction to Fault Tree Analysis

Fault tree analysis begins with a known event (referred to as the top event) and describes possible combinations of events and conditions that can lead to this event. The top event in the fault tree can be the loss event under investigation or a specific event that is involved in the incident.

The fault tree looks backward in time to describe the potential causes of the top event. AND and OR logic is used to graphically show potential combinations of events and conditions leading to the top event. It is commonly used proactively during risk assessments to identify dominant potential contributors. For incident investigation applications, however, the smallest possible tree is developed. As soon as a branch is shown not to be credible, development of that branch is stopped.

Most reactive and proactive analysis techniques only identify single-event failures. One significant advantage of the fault tree technique is that it can help identify multiple-event failures. Multiple-event failures are those that require more than one event for a failure to occur. For example, for a fire, three conditions must exist simultaneously: fuel, oxygen and an ignition source. Most incidents involve multiple-event failures. Therefore, the ability to model multiple-event failures is an essential element for any incident modeling methodology.

A fault tree can also show design and operational errors. In some cases, equipment performs to its capabilities, but its capabilities are insufficient for the task. For example, a generator fails when it is overloaded or a diesel engine fails following a loss of its fuel. Examples of fault trees are provided below, as well as an explanation about the building blocks of such trees and a procedure for constructing a tree.

2 Fault Tree Examples

2.1 Example 1: Spill from a Tank

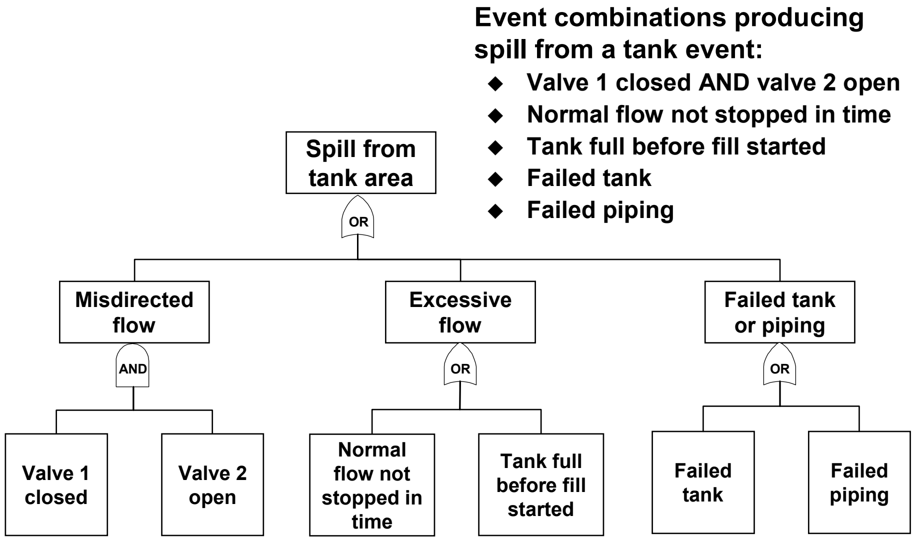
Appendix 2, Figure 1, "Tank Spill Example Fault Tree," shows a portion of a fault tree for a spill from a tank. In this case, three possible causes were identified by the investigator: (1) misdirected flow, (2) excessive flow and (3) failed tank or piping. Each of these, by itself, is sufficient to cause the spill from the tank, so an OR gate is used. Next, each of these three items is examined to determine the causes of each.

For the misdirected flow event, two events have to be present at the same time: Valve 1 must be closed and Valve 2 must be open. Closing Valve 1 is not enough to cause the misdirected flow. If Valve 2 is not open, the flow will not go through Valve 1, but it will not go through Valve 2 either. Therefore, both conditions must be present for the misdirected flow to occur, and an AND gate is used.

For the other two events, excessive flow and failed tank or piping, two possibilities were identified for each. Any one of these items is sufficient to cause the event above it, thus OR gates were used.

In an actual analysis, efforts are made to cut the branches off as soon as possible by collecting data to determine the validity of the branches. This will be examined in the next example.

FIGURE 1
Tank Spill Example Fault Tree



2.2 Example 2: Lighting Failure

Work in a portion of the vessel has just been halted because the overhead lighting has just gone out. Quickly, troubleshooting is needed to determine the source of the problem in order to restore routine lighting and minimize the potential for injuries to workers moving around in the dark area. (The emergency lighting has illuminated, but it is not sufficient to continue normal operations; see Appendix 2, Figure 2, “Circuit Diagram”.)

The fault tree in Appendix 2, Figure 3, “Lighting Failure Fault Tree,” was constructed based on the assumption that the switch and relay were closed before the lighting was lost. First, the tree starts with very general concepts and works down to specifics. The primary reason to do this is to save effort. The tree was drawn by starting at the top and work towards the bottom. In an actual investigation, it is possible that only a small portion of the tree would be needed. For example, Appendix 2, Figure 4, “Fault Tree with Events A, B and C Only,” is drawn to highlight particular events.

To save some effort, if it can be determined which of the two branches is correct, it is not necessary to pursue the other. To figure this out, data is needed. A question to ask at this point is “What data can we collect to determine if the problem is with the lights, the power, or both?” This will help to decide what information is needed and how the tree might be drawn.

FIGURE 2
Circuit Diagram

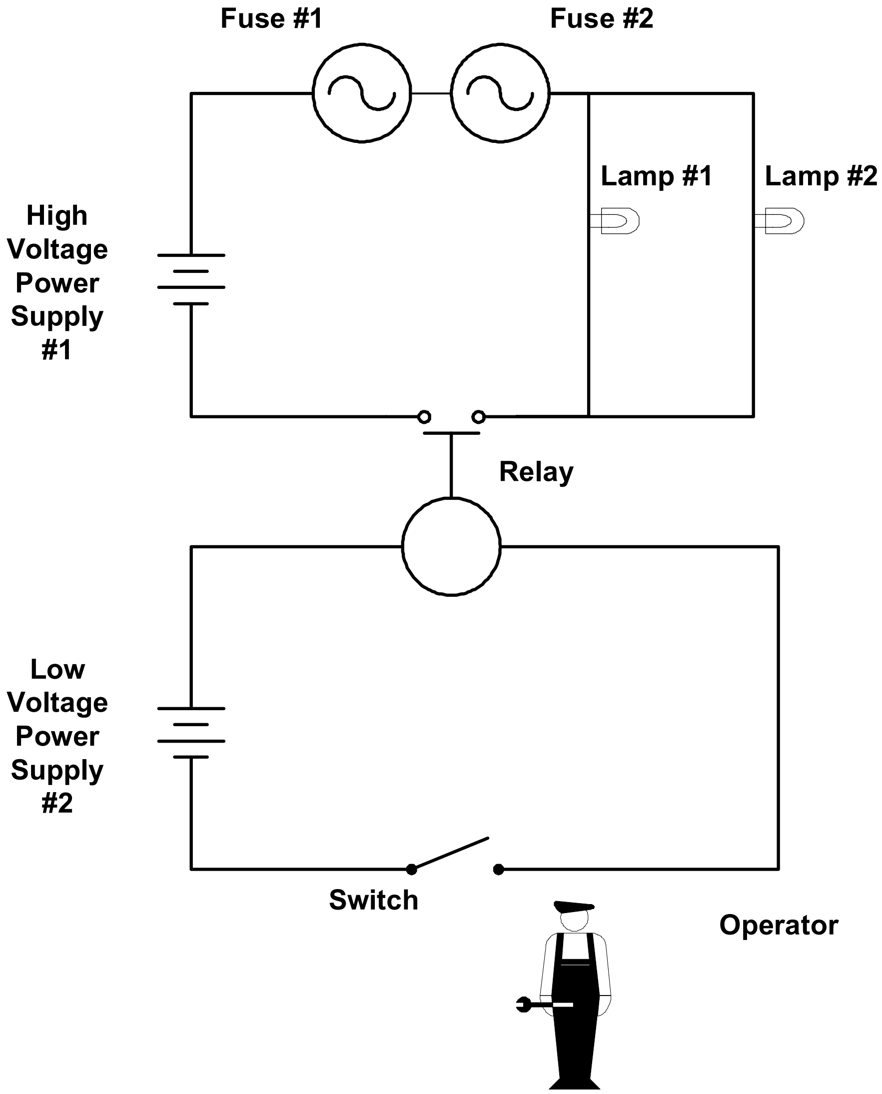


FIGURE 3
Lighting Failure Fault Tree

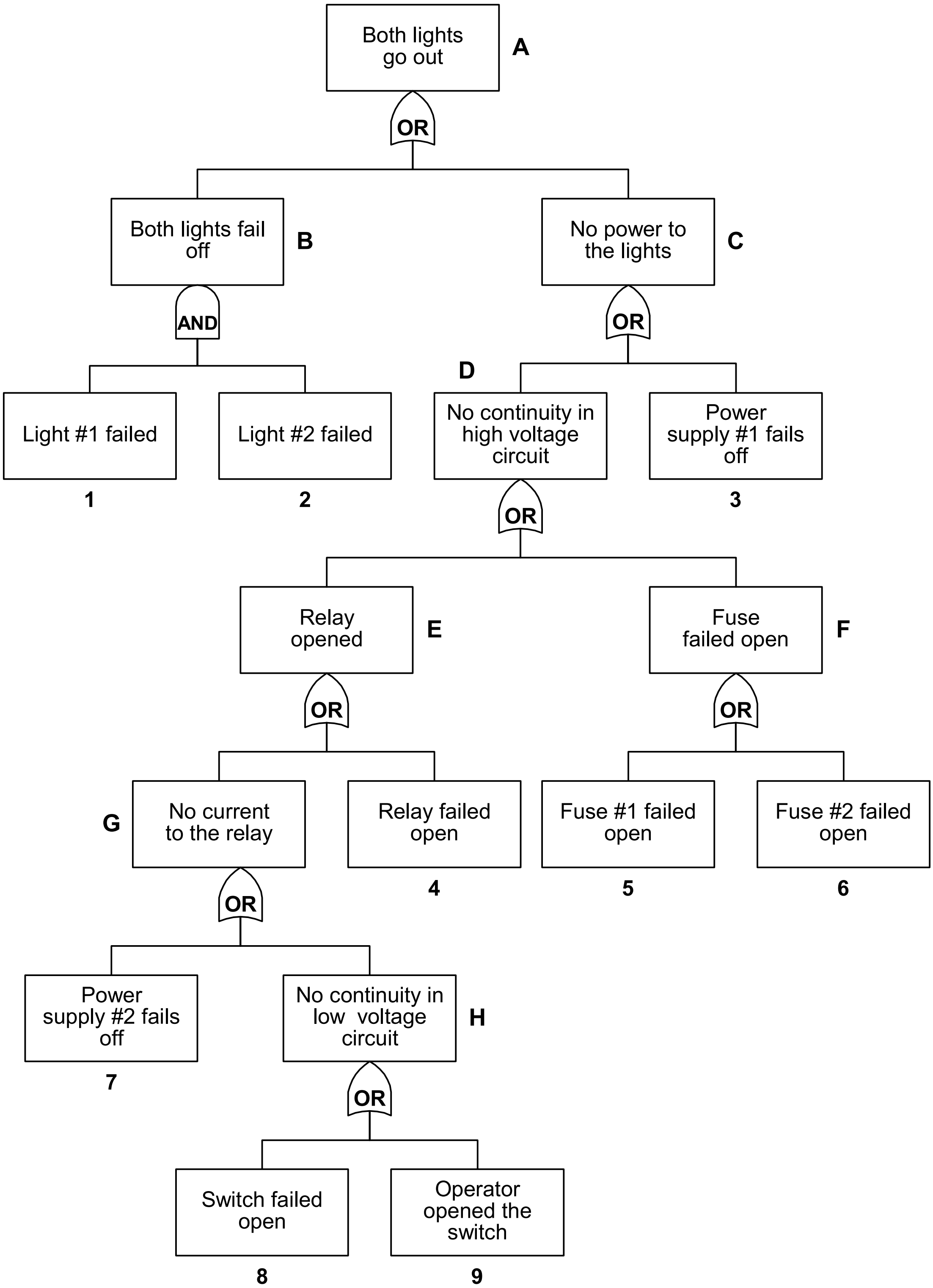
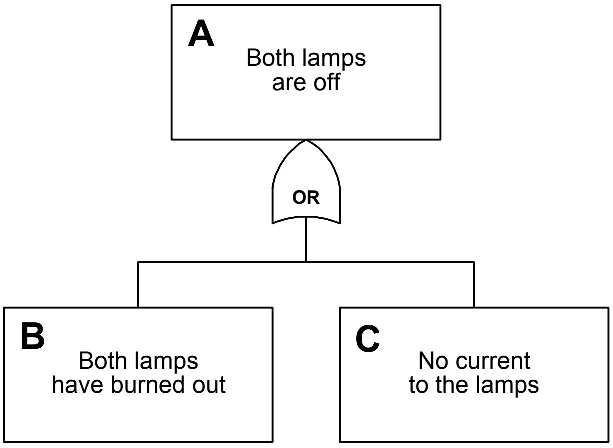


FIGURE 4
Fault Tree with Events A, B and C Only



2.2.1 Case 1

An electrician using a multi-meter determines that there is power to the light sockets. Having this information can save a lot of effort because it is now known that none of the events below Event C are causing a problem with the lights. As a result, no time needs to be spent developing the tree below Event C. Any events below Event C would lead to loss of power to the light socket and it has just been proved that was not true. To graphically represent this, an X is put through Event C and attention would be shifted to examining the lights (Event B). Because this is the only other cause identified, replacing the lights should make them operable again.

2.2.2 Case 2

The same test as in Case 1 is performed using an electrician, but this time the electrician says there is no power to the light sockets. Now more work has to be done developing the tree below Event C. While individual components could be tested, it would be better to test on a more global scale, testing many components at the same time. As a result, the next level of the fault tree is marked with a general item, "No continuity in the high voltage circuit" (Event D) along with "Power supply #1 fails off" (Event 3).

By testing the continuity in the high voltage circuit, a number of components can be checked with a single test. The electrician determines that there is no continuity in the circuit. That means the fault tree needs to be developed below Event D. The next level, with Events E and F, is outlined. First, "relay opened" is investigated. The electrician tests the relay and finds it is closed. An X can now be placed over Event E and the development of the tree below Event E can be stopped. Finally, it needs to be determined which fuses have failed. Through testing, it is found that both fuses have failed. Events 5 and 6 are circled and the fuses are replaced. If these are the only failures, the lights will come back on.

2.2.3 Case 3

For this case, suppose the lights and the power to the sockets are tested and neither of them is the cause of the failure. To represent this on the tree, an X is put through Events A and B.

There are two other possible causes of this situation. The first is that there is a cause of the top event that has not been identified. For example, maybe the lights are installed incorrectly or, they could have vibrated loose.

The second possibility is that one of the tests used to eliminate Events A and B was faulty. For example, to test the lights, two lights were obtained from stores. When these were installed, they did not work. There was power to the light sockets already, so it was concluded it could not be the bulbs because they were new. It is unlikely, but both bulbs could be faulty due to damage in shipment, manufacturing errors or damage during storage. *"Light #1 failed"* and *"Light #2 failed"* was eliminated as a possibility based on using new bulbs, not necessarily good bulbs. A better test would be to take two lights that are working in another fixture and install them in the problem circuit. If they do not work, take them back to the original system and reinstall them to make sure they are still functional. This is a better test of the lights.

2.3 Example 3: Hand Injury During Sandblasting

The first two examples primarily involved equipment; this example will primarily involve people.

2.3.1 Incident Description

The incident occurred when the operators were sandblasting a portion of the structure in preparation for repainting. Each sandblasting machine was staffed with the normal two-person crew.

When the nozzle operator observed that abrasive material was no longer flowing through the nozzle of his machine, he suspected a clog in the blast hose. He responded by releasing (disengaging) the "deadman's" switch and signaling his co-worker.

Assuming that the system was depressurized, the co-worker attempted to disconnect the blast hose from the equipment so that he could clean away the suspected clog.

The coworker was unable to rotate the quick-disconnect coupling the one-quarter turn required to remove the blast hose. Assuming the fitting was stuck because of dirt or contamination, he asked the nozzle operator to assist him.

Acting together, the two workers were able to twist the hose fitting to the point where it could be forcibly disconnected. The system rapidly depressurized, spraying abrasive material through the coupling and onto the hands of the worker nearest the outlet. This worker sustained relatively minor, but painful, skin abrasions to both hands.

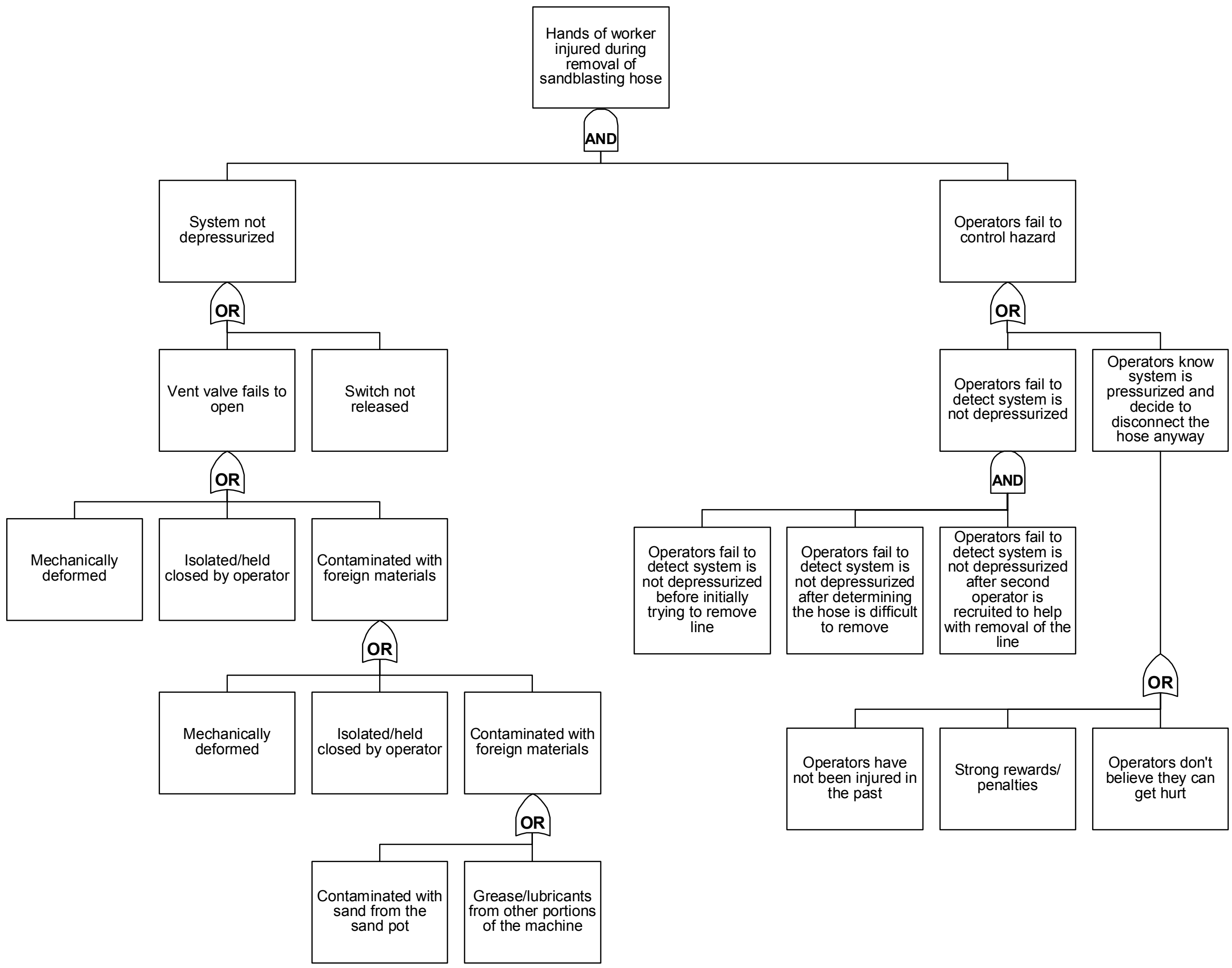
Both workers were fortunate in that their eyes and faces were not injured, and the injured worker was lucky in that his wounds did not become infected from the embedded sand.

2.3.2 Equipment Description

The sandblasting machine involved in this incident is a relatively common piece of equipment. The machine consists primarily of a pot to hold material and a flexible, 1-inch (2.5 cm) diameter blast hose to carry and direct abrasive material to the surface being cleaned. The machine is designed to be connected to a compressor and to operate at a pressure of 100 pounds per square inch (6.89 bar).

The pot can be pressurized and depressurized by the blast-hose-nozzle operator using a pneumatic deadman's switch, which controls and synchronizes the opening and closing of the air inlet and outlet valves located on the pot. When someone engages the deadman's switch to start the sandblasting process, the air inlet valve opens, the outlet valve and the pop-up valve close to seal the pot and the pressure in the pot forces sand through the blast hose. (See the fault tree in Appendix 2, Figure 5, "Sandblasting Fault Tree Example").

FIGURE 5
Sandblasting Fault Tree Example



When the switch is disengaged, the air inlet valve closes and the air outlet valve opens. This allows the pot to depressurize through the air outlet valve and the blast hose. When the pressure in the pot nears atmospheric pressure, the pop-up valve opens to allow more abrasive to be added to the pot.

In this case, the top event is "Hands of worker injured during removal of sandblasting hose." For this to occur, two general events need to occur: the system must be pressurized and the users detach the hose with the system still pressurized. Both events need to occur, so an AND gate is used. If the system fails to depressurize but the users never take the hose off, they will not get injured in the way the top event describes their injuries. If the system is depressurized when they take the hose off, they will not be injured either. So why would they disconnect the hose with the system still pressurized? The fault tree identifies two possibilities:

i) They did not detect that the system was pressurized

ii) They knew there was a hazard but decided they could disconnect the hose anyway

Data are gathered to determine which branches are true and which are not. Instead of using an electrician as was done in the first example, interviews need to be performed and the equipment looked at to determine which branches should be eliminated. In this case, multiple causes may exist. Although it may end up being necessary to train personnel on how to determine whether the system is still pressurized, they may still not know that a pressurized system poses a hazard. So it may be necessary to address both of these potential causes, not just one.

In the next branch, the event "Users knew system was pressurized and decide to disconnect the hose anyway." Why would they decide to do this? The fault tree shows three possible reasons for this:

i) The operators have disconnected the hose with the systems pressurized in the past and have not been injured,

ii) The operators have a strong motivation to believe this based on job rewards/penalties, and

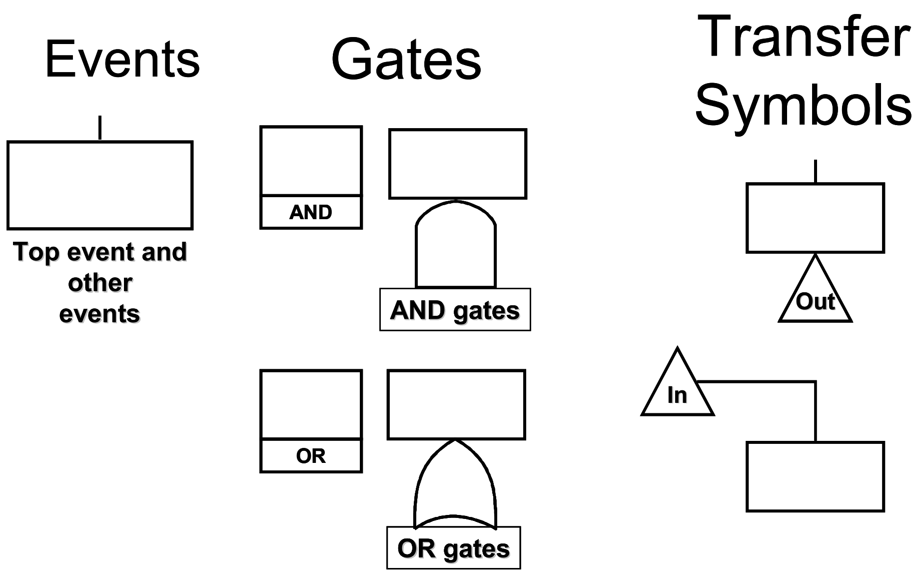
iii) The operators believe they cannot be hurt by this situation.

If the first case is true, it needs to be asked why the improper behavior has not been corrected in the past. In the second case, we need to ask why an unsafe behavior has been encouraged. In the third case, we need to change the operator's perceptions of the risk. Of course, this incident will work to change the risk perception of the injured operator, but we also need to change the risk attitudes of the other personnel.

3 Fault Tree Symbols

The basic symbols used to construct a fault tree are shown in Appendix 2, Figure 6, "Fault Tree Symbols". Different symbols can be used to draw the fault tree. For example, for the gates, graphic symbols (arrowheads and tombstones) can be used for the OR and AND gates. Alternatively, simple boxes with the words OR and AND can also be used. The transfer symbols are used to connect portions of the fault tree that span from one page to another.

FIGURE 6
Fault Tree Symbols

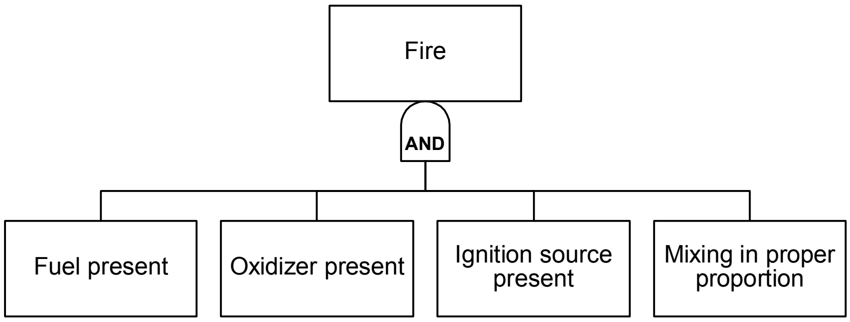


4 Using AND and OR Gates

4.1 With Multiple Elements

Use AND/OR gates when multiple elements must be present for an event to occur or a situation to exist (see Appendix 2, Figure 7, "Multiple Elements," for an example).

FIGURE 7
Multiple Elements



4.2 With Multiple Pathways

Multiple pathways (flow, pressure, current, etc.) must all be in specific states (all open, all closed or some combination) for an event to occur or a situation to exist (see Appendix 2, Figure 8, "Multiple Pathways – No Flow" and Appendix 2, Figure 9, "Multiple Pathways – Misdirected Flow" for examples).

FIGURE 8
Multiple Pathways – No Flow

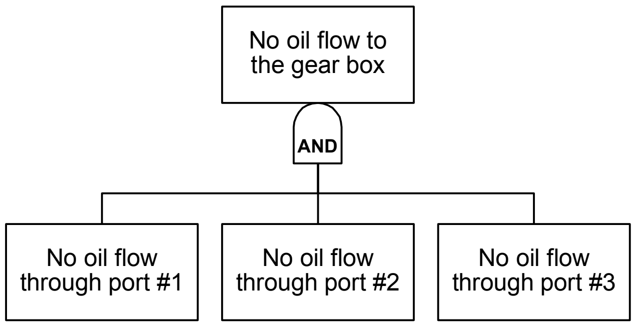
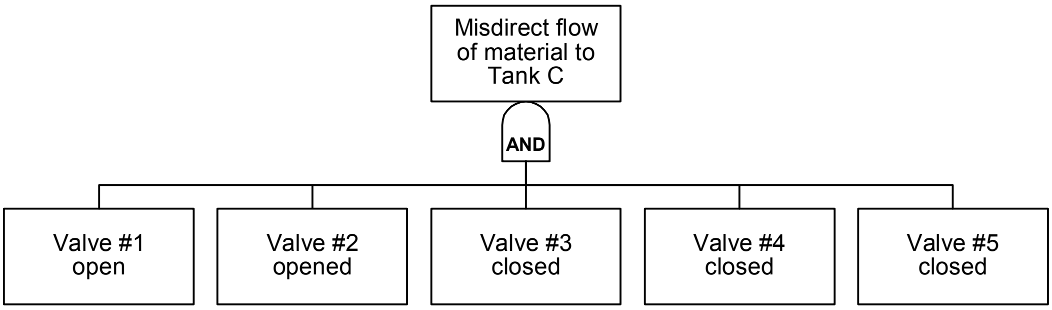


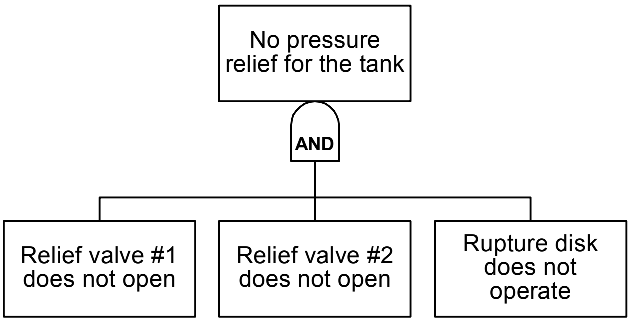
FIGURE 9
Multiple Pathways – Misdirected Flow



4.3 With Redundant Equipment Items

Redundant equipment items must all fail for an event to occur or a situation to exist (see Appendix ,2 Figure 10 "Redundant Equipment Fails," for an example).

FIGURE 10
Redundant Equipment Fails



4.4 With Safeguard Failures

Safeguards must fail for an event to occur or a situation to exist (see Appendix 2, Figure 11, "Safeguards Fail" and Appendix 2, Figure 12, "Safeguards Fail" for examples).

FIGURE 11
Safeguards Fail

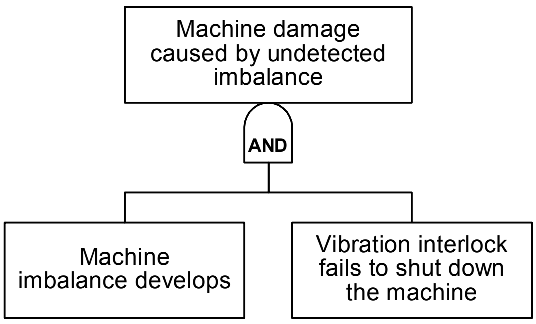
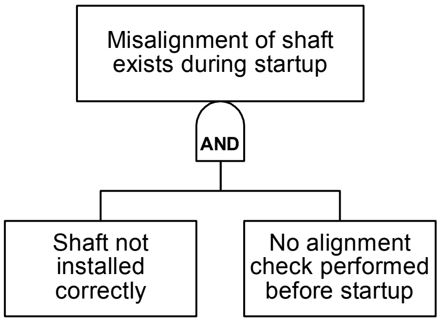


FIGURE 12
Safeguards Fail

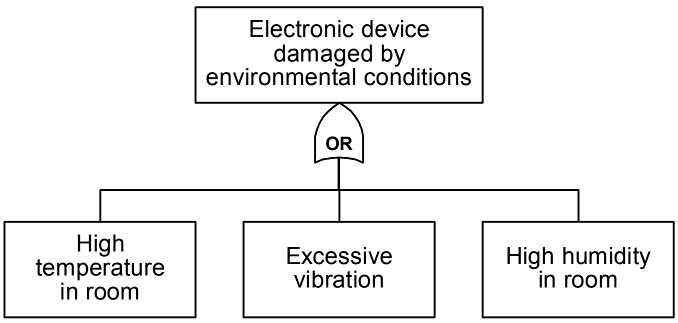


5 Using "OR" Gates

5.1 With Multiple Elements

One or more of multiple elements can cause an event to occur or a situation to exist (see Appendix 2, Figure 13, "Multiple Elements," for an example).

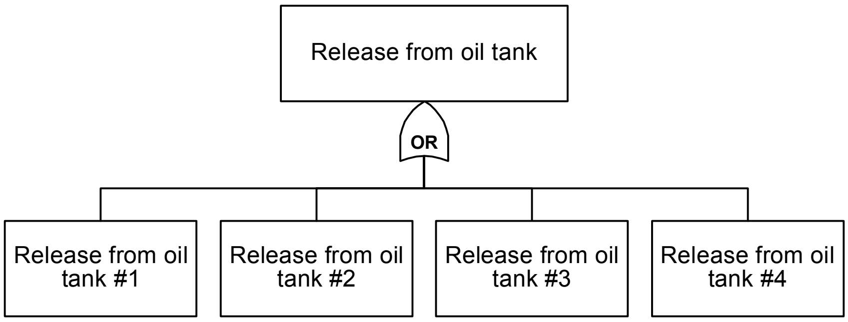
FIGURE 13
Multiple Elements



5.2 With Part Failures

Failure of one or more parts of a system causes it to fail (see Appendix 2, Figure 14 "Part Failures," for an example).

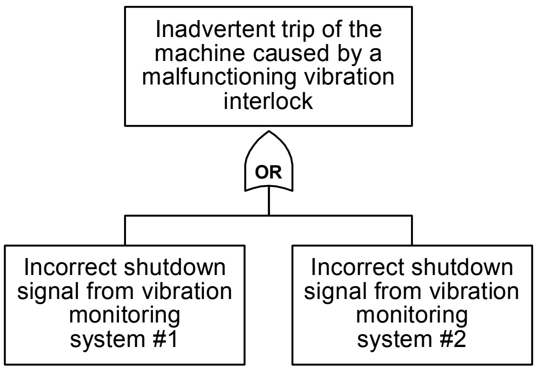
FIGURE 14
Part Failures



5.3 With Safeguard Failures

One or more of several pathways (flow, pressure, current, etc.) in a specific state (open or closed) allow an event to occur or a situation to exist (see Appendix 2, Figure 15 "Safeguard Failures," for an example).

FIGURE 15
Safeguard Failures



6 Example Fault Tree Structures

Two examples of common fault tree structures are shown in Appendix 2, Figure 16, "Common-mode Failure" and Appendix 2, Figure 17, "Human Error with Impact". The first example shows a common-mode failure. In this case, the top event is no lube oil cooling. Although there are two coolers (a primary and an emergency cooler), both coolers are supplied from Bus 1. Therefore, when that electrical bus fails, both coolers fail.

Other examples of common-mode failures include:

i) A power failure that could cause multiple pumps to fail,

ii) Loss of cooling water that could cause failure of multiple engines, and

iii) Calibration errors that can lead to multiple human errors.

These common-mode failures can be explicitly shown on a fault tree.

FIGURE 16
Common-mode Failure

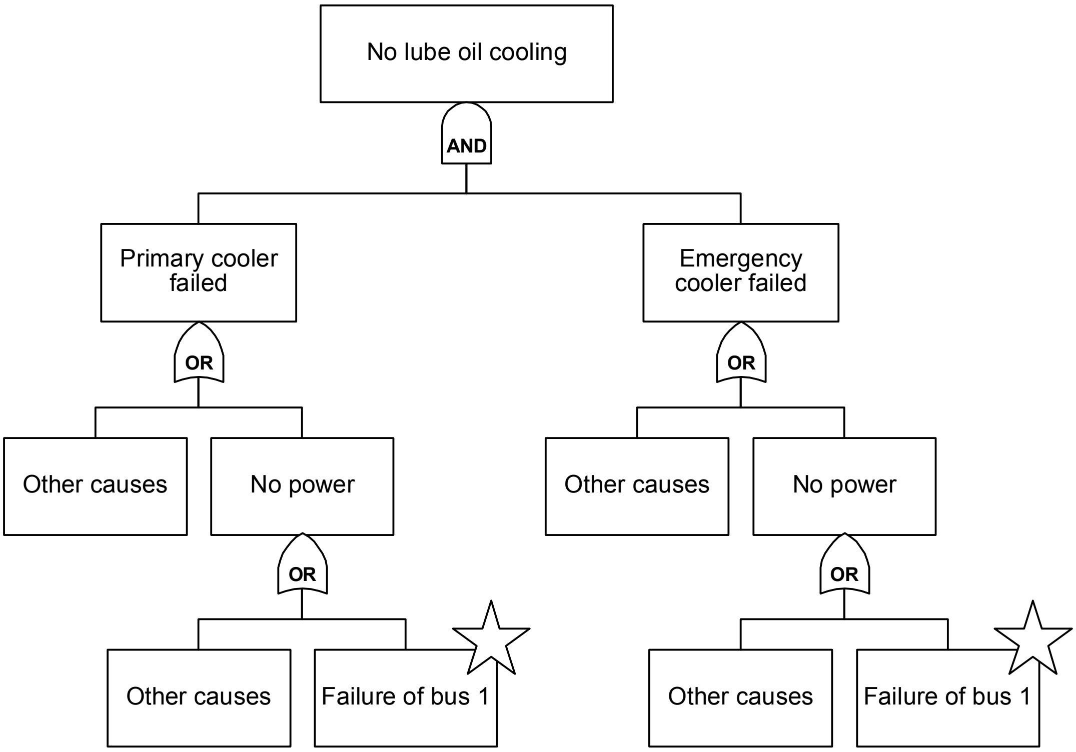
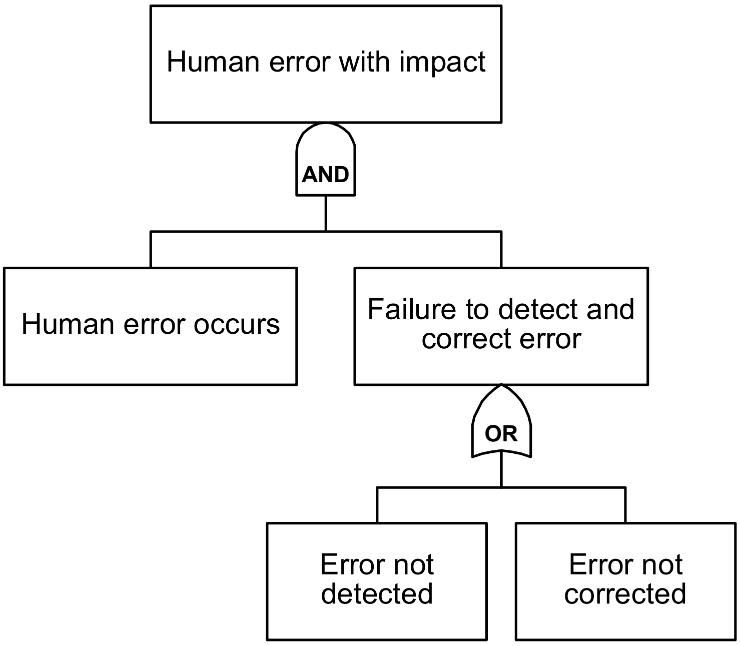


FIGURE 17
Human Error with Impact

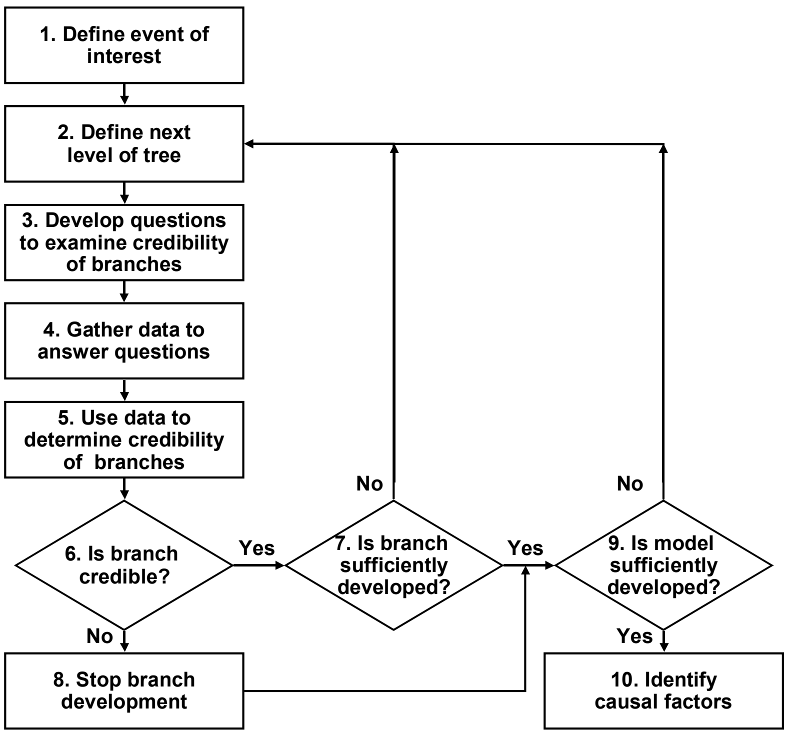


A second common structure, shown in Appendix 2, Figure 17, "Human Error with Impact", is that of a human error with impact. This tree shows that not only does the human error have to occur, but there also has to be a failure to detect or correct the error. For most human errors, safeguards exist to detect and correct the human error. For each human error, not only do we want to understand why the original error was committed, but also why the error was not detected or corrected.

7 Procedure for Creating a Fault Tree

Appendix 2, Figure 18, "Procedure for Creating a Simplified Fault Tree," shows a step-by-step process for the development of a fault tree. Examples of most of the steps are shown in subsequent figures.

FIGURE 18
Procedure for Creating a Simplified Fault Tree



7.1 Step 1: Define an Event of Interest as the Top Event of the Fault Tree

Clearly describe a specific, known event/condition of interest for which you will explore the potential underlying causes. Human errors and structural/machinery/equipment/outfitting failures (causal factors) can be the events/conditions of interest (e.g., "Flow control valve FCV-1 opened prematurely" or "The room temperature was greater than 80°F") or the loss event/condition can be the top event/condition. For a near miss, the top event can be the potential loss event/condition. It could also be an event or condition for which there is a knowledge gap in the incident model.

When using a fault tree as the primary analysis tool, the loss event/condition or potential loss event (for a near miss) is the top event/condition.

The top event/condition needs to be specifically defined because it determines the scope of the fault tree analysis. For example:

- Selecting *engine failure* as the loss event will result in focusing on the engine failure.
- Selecting *vessel grounding after engine failure* as the loss event/condition will result in focusing on the engine failure as well as the grounding incident.
- Selecting *oil release after grounding following engine failur*e as the loss event/condition will result in the investigation of all three aspects of the incident.

In order to correctly define the scope of an analysis, the loss event/condition should be selected carefully and precisely defined. A loss event/condition definition that only includes the immediate consequences results in recommendations that are fairly narrow in scope. A loss event/condition definition that also includes the subsequent consequences of the incident results in recommendations that are broader in scope.

Multiple loss events/conditions may be identified as part of a single investigation. Multiple loss events/conditions are usually needed when there are different types of consequences and/or the consequences affect different stakeholders. When this occurs, multiple fault trees may be used. In most cases, events and conditions from one fault tree will feed into others. For example, two fault trees could be developed for a vessel grounding that results in an oil spill: one for the loss of the availability of the vessel (a loss to the company) and one for the loss of the decline in the fishing capability in the area of the spill (a loss to the local fisherman). The grounding of the vessel will be part of both of these fault trees.

7.2 Step 2: Define the Next Level of the Tree

Determine the combinations of events and conditions that can cause the event/condition to occur.

- *AND Gates*. If a number of events and conditions (i.e., two or more) must occur to cause the event, use an AND gate and draw the event/conditions under the AND gate. For example, for a fire to exist, fuel, an oxygen source *and* an ignition source must all be present simultaneously
- *OR Gates*. If there are multiple potential ways for an event/condition to occur, use an OR gate. For example, the fuel for a fire can be paper, gasoline *or* grain dust.

Regardless of whether an AND gate or an OR gate is selected, this level of development should be the smallest logical step (within reason), a "baby step," toward the underlying potential causes of the event/condition above it.

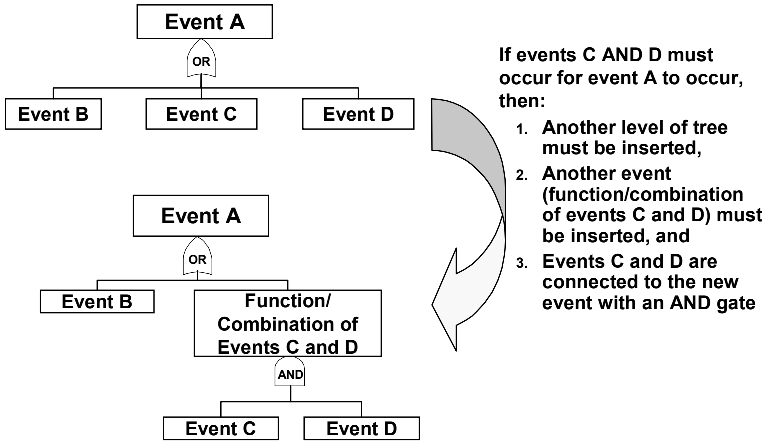
Taking too large of a step can cause you to overlook important possibilities. Try to group components or actions by function. These high-level functions allow you to take "baby steps" as you develop the tree. These small steps also allow testing of a large number of possibilities with a single test. Remember to include structural/machinery/equipment/outfitting problems, human errors and external events, as appropriate.

As each item is added to the tree, test the logic. Start with each event/condition at the bottom of the tree. Does the logic of the tree reflect your understanding of the event/condition or system?

- *Testing Gate Logic – Example 1*. If an event/condition is connected to an OR gate above, then each event/condition connected to the OR gate must be enough, on its own, to cause the event/condition above. If a combination of two or more inputs is needed, then the OR gate logic is not correct.

  For example, Appendix 2, Figure 19, "Testing OR Gate Logic," shows a fault tree with three inputs into an OR gate. After reviewing the logic, the investigator determines that Events C and D are both needed to cause Event A to occur (neither Event C or Event D can cause Event A by itself). To correct the logic, another event and an AND gate must be added to the tree, as shown in the figure.

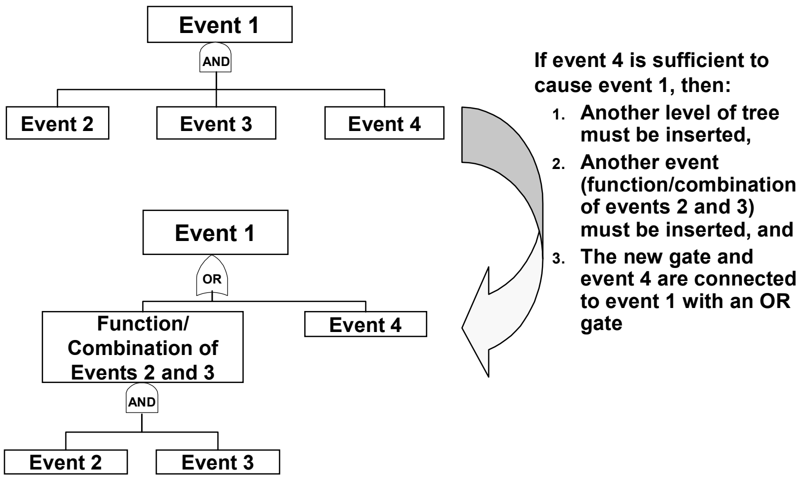
FIGURE 19
Testing OR Gate Logic



- *Testing Gate Logic – Example 2.* If an event/condition is connected to an AND gate above, all of the events/conditions connected to the AND gate must occur for the event/condition above to occur. If only one of the inputs is needed, then the AND gate logic is not correct.

  For example, Appendix 2, Figure 20, "Testing AND Gate Logic", shows a fault tree with three inputs into an AND gate. After reviewing the logic, the investigator determines that Event 4 is sufficient by itself to cause Event 1. To correct the logic, another event and an OR gate must be added to the tree, as shown in the figure.

FIGURE 20
Testing AND Gate Logic



- *When to use an AND Gate.* If faced with the following situations, an AND gate would be used in a fault tree:
  - *i)* Multiple elements must be present for an event to occur or a situation to exist.
  - *ii)* Multiple pathways (flow, pressure, current, etc.) must all be in specific states (all open, all closed or some combination) for an event/condition to occur or a situation to exist.
  - *iii)* Redundant equipment items must all fail for an event/condition to occur or a situation to exist.
  - *iv)* Safeguards must fail for an event/condition to occur or a situation to exist
- *When to use an OR Gate.* If faced with the following situations, an OR gate would be used in a fault tree:
  - *i)* One or more of multiple elements can cause an event/condition to occur or a situation to exist.
  - *ii)* Failure of one or more parts of a system causes it to fail.
  - *iii)* Any one or more of several pathways (flow, pressure, current, etc.) in a specific state (open or closed) allows an event/condition to occur or a situation to exist.

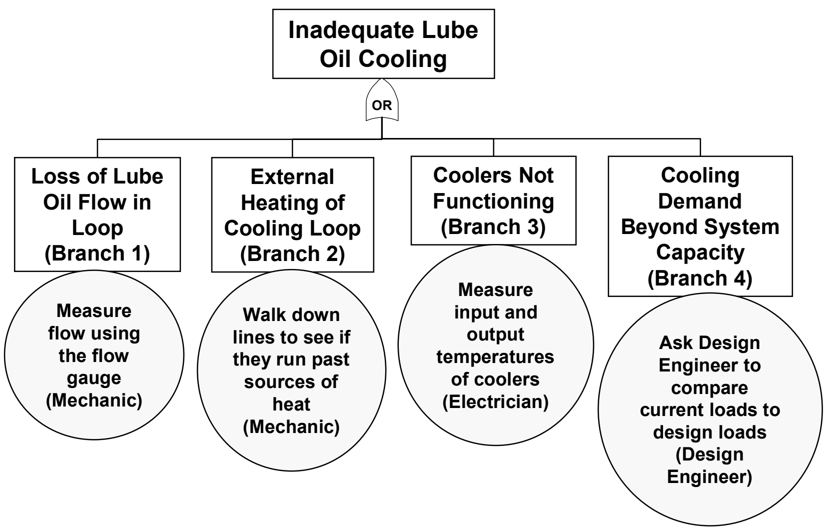
7.3 Step 3: Develop Questions to Examine the Credibility of Branches

Develop questions to test the credibility of each branch. For example: "What evidence would be present if this branch was true?" "What data should be missing if this branch was true?"

Remember, you do not have to be the subject matter expert for the analysis. Use the expertise of others to help you develop the fault tree structure and apply the data to assess each branch appropriately.

Appendix 2, Figure 21, "Testing Credibility," shows an example of the types of questions that might be generated to test the validity of four branches of a fault tree. For each question asked, a potential source(s) of the data is also identified.

FIGURE 21
Testing Credibility



7.4 Step 4: Gather Data to Answer Questions

Gather data to answer the questions that were generated in the previous step. Use the techniques in Section 4, "Gathering and Preserving Data," to perform data gathering.

7.5 Step 5: Use Data to Determine the Credibility of Branches

Use the data gathered in the previous step to determine which branches of the tree are valid (are true or happened) and which are invalid (are false or did not happen). Ask questions like:

- Do the data support or disprove the credibility of this branch?
- Do you have sufficient information to make a decision whether the branch is valid or not? If you do not, you need to gather more data or continue on to the next level of the tree.

Cross out any branches that you can dismiss with high confidence, and list the specific data used to make this determination beneath or next to the crossed-out item. If all branches leading to the event/condition through an OR gate are eliminated, or if one or more branches leading to the event/condition of interest through an AND gate are eliminated, either

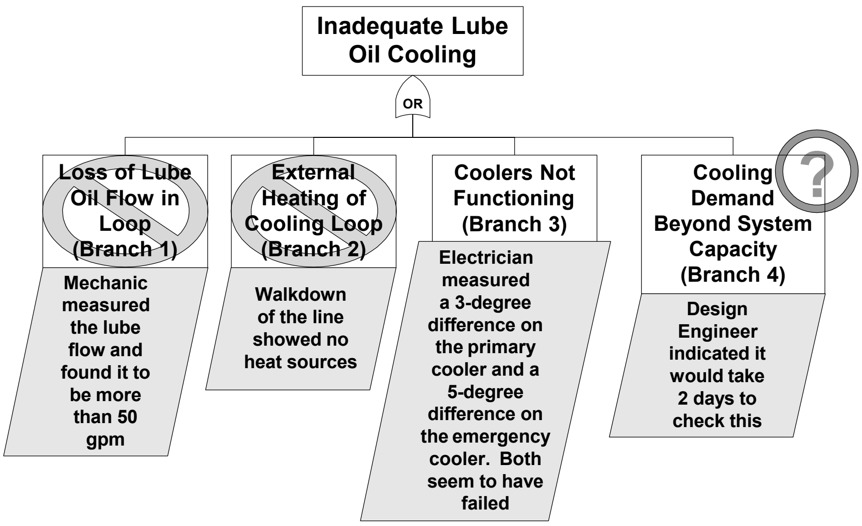
i) The event/condition of interest did not occur,

ii) Some of the data are inaccurate or were misapplied, or

iii) Other ways exist for the event/condition of interest to occur.

Appendix 2, Figure 22, "Data-gathering Results," shows a fault tree with four events. Some data have been gathered for each of the possibilities. For the first two branches, sufficient data was gathered to eliminate them. Not enough data are currently available to determine the status of the fourth branch. The Design Engineer indicated it would take two days to obtain the information. In the meantime, the data appear to support the validity of the third branch. Therefore, it will be pursued while waiting for the data from the Design Engineer.

FIGURE 22
Data-gathering Results

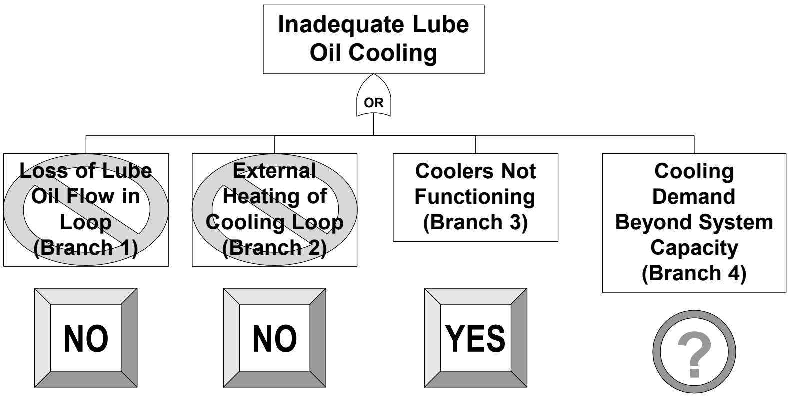


7.6 Step 6: Determine if the Branch Is Credible

Determine if the branch is credible. If the branch is credible, continue on to Step 7. If the branch is not credible, proceed to Step 8.

In the case of the fault tree in Appendix 2, Figure 23, "Determining Branch Credibility," the first two branches were not valid, so development of these branches will be stopped. The validity of Branch 4 will not be known until more data are obtained. Branch 3 appears to be a valid branch.

FIGURE 23
Determining Branch Compatibility

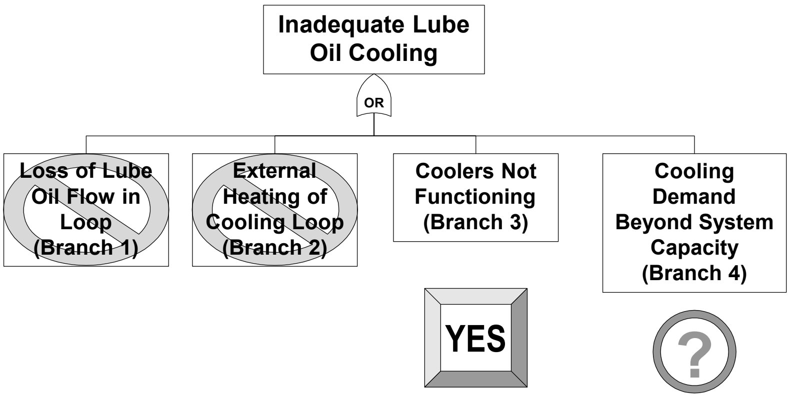


7.7 Step 7: Determine if the Branch Is Sufficiently Developed

Determine if the branch is sufficiently developed. The branch is complete when it is detailed enough to understand how the top event/condition occurred. If the branch is not complete, return to Step 2. If the branch is complete, move on to Step 9.

Appendix 2, Figure 24, "Determining Branch Development," shows the same fault tree as in the previous figure. In this case, Branches 1 and 2 will not be developed further as they are not valid. Branch 4 will not be developed until more data are obtained. For now, Branch 3 is the only one where development will continue.

FIGURE 24
Determining Branch Development

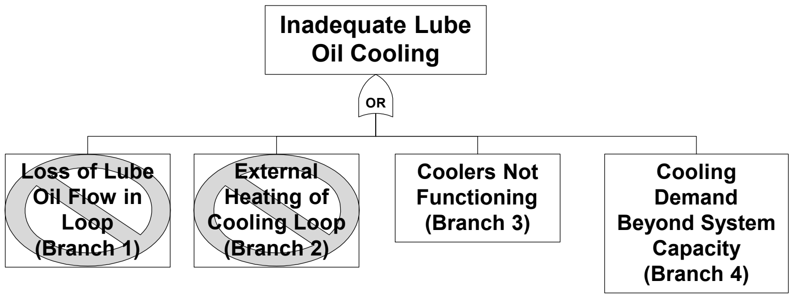


7.8 Step 8: Stop Branch Development

If you have determined that the branch is not valid, there is no reason to develop the branch further. Stop development of this branch and move on to Step 9.

Appendix 2, Figure 25, "Branch Development Results," shows the same fault tree as in the previous figure. In this case, Branches 1 and 2 will not be developed further as they are not valid.

FIGURE 25
Branch Development Results



- Development of branches 1 and 2 is stopped
- Development of branch 3 continues
- Development of branch 4 may continue, depending upon what the Design Engineer tells us

7.9 Step 9: Stop When the Scenario Model Is "Complete"

The model is complete when you have a clear understanding of how the top event/condition occurred. Keep your model "barely adequate" for identifying the issues of concern for your analysis. Avoid unnecessary detail and/or resolution that will not affect your results. If you have more than one possible way for the event of interest to have occurred and you cannot gather data to dismiss any of the remaining possibilities, you should consider each as a potential causal factor and make recommendations to prevent each possible way that the event may have occurred.

Conversely, if you have data that appear to dismiss *all* the events, then the model is not complete. Revise the model to include additional possibilities.

7.10 Step 10: Identify Causal Factors

If the fault tree method is being used as the primary analysis tool, causal factors should be identified.

8 Drawing the Fault Tree

To draw the fault tree, a very simple approach is recommended: putting Post-it notes on a large sheet of paper. Use different colors for different items on the fault tree. For example, use different colored self-stick removable (Post-it) notes for each part of the tree:

- Green for events,
- Yellow for gates,
- Pink for questions, and
- Blue for supporting data.

Using this very simple approach allows for rapid revision of the tree during the early stages and for the investigator to focus on the analysis instead of the computer program.

Once the tree is finalized or nearly finalized, it can be put into software. We recommend documenting the fault tree using a very simple Excel™ spreadsheet or the ABS Software program. (The spreadsheet can be downloaded from the ABS website at "http://www.eagle.org/rules/downloads.html" under the publication entitled "ABS *Guidance Notes the Investigation of Marine Incidents*".). This simple approach allows the results to be easily distributed to others and incorporated into reports. More importantly, almost any computer can be used to write the report because no special software is needed. With a little guidance (provided in the file), a fault tree template and a few minutes of practice, fault trees can be drawn very rapidly using this method.

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APPENDIX 3 Causal Factor Charting Details

1 Introduction

Fault tree analysis (and the 5-Whys technique) is a good analysis technique for equipment and machinery-oriented problems. Its structure works very well when dealing with the structured behavior of the equipment. However, fault trees and 5-Whys trees have one major drawback: they do not show the relative timing of events.

Timing is usually important when people are involved in incidents. It is also important in most safety and environmental incidents. Causal factor charting specifically addresses the timing of events. It also tries to incorporate some of the logic that we saw in the fault and 5-Whys trees. In other words, it tries to combine timing and logic into one technique.

Causal factor charting establishes the relative timing of events and sets the time frame of interest for the incident. It sorts the data we have (events and conditions) into the following:

i) The loss event(s),

ii) Main events and conditions,

iii) Reasons why the main events and conditions occurred or exist,

iv) Other significant events, and

v) Unimportant, insignificant events that do not affect our analysis.

Like fault tree analysis and the 5-Whys technique, it helps ensure that all data are gathered and analyzed for causal factors.

Causal factor charts are constructed by working backwards. We start with the loss event/condition and work backwards in time. This is essentially the same approach used to construct fault or 5-Whys trees. The top event in these is equivalent to the loss event in the causal factor chart. As we work backwards, building blocks (events and conditions) are added to the chart based on time and logic.

2 Causal Factor Chart Example

Appendix 3, Figure 1, "Sandblasting Causal Factor Chart Example," illustrates the form and content that such a chart takes. Note that the chart, as is standard for such charts, has four major elements. These elements are:

i) *The Main Event Line* contains the most important events. Reading the events on the main event line provides an overview of the events leading up to and causing the loss event/ condition

ii) *Events and conditions* explaining why the events on the main event line occurred. The events above the main event line explain why the events on the main event line occurred. These answer the question "Why did this happen?"

iii) *Less significant events and conditions* that help explain the loss event are located below the main event line and help put the loss event/condition in perspective. These events provide the details of the event.

iv) *The loss event(s)/condition(s)* provides the reason why the analysis is being performed. The loss event(s)/condition(s) provides a scope for the analysis.

3 Overall Causal Factor Chart Guidance

The following subsections provide hints and rules for building a causal factor chart. These hints and rules have been developed from years of experience. By following these, it will be easier to successfully build a causal factor chart and identify the causal factors as well as underlying causes. Deviating from this information could result in failure to identify one or more causal factors or associated underlying causes.

3.1 Use Different Colors for Different Types of Data

The reader may find it beneficial to use different-colored self-stick removable (Post-It) notes for different types of data. One suggested color scheme is as follows:

i) Green for events and conditions

ii) Pink for questions

iii) Blue for loss events/conditions.

3.2 Use a Simple, Flexible Format

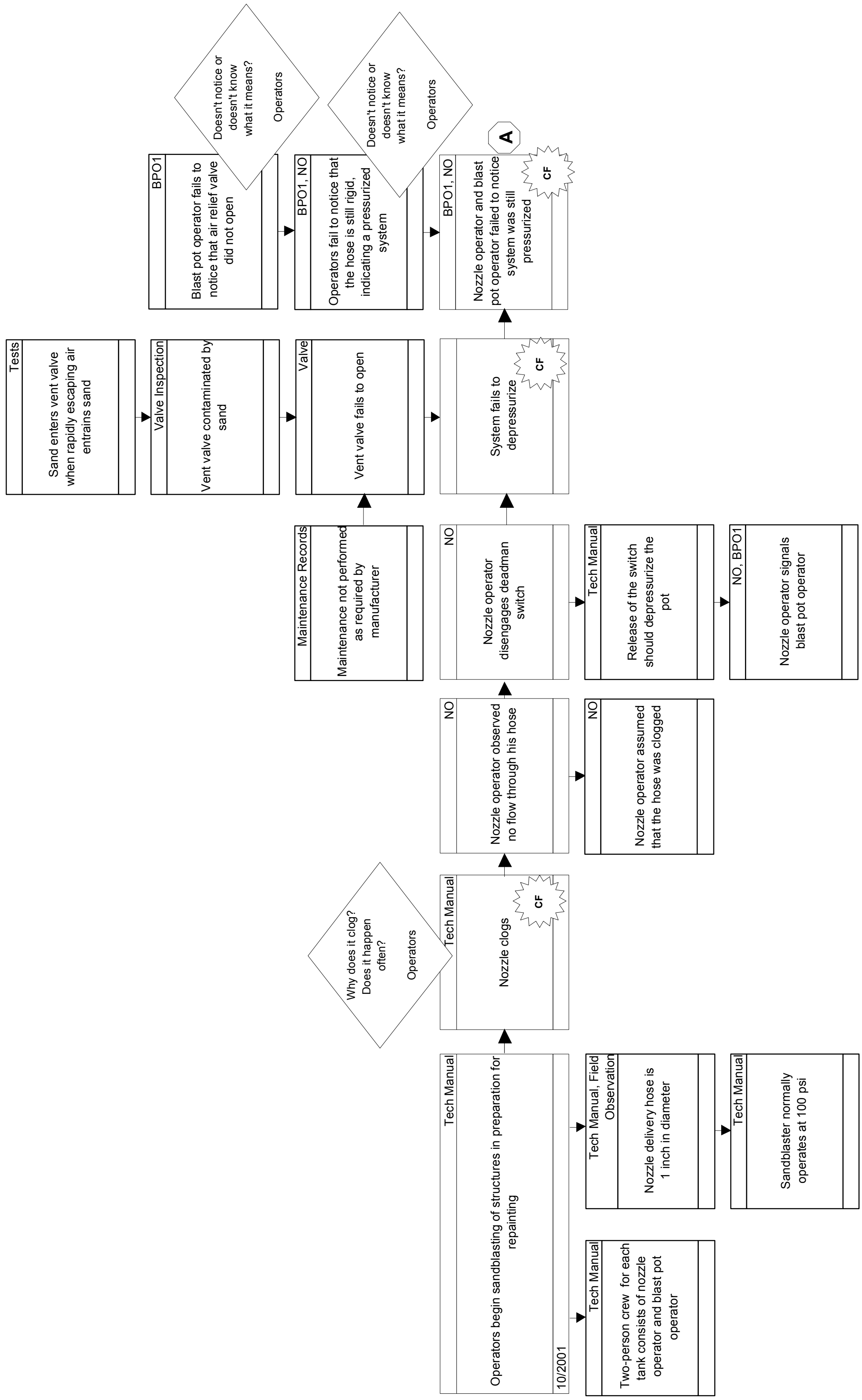
It may prove useful to develop the causal factor chart on a large sheet of paper using self-stick removable (Post-It) notes. Do not try to use a software package during the initial development of the chart. Using software will slow down the analysis. Worry about software after the analysis is complete. Once the chart is finalized or nearly finalized, it can be put into software.

A very simple Excel spreadsheet can be used to document initial thoughts and ideas. (This worksheet can be downloaded from the ABS website at "http://www.eagle.org/rules/downloads.html" under the publication entitled "ABS *Guidance Notes on the Investigation of Marine Incidents*".) Alternatively, the ABS software can be used to document a casual factor chart. This simple approach allows for results to be easily distributed to others and incorporated into reports. More importantly, almost any computer can be used to write the report because no special software is needed. With a little guidance (provided in the file), a causal factor chart template and a few minutes of practice, causal factor charts can be drawn very rapidly using this method.

3.3 Keep the Level of Detail to a Manageable Level

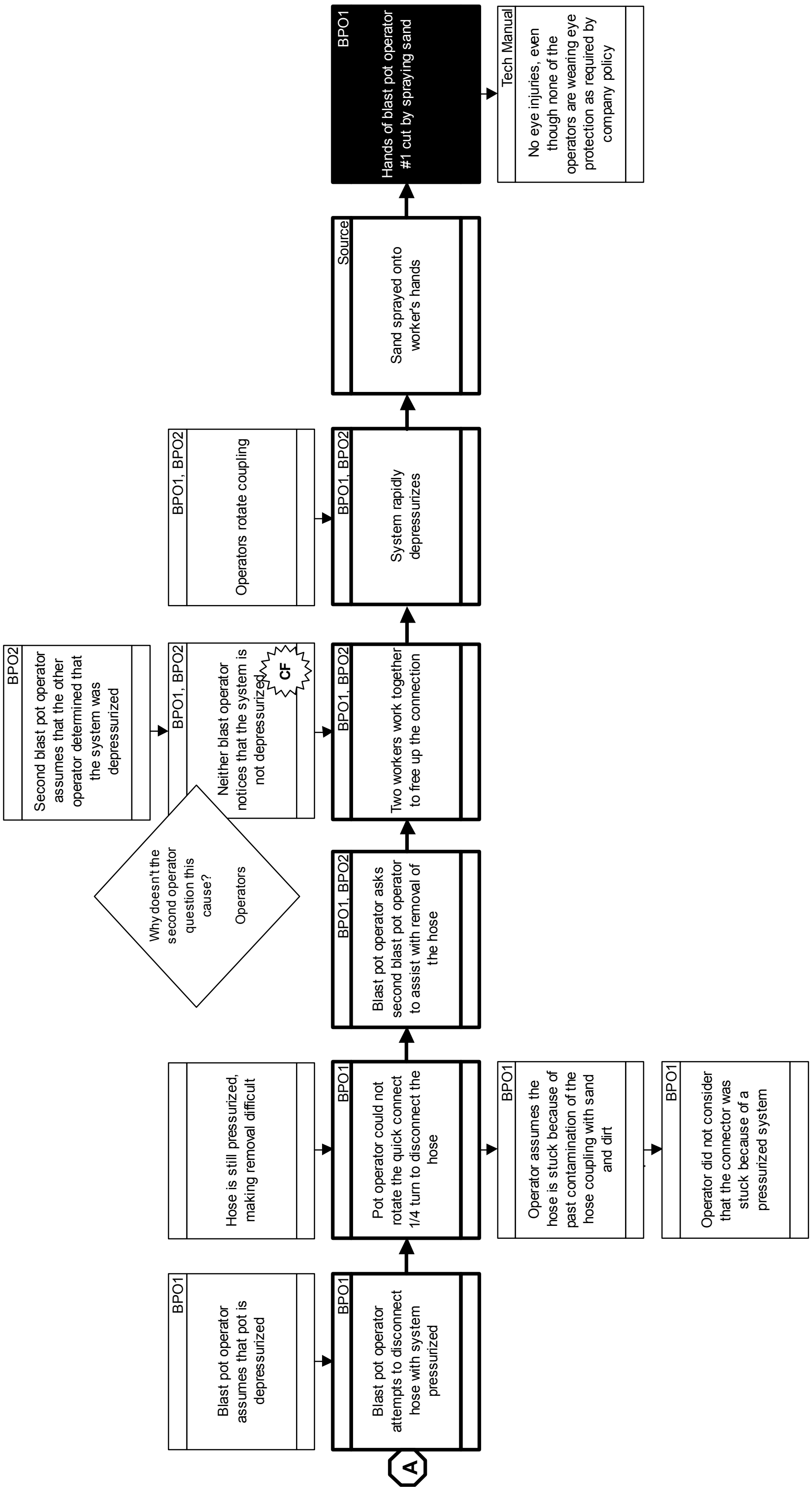
Do not add everything you know to the chart. Only add building blocks when sufficiency testing indicates the building block is needed on the chart.

FIGURE 1
Causal Factor Chart for Hand Injury During Sandblasting



CF designates Causal Factor

FIGURE 1 (continued)
Causal Factor Chart for Hand Injury During Sandblasting



4 Defining Building Blocks

4.1 Use Complete Sentences

Each building block MUST be a complete sentence. Complete sentences are needed to ensure that we are adequately describing the event/condition.

4.2 Only One Idea per Building Block

Avoid the use of the following words and phrases: and, because, that resulted in, then, as a result of, after.

4.3 Be as Specific as Possible

Ensure that each building block answers the following: who, what, where, when and how. Use quantities when they can be obtained. Specify where the event occurred. If you do not have the detailed information, generate questions to obtain this information (merely stating that "Pump 1A was destroyed" is not sufficient; include a quantification of the damage to the pump).

4.4 Document the Source for Each Event and Condition

This is helpful in detecting and resolving inconsistencies in the data that are gathered. If you do not have this information, generate questions to determine the source of the data.

5 Causal Factor Chart Construction

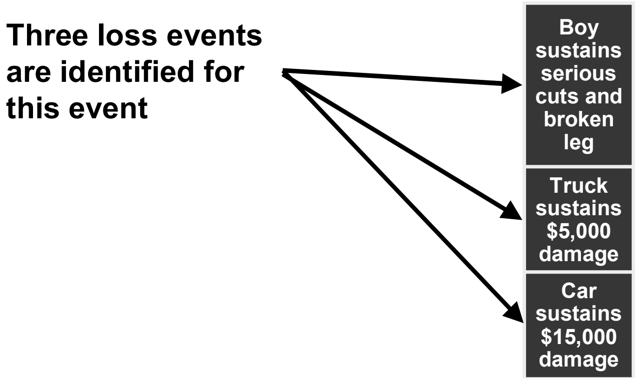
5.1 Step 1 – Identify the Loss Event(s)

Identify the loss event(s) first. Loss events can be actual or potential losses.

- If there is more than one loss event, generate building blocks for all of the loss events (use the rules for building blocks above).
- Arrange the loss events in chronological order on the main event line. If the loss events occurred simultaneously, arrange them in a vertical column on the chart.

Appendix 3, Figure 2, "Step 1 – Identify the Loss Event(s)," shows Step 1 for a causal factor chart involving a truck rolling down a hill that results in three loss events. The three loss events are shown in a vertical column because all three occurred simultaneously.

FIGURE 2
Step 1 – Identify the Loss Event(s)



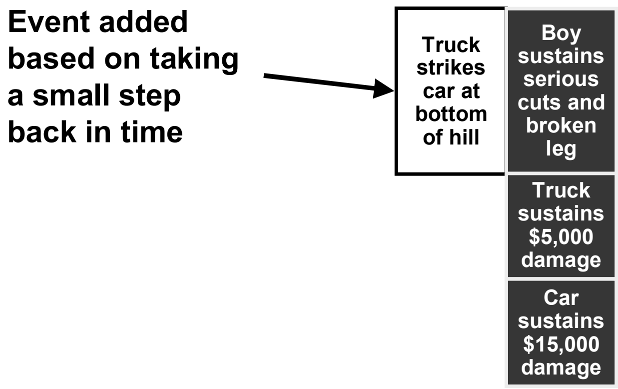
5.2 Step 2 – Take a Small Step Back in Time and Add a Building Block to the Chart

For each building block added to the chart, take a very small step back in time from the event by asking, "What happened just before this event?" The answer may be an action by a human or machinery/equipment or an external event or condition. If there are multiple choices for the size of the step backwards, take the smallest step identified.

- Use the building block rules above to create this building block.
- Add the new building block to the chart.

Appendix 3, Figure 3, "Step 2 – Take a Step Backward," shows Step 2 for the example causal factor chart. Because this is an iterative (repetitive) process, Step 2 will be used numerous times during the construction of the chart. Appendix 3, Figure 6 "Step 2 – Take a Small Step Back in Time" shows the application of Step 2 on the second iteration (repetition) after completion of Step 3 for the first time.

FIGURE 3
Step 2 – Take a Step Backward



5.3 Step 3 – Test for Sufficiency

For each new building block added to the chart, test for sufficiency of information. Using the event that was just added to the chart (Event B) and the event that appears next on the chart (Event A), ask the following three questions:

5.3.1 Question A

Does anything else have to occur or does any other condition have to be satisfied for "B" to lead to "A"?

i) If the answer is "yes," see if the additional items that have to occur are already on the chart. If they are not, proceed to Step 4. If they are already on the chart, go on to Question B.

ii) If the answer is "no," go on to Question B.

5.3.2 Question B

Are there any safeguards that should have prevented "B" from progressing to "A"?

i) If the answer is "yes," see if the additional safeguards are already on the chart. If they are not, proceed to Step 4. If they are already on the chart, go on to Question C.

ii) If the answer is "no," go on to Question C.

5.3.3 Question C

Are there other potential causes of "A" other than "B"? Can anything else cause "A" other than "B"?

i) If the answer is "yes," see if the additional causes are already on the chart. If they are not, proceed to Step 4. If they are already on the chart, go on to Step 7.

ii) If the answer is "no," go on to Step 7.

Appendix 3, Figure 4, "Step 3 – Sufficiency Testing – Question A" and Appendix 3, Figure 5, "Step 3 – Sufficiency Testing – Question B," shows the application of Question A and Question B to the example causal factor chart. In this case, Question C did not result in any additions to the chart because no other plausible explanations could be identified. Because this is an iterative (repetitive) process, Step 3 will be applied numerous times during the construction of the chart.

Appendix 3, Figure 7, "Step 3 – Sufficiency Testing – Question A" and Appendix 3, Figure 8, "Step 3 – Sufficiency Testing – Question B," show the application of Question A and Question B to the example causal factor chart during the second iteration (repetition).

Using self-stick removable (Post-It) notes labeled "Event or Condition B" and "Event or Condition A" can help keep the team focused on the proper items on the causal factor chart.

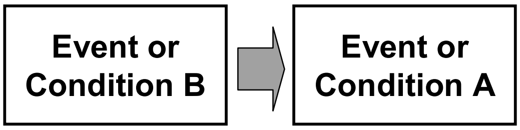


FIGURE 4
Step 3 – Sufficiency Testing – Question A

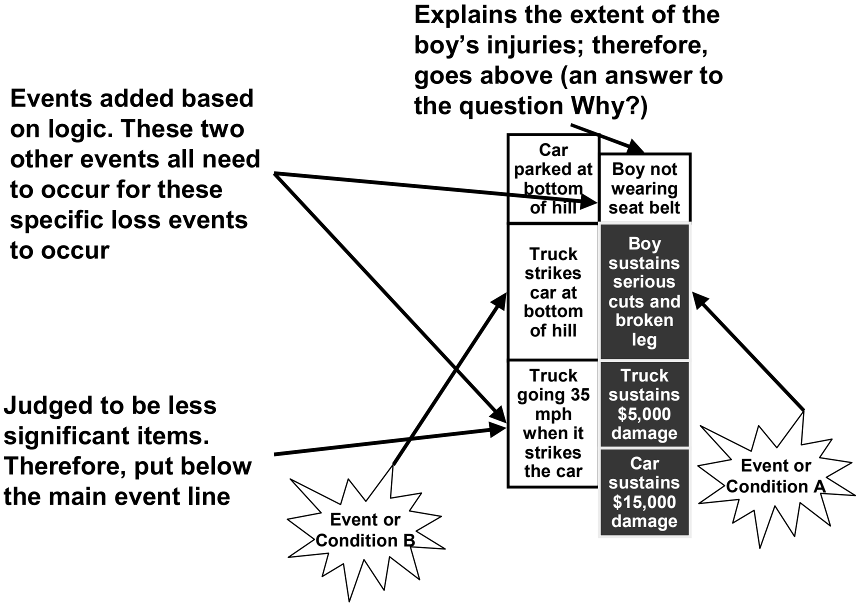


FIGURE 5
Step 3 – Sufficiency Testing – Question B

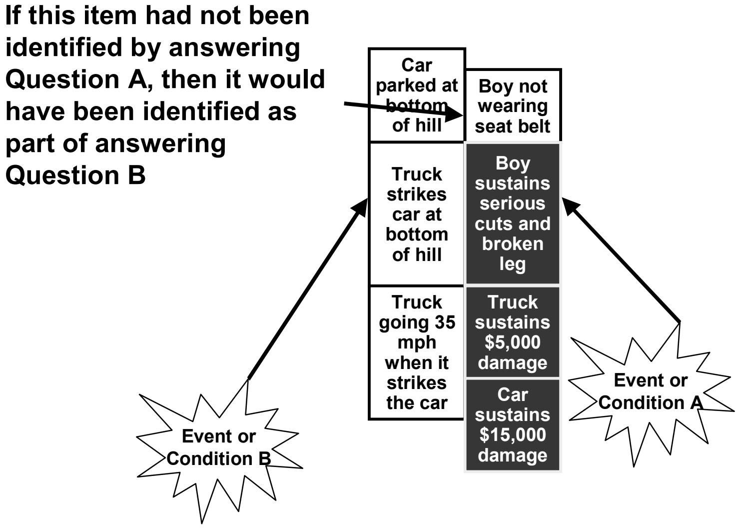


FIGURE 6
Step 2 – Take a Small Step Back in Time

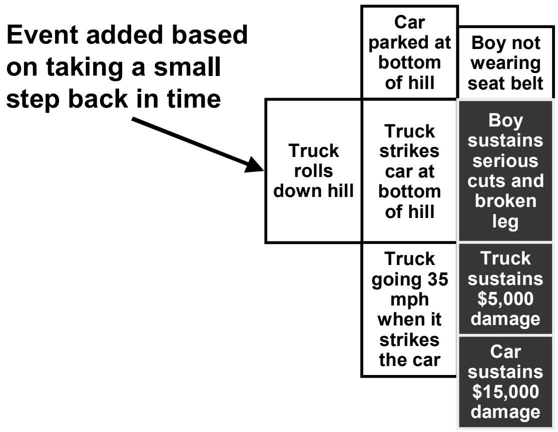


FIGURE 7
Step 3 – Sufficiency Testing – Question A

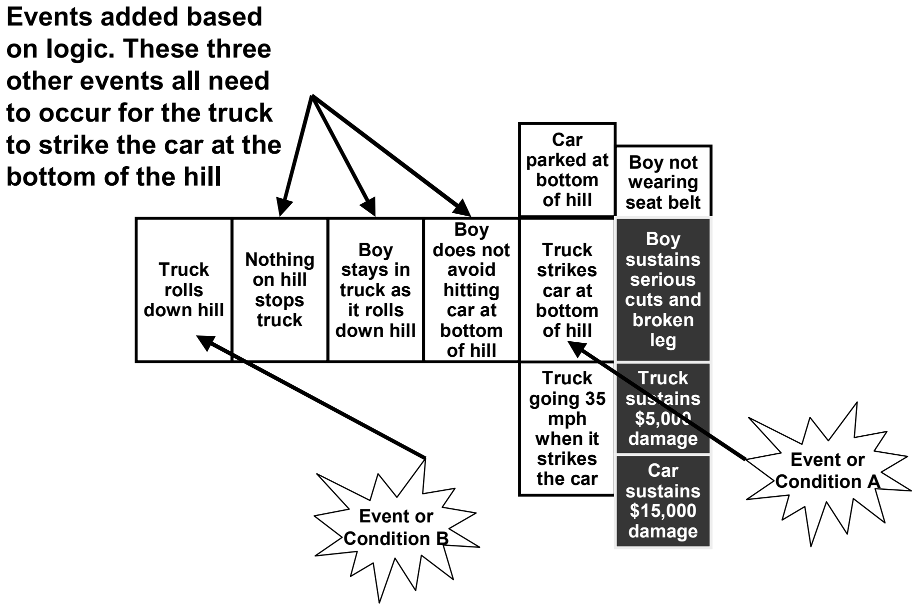
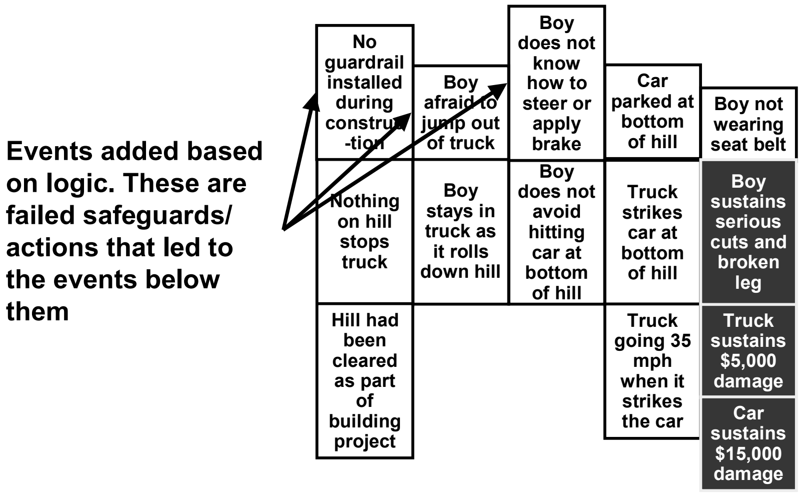


FIGURE 8
Step 3 – Sufficiency Testing – Question B

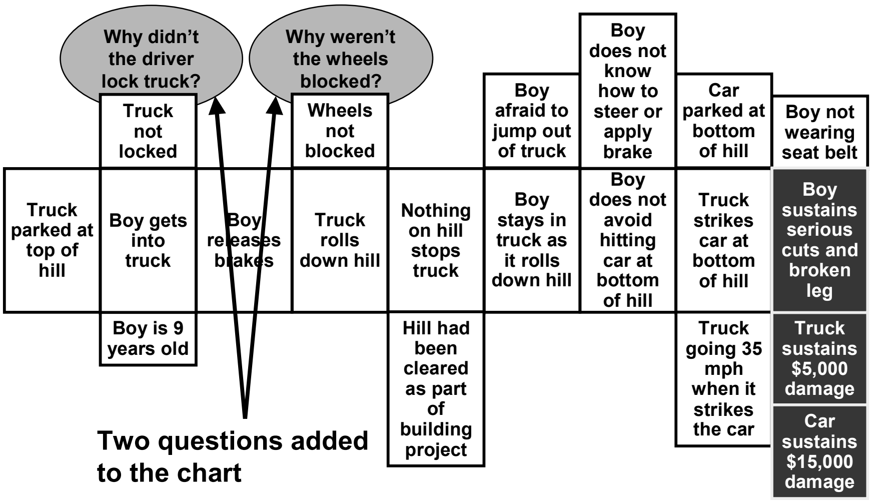


5.4 Step 4 – Generate Questions and Identify Data Sources to Fill in Gaps

Brainstorm what else would have to occur or what other conditions would have to be satisfied for "B" to lead to "A." Generate the questions or list the data needed to answer the hypothetical questions/ concerns.

Appendix 3, Figure 9, "Step 4 – Generate Questions," shows questions being added to the chart for the example causal factor chart.

FIGURE 9
Step 4 – Generate Questions



5.5 Step 5 – Gather Data

Gather data to answer the questions or address the data needs identified in Step 5. If you cannot answer a question at this point, leave it on the chart as a reminder that this information still needs to be collected. You will have to come back later and resolve this issue. In the meantime, proceed with the remainder of the steps.

5.6 Step 6 – Add Additional Building Blocks to the Chart

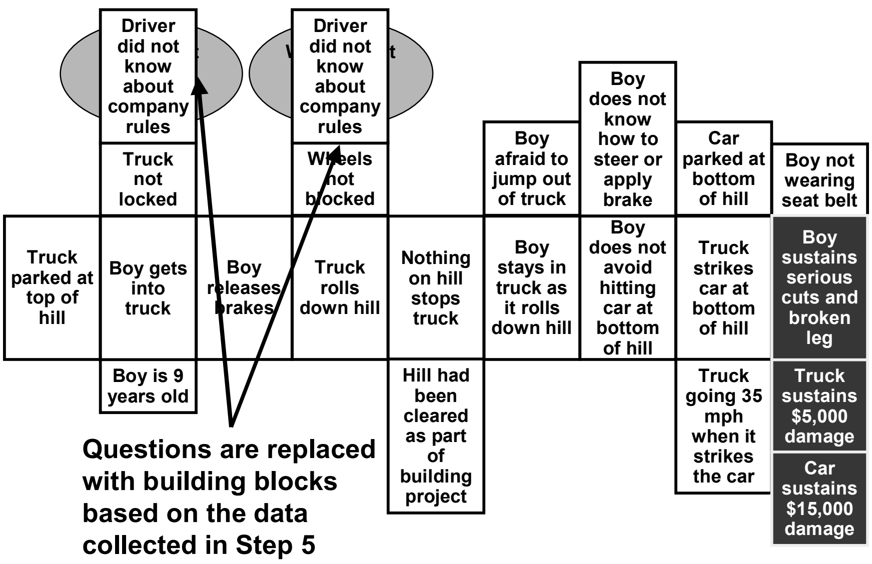
If any of the new data (events or conditions) are relevant, convert them into building-block format (described above) and insert them into the causal factor chart at the appropriate location on the timeline.

i) If the building block completely answers a question, remove the question from the chart. If it only partially answers the question, then revise the question or replace it with a new question that addresses the information that is still unknown. If you cannot answer a question, leave it on the chart to demonstrate what is still unknown.

ii) Return to Step 3 to repeat sufficiency testing until all of the questions in Step 3 can be answered "no" or all of the items have already been added to the chart.

Appendix 3, Figure 10, "Step 6 – Add Additional Building Blocks to the Chart," shows the two questions asked in Step 4 (Appendix 3, Figure 9) being replaced with answers from the data collected in Step 5. Usually the questions are just covered until the final chart is completed. This helps the team members remember the questions they have already asked as part of the analysis.

FIGURE 10
Step 6 – Add Additional Building Blocks to the Chart



5.7 Step 7 – Check to see if the Sequence of Events is Complete

Determine if the sequence of events is complete. Verify that the causes of all loss events are sufficiently described by the building blocks on the chart. If you fail to complete the chart with sufficient information, then you will run into difficulties later. When you try to perform root cause identification, you will find that you do not have sufficient information to determine the underlying causes. It is better to identify the underlying causes on the causal factor chart so that the root cause identification process will proceed more smoothly. In addition, having the information on the causal factor chart makes it easier for others to see the logical connection between the causal factors and the underlying causes. If the chart is complete, go on to Step 8. Otherwise, go back to Step 2.

5.8 Step 8 – Repeat Sufficiency Testing for all Items on the Chart

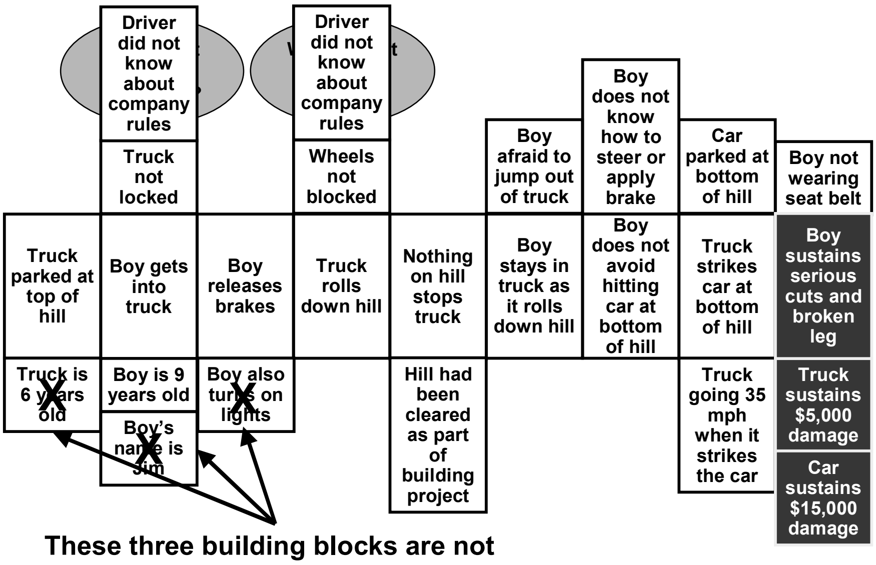
Once sufficiency testing has been completed by testing each building block pair and all data are exhausted, retest each event again. Select each building block on the chart, one at a time. Ask the following question: "What caused this event/condition?" The answers to this question must always be found on a building block on your chart. If you find yourself identifying anything that is not on the chart, then return to Step 7 to add more building blocks. If the chart meets the sufficiency test, then proceed to Step 9.

5.9 Step 9 – Perform Necessity Testing

Review the entire causal factor chart and eliminate any building blocks that are not necessary to describe the event.

Appendix 3, Figure 11, "Step 9 – Perform Necessity Testing," shows an example of performing necessity testing. Typically, necessity testing will not result in the elimination of many building blocks. If the building blocks were only added as required by the steps outlined above, very few extra building blocks should be present. In this example, three extra building blocks were added. These will be deleted as part of performing Step 9.

FIGURE 11
Step 9 – Perform Necessity Testing



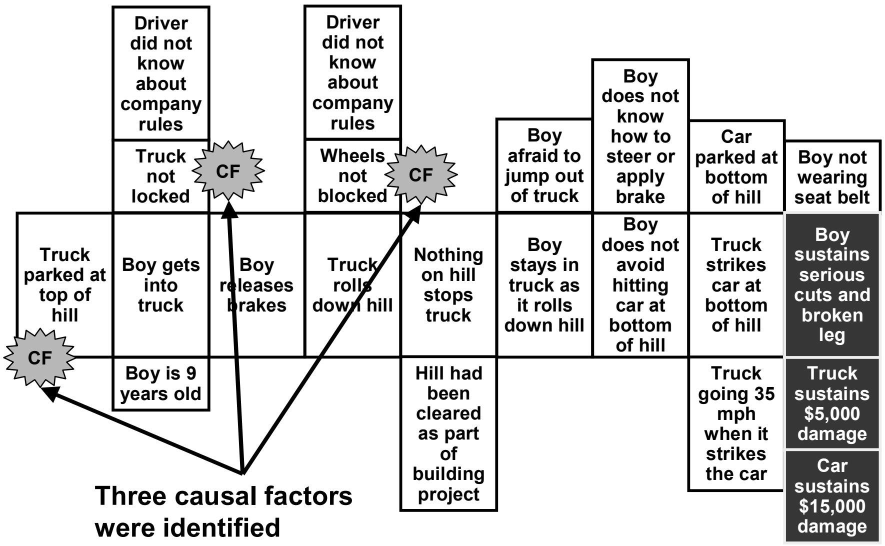
5.10 Identify Causal Factors

Find the building blocks on the causal factor chart that describe a structural/machinery/equipment/ outfitting problem, a human error or an external factor. Ensure that the building block is not describing a management system failure (i.e., ensure that the item is not a root cause or an intermediate cause). The identified negative events/conditions are candidate causal factors. Any candidate causal factor that is not dependent on another candidate causal factor is a valid causal factor.

Appendix 3, Figure 12, "Step 10 – Identify Causal Factors," shows three causal factors identified for the example causal factor chart.

Use the Causal Factor, Root Cause and Recommendation Checklist in the MaRCAT Toolkit in Appendix 7 to ensure that the causal factor meets all the required criteria.

FIGURE 12
Step 10 – Identify Causal Factors



6 Types of Building Blocks

There are four types of building blocks on the causal factor chart. Building blocks are either events, conditions, questions or loss events.

6.1 Events and Conditions

It is suggested that Events and Conditions be drawn as rectangles. Alternatively, *green* self-stick removable (Post-It) notes can be used to represent events and conditions. The following are suggestions for documenting these:

- Use complete sentences
- Be as specific as possible, ensuring that who, what, where and when are included in the description
- Include the timing of the event when known (relative or absolute)
- Underline assumed information.

6.2 Questions

It is suggested that Questions be drawn as diamonds or ovals. Alternatively, *pink* self-stick removable (Post-It) notes can be used to represent questions. The following are suggestions for documenting questions:

- When questions arise that must be resolved by gathering additional data, add them to your chart. Describe the information that needs to be obtained or the issue that needs to be resolved (i.e., "Where was Tom when he first discovered the pump vibrating?" or "Resolve inconsistencies in the navigational data from the computer and the logbook.")
- List potential sources of data that could be used to answer the question or resolve the issue. This will be helpful in guiding further data gathering.

6.3 Loss Events

It is suggested that Loss Events be drawn as reversed-text rectangles. Alternatively, *blue* self-stick removable (Post-It) notes can be used to represent these. The following are suggestions for documenting loss events/conditions:

- This is a special event or condition that describes the reason for the investigation
- The definition of the loss event scopes the investigation

  The purpose of the investigation is to determine why this event/condition occurred and to develop recommendations to prevent it from recurring.

  For near misses, this is a potential loss event.

APPENDIX 4 Marine Organizations of Interest

Worldwide, there are many regulations, rules and guidelines that may potentially govern or influence your incident investigation program. This Appendix lists some of the more broadly applicable regulations, codes, rules and guidelines.

When setting up an incident investigation program, your organization should review the appropriate governing documents to ensure your program will meet all of the applicable requirements.

TABLE 1
Regulations and Codes

Code or Regulation	*Website*
International Convention for the Safety of Life at Sea (SOLAS)	http://www.imo.org
International Convention for the Prevention of Pollution from Ships (MARPOL)	
International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)	
Convention on the International Regulations for Preventing Collisions at Sea (COLREG)	
International Convention on Load Lines (Load Lines)	
International Maritime Organization (IMO) Resolutions	
International Maritime Organization (IMO) Circulars	
International Labor Organization (ILO) Conventions	
International Safety Management Code (ISM)	
International Ship and Port Facility Security Code (ISPS)	
Port State Code	
Flag Administrations	http://www.gpoaccess.gov/cfr (USA) http://www.mcga.gov.uk/c4mca/mcga-home (UK) http://www.tc.gc.ca/ctrg-prtc/en/040.aspx (Canada) http://www.atsb.gov.au/ (Australia)

TABLE 2
Regulatory Organizations

Organization	*Website*
Accident Investigation Board of Finland	http://www.onnettomuustutkinta.fi/
Australian Transport Safety Bureau (ATSB)	http://www.atsb.gov.au/
Board of Accident Investigation, Sweden	http://www.havkom.se/
Dutch Transport Safety Board (DTSB)	http://www.rvtv.nl/
Hong Kong Marine Department	http://www.info.gov.hk/mardep/register/casualty.htm
International Maritime Organization	http://www.imo.org/
International Transportation Safety Association (ITSA)	http://www.itsasafety.org/
Marine Accident Investigation Branch, UK	http://www.maib.dft.gov.uk/
Marine Accidents Inquiry Agency, Japan	http://www.motnet.go.jp/maia/english.htm
National Transportation Safety Board, USA (NTSB)	http://www.ntsb.gov/
Transport Accident Investigation Commission, New Zealand	http://www.taic.org.nz/
Transportation Safety Board of Canada	http://www.bst-tsb.gc.ca/marinelist.html
US Coastguard Office of Investigation and Analysis	http://www.dot.gov/dotinfo/uscg/hq/g-m/moa/mao1a.htm

TABLE 3
Classification Rules

Class Society	*Website*
International Association of Classification Societies	http://www.iacs.org.uk/index1.htm
American Bureau of Shipping (ABS)	http://www.eagle.org
Bureau Veritas	http://www.veristar.com
DNV	http://www.dnv.com
Germanischer Lloyd’s	http://www.gl-group.com
Lloyd’s Register	http://www.lr.org
Korean Register	http://www.krs.co.kr/
Nippon Kaiji Kyokai	http://www.classnk.or.jp/hp/top.asp
Registro Italiano Navale	http://www.rina.org

TABLE 4
Organizations of Interest

Organization	*Website*
America Club	http://www.american-club.com/
American Waterways Operators (AWO)	http://www.americanwaterways.com
Baltic and International Maritime Council (BIMCO)	http://www.bimco.dk/
Confidential Hazard Incident Reporting Forum – Charitable Trust	http://www.chirp.co.uk/new/default.htm
Gard	http://www.gard.no/
Institute of Marine Engineering, Science and Technology	http://www.itsasafety.org/
International Association of Dry Cargo Shipowners (Intercargo)	http://www.intercargo.org/
International Association of Independent Tanker Owners (Intertanko)	http://www.intertanko.com
International Chamber of Shipping (ICS)	http://www.marisec.org/ics/index.htm
International Council of Cruise Lines (ICCL)	http://www.iccl.org
International Shipping Federation (ISF)	http://www.marisec.org/isf/index.htm
International Transportation Safety Association	http://www.itsasafety.org/
Marine Accident Investigator's International Forum (MAIIF)	http://www.maiif.net
Nautical Institute	http://www.nautinst.org/
Oil Companies International Marine Forum (OCIMF)	http://www.ocimf.com
Seafarers International Research Center	http://www.sirc.cf.ac.uk/
Shipowners P&I	http://www.shipownersclub.com/
Shiptalk	http://www.shiptalk.com/shiptalk1024.asp
Society of International Gas Tanker & Terminal Operators (SIGTTO)	http://www.sigtto.org
Society of Naval Architects and Marine Engineers	http://www.sname.org/
The Royal National Lifeboat Institution	http://www.rnli.org.uk/Home.asp
UK P&I Club	http://www.ukpandi.com

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APPENDIX 5 Acronyms and Abbreviations

°C	Degrees Centigrade
°F	Degrees Farenheit
ABS	American Bureau of Shipping
ACA	Apparent Cause Analysis
BBRM	Behavior-based Resource Management
CAR	Corrective Action Request
CD	Compact Disk
FMECA	Failure Modes, Effects and Criticality Analysis
FTA	Fault Tree Analysis
HAZOP	Hazards and Operability Analysis
HSE	Health, Safety and Environment
HVAC	Heating, Ventilation and Air Conditioning
ION	Item-of-Note
IMO	International Maritime Organization
ISM	International Safety Management
ISO	International Organization for Standardization
ISPS	International Ship and Port Facility Security
LTA	Loss Time Accident
MaRCAT	Marine Root Cause Analysis Technique
MS	Management System
OCIMF	Oil Companies International Marine Forum
PPE	Personal Protective Equipment
RCA	Root Cause Analysis
SPACs	Standards, Policies or Administrative Controls
SQE	Safety, Quality and Environment
TMSA	Tanker Management and Self-Assessment
USCG	United States Coast Guard

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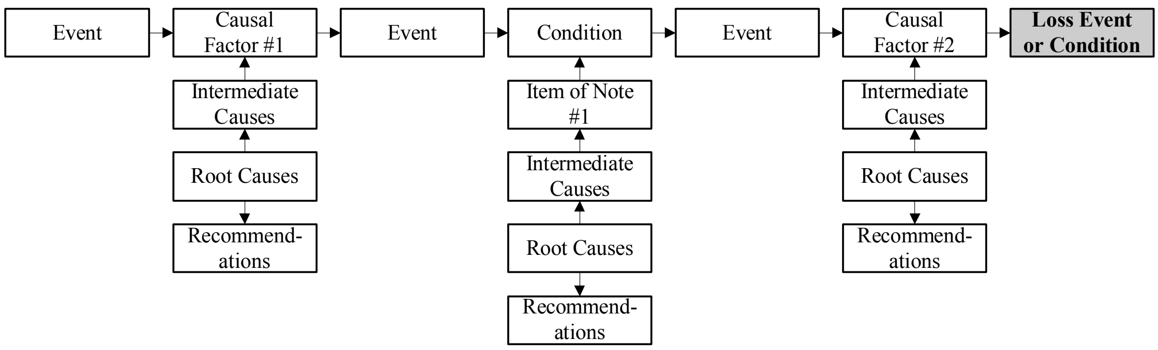
APPENDIX 6 Glossary

The same terms, relating to incident investigation, are often used differently by different organizations or sometimes within the same organization. Amongst investigators different terms may be used. For the purpose of clarity, a listing of terminology complete with definitions (complete with Notes) is provided so that the user of these Guidance Notes can better understand the information within the context in which it was created. In this Appendix, the terms are listed alphabetically to aid the reader in searching for terms within the list. Appendix 6, Figure 1, "Relationship of Incident Investigation Terms," is provided to show the interrelationship of the various terms defined here.

FIGURE 1
Relationship of Incident Investigation Terms



Accident

An incident with unexpected or undesirable consequences. The consequences may be related to personnel injury or fatality, property loss, environmental impact, business loss, etc. or a combination of these.

Apparent Cause Analysis (ACA)

An analysis that identifies the causal factors for the event and develops recommendations to address them, but does not necessarily identify the root causes of the incident.

Causal Factor

Structural/Machinery/Equipment/Outfitting problems, human errors and external factors that caused an incident, allowed an incident to occur or allowed the consequences of the incident to be worse than they might have been.

Notes:

- For a typical incident, there are multiple causal factors
- Causal factors are identified during the first stage of the analysis.
- Each causal factor is an event or condition for which steps should be taken to reduce or mitigate its occurrence.
- For each causal factor, underlying causes will be identified and recommendations will be developed.

Condition

A state of being.

Notes:

- Includes process states, such as pressure, temperature, composition and level. Also includes the state of training of an employee, the condition of supplies and cargo and the state of equipment/structure/outfitting. If negative, then it can be a causal factor, intermediate cause or root cause.
- These typically include passive verbs such as "was" and "were". No time is typically associated with a condition.

Consequences

Undesirable or unexpected outcomes may result in negative effects for an organization. These consequences can range from minor injuries to major events involving loss of life, extensive property loss, environmental damage, and breaches related to security.

Notes:

- Negative effects can include property damage or loss, personnel injury or illness, spills, loss of marine commerce, loss of reputation, etc. Consequences can be of different magnitudes. For example, grounding can result in no damage to the vessel and just a short delay in completing the voyage. Another grounding can result in hull damage and a large release of cargo. The same level of effort may be put into investigating these two incidents, the first based on the potential consequences (a near miss) and the second based on the actual consequences (an accident).
- The consequences and potential consequences of the incident should determine the level of effort to invest in the analysis.

Event

A happening caused by humans, automatically operating equipment/components, external events or the result of a natural phenomenon.

Note: Event descriptions typically include action verbs such as walked, turned, opened, said, radioed, discovered, decided, saw, etc. If negative (an error, failure or external factor), then the event may also be a causal factor, intermediate cause or root cause.

External Factors

Issues outside the control of the organization. Examples include uncharted/unknown hazards to navigation, some sea or weather conditions, suicides or homicides and external events.

Human Errors

Performance of humans that deviates from the desired performance.

Notes:

- This definition is not a failure to perform as directed, but failure to perform as desired. An individual can follow the procedure precisely and still perform a human error, because the individual does not perform as desired (i.e., there is a gap between actual and desired performance). In this situation, the procedure specifies the incorrect method for performing the task.
- Human errors that are causal factors are might be performed by frontline personnel on the vessel. Human errors performed by support organizations and management are commonly classified as root causes.

Incident

An unplanned sequence of events and/or conditions that results in, or could have reasonably resulted in, a loss event.

Notes:

- This definition includes both accidents and near misses (defined below).
- Incidents are a series of events and/or conditions that contain a number of structural/machinery/equipment/outfitting problems, human errors, external factors, as well as positive actions and conditions.
- An incident can be depicted using a timeline that includes the events and conditions that occurred during the incident. However, it also includes information about the context in which the events and conditions were performed.

Intermediate Cause

An underlying reason why a causal factor occurred, but it is not deep enough to be a root cause.

Note: Intermediate causes are underlying causes that link causal factors and items-of-note to root causes.

Item-of-Note (ION)

A deficiency, error or failure that is not directly related to the incident sequence that is discovered during the course of the investigation.

Note: IONs are usually at the causal factor or intermediate cause level. IONs are similar to audit findings. If left uncorrected, these IONs may become causes of future incidents. Underlying causes and recommendations can be developed for IONs as part of the investigation. Some organizations assign responsibility for causal analysis of IONs to the individual departments.

Loss Event

Undesirable consequences resulting from events or conditions or a combination of these.

Notes:

- Loss events will appear as statements within fault trees, 5-Why trees or causal factor charts. They are developed by the investigator/investigation team to define the scope of the investigation or analysis.
- The way the loss event is stated and understood will define the scope of the incident analysis. For example, selecting engine failure as the loss event will result in focusing on the engine failure. Selecting vessel grounding after engine failure as the loss event will result in focusing on the engine failure as well as the grounding incident. Selecting oil release after grounding following engine failure as the loss event will result in the investigation of all three aspects of the incident. Because of this, the loss event should be stated carefully and be precisely defined. A loss event definition that only includes the immediate consequences results in recommendations that are fairly narrow in scope. A loss event definition that also includes the subsequent consequences of the incident results in recommendations that are broader in scope.
- Multiple loss events may be identified as part of a single investigation. Multiple loss events are usually needed when there are different types of consequences and/or the consequences affect different stakeholders.
- Consequences of loss events can be realized immediately, or they can be delayed (for example, future expenses incurred during repairs and costs of lost time of a vessel in service).

Management System (MS)

A system put in place by management to encourage desirable behaviors and discourage undesirable behaviors.

Note: Examples of management system elements include policies, procedures, training, communications protocols, acceptance testing requirements, incident investigation processes, design methods and codes and standards. Management systems strongly influence the behavior of personnel in an organization.

Near Miss

i) An incident with no consequences, but that could have reasonably resulted in consequences under different conditions.

OR

ii) An incident that had some consequences that could have reasonably resulted in much more severe consequences under different conditions.

Notes:

- An incident can be both an accident and a near miss, an accident because it has immediate consequences, but also a near miss because the incident could have resulted in more severe consequences.
- Everyone in the organization needs to have an understanding of how near misses are defined by the organization so that they can report appropriate incidents that meet the definition. An incident can not be investigated if it is not reported. Examples of what is and what is not a near miss are usually required. To define a event that “almost was” is difficult, but near misses can be operationally defined, for example, a near miss can be operationally defined as:

- Passing a ship or fixed structure by 50 meters
- Touching soft bottom without grounding or stranding
- Restarting a lube oil system before vital system damage or failure occurs.

- It should be evident that there are very many possible operational definitions for a near miss. More global definitions are more easily achievable, such as:
  - An unexpected deviation from a passage plan
  - A period of operations where emergency or unusual rapid action is required
  - An event that, under more usual circumstances would have resulted in a loss

Problem

Performance related to Structural/Machinery/Equipment/Outfitting that deviates from the desired performance of the item.

Note: The definition is not failure to perform as designed, but failure to perform as desired. This means that items can perform as designed and still fail or be degraded because it fails to perform as desired. By defining failures in this way, structural/machinery/equipment/outfitting design issues can cause failures/degradations.

Recommendation

A suggestion to develop, modify or enhance management systems or safeguards.

Note: Recommendations can be made to address the causal factor, intermediate cause and/or root cause levels of the incident. Recommendations are the most important product of the analysis. They are what will be implemented to change the organization's behavior and prevent recurrence of the incident or to minimize the consequences of the incident.

Resolution

The disposition of a recommendation.

Note: Often, recommendation resolution results in implementation of the recommendation. However, resolution could also result in implementing an alternate recommendation or no action at all.

Root Cause

Deficiency of a management system that allows the causal factors to occur or exist.

Notes:

- Root causes must be within the control of management to address. For a typical causal factor, there are one to four root causes.
- Root causes are usually as deep as a typical root cause analysis will go in attempting to identify the underlying causes of an incident. Organizational culture issue, which are deeper than root causes, could also be identified and addressed, but most root cause analyses do not go to this level because developing effective recommendations at the organizational culture level may be difficult.

Root Cause Analysis (RCA)

An analysis that identifies the causal factors, intermediate causes and root causes of an incident and develops recommendations to address each level of the analysis.

Safeguard

A physical, procedural or administrative control that prevents or mitigates consequences associated with an incident.

Note: These are physical, procedural and administrative systems controlled by the organization's management systems. For example, a design process (the management system) will result in installation of dual electric generators (the safeguard). The procedure development process (the management system element) will result in a procedure on how to perform vessel loading of fuel (the safeguard).

Structural/Machinery/Equipment/Outfitting Problems

Structural/Machinery/Equipment/Outfitting performance that deviates from the desired performance of the item.

Note: The definition is not failure to perform as designed, but failure to perform as desired. This means that items can perform as designed and still fail or be degraded because it fails to perform as desired (i.e., there is a gap between actual and desired performance). By defining failures in this way, structural/machinery/equipment/outfitting design issues can cause failures/degradations.

APPENDIX 7 MaRCAT Toolkit

This Appendix, the MaRCAT Toolkit, contains a number of different resources for use by the investigator and/or the investigation team. .The toolkit includes data collection and analysis forms, checklists and summary guidance. The various materials presented here can be downloaded in electronic form from the ABS website at "http://www.eagle.org/rules/downloads.html" under the publication entitled "ABS *Guidance Notes on the Investigation of Marine Incidents*".

1 General Resource Materials

- Investigation Tools Checklist
- Simple Investigation Plan Form
- Detailed Investigation Plan Form
- Team Leader Responsibilities Checklist
- Meeting Notes Form

2 General Data Gathering Resource Materials

- Investigator's Log Form
- Initial Call Checklist
- Data Needs Form
- Data Needs Checklist
- Initial Incident Scene Tour Checklist
- Post-Tour Checklist
- Open Issues Log Form

3 People Data Gathering Resource Materials

- Contacts Form
- Meetings Attendees Form
- Interview Scheduling Form
- Initial Witness Statement Form
- Interview Preparation Guidelines
- Interview Guidelines
- Interview Documentation Form

4 Data Control Resource Materials

- Data Log Form
- Data Correspondence Log Form
- Data Checkout Log Form

5 Physical Data Gathering Resource Materials

- Test Plan Form - Parts Analysis
- Test Plan Form – Sample/Chemical Analysis

6 Paper Data Gathering Resource Materials

- Paper Chart Data Collection Guidelines

7 Position Data Gathering Resource Materials

- Position Data Form
- Photography Guidelines – Stills
- Photography Guidelines – Video
- Photographic Record Form

8 Data Analysis Resource Materials

- 5-Whys Worksheet
- Root Cause Summary Table Form
- Causal Factor, Root Cause and Recommendation Checklist
- Recommendation Tracking Summary Form
- Management Resolution of Recommendations
- Change Analysis Worksheet
- HAZOP Worksheet

9 Report Resource Materials

- Incident Investigation Report Form
- Report Checklist
- Report Comment Form
- Report Routing Form

10 Investigation Resource Materials

- Investigation Checklist
- Incident Investigation/Root Cause Analysis Program Evaluation Checklist

11 Causal Factor Charts, 5-Whys and Fault Trees Resources

A simple Excel template for documenting causal factor charts and fault trees can be found on the ABS website at “http://www.eagle.org/rules/downloads.html” under the publication entitled “ABS *Guidance Notes on the Investigation of Marine Incidents*”.

Means for creating causal factors charts, 5-Whys and fault trees is provided in an Incident Investigation/Root Cause Analysis software tool available from ABS.

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Investigation Tools Checklist

Incident Number		Incident Date and Time	/ /	
Incident Title:				

Item No.	Description	Number	Color	Quantity	Packed?
1	**Forms (following forms with multiple copies**):**	**Number**	**Color**	1 Package	
	Detailed Investigation Checklist	15	White		
	Pocket Guide	15	Green		
	Data Log Form	5	Salmon		
	Interview Scheduling Form	5			
	Investigator's Log	5	Gold		
	Initial Witness Statement Form	15	Blue		
	List of Contacts	3	Pink		
	Test Plan Form – Parts Analysis	5			
	Data Needs	5			
	Test Plan Form – Sample/Chemical Analysis	5			
	Avery 5160 label sheets	4			
	Photographic Record Form	15	Yellow		
	Meeting Notes Form:	5	Green		
2	Root Cause Maps ___A3 (11 X 17) text only version: 5 copies ___Color version: 2 copies			1 Package	
3	ABS Guidance Notes on the Investigation of Marine Incidents			1	
4	Electronic data storage means (e.g., floppy discs, blank CDs, thumb drive)			As required	
5	Digital camera (in camera bag)*			1	
6	Extra batteries for the digital camera (in camera bag)*			8 AA	
7	Serial cable to connect digital camera to laptop computer (in camera bag)*			1	
8	Memory modules for digital camera (in camera bag)*			2	
9	128 mb Flash card for digital camera (in camera bag)*			2	
10	Self-stick removable (Post-it) Notes 73 mm × 73 mm (3" × 3"), blue			3 packages	
11	Self-stick removable (Post-it) Notes 73 mm × 73 mm (3" × 3"), green			6 packages	

Investigation Tools Checklist (continued)

Item No.	Description	Quantity	Packed?
12	Self-stick removable (Post-it) Notes 73 mm × 73 mm (3” × 3”), yellow	3 packages	
13	Self-stick removable (Post-it) Notes 73 mm × 73 mm (3” × 3”), pink	2 packages	
14	Self-stick removable (Post-it) Notes 73 mm × 123 mm (3” × 5”), yellow	2 packages	
15	Self-stick removable (Post-it) Notes 34.9 mm × 47.6 mm (1½” × 2”), yellow	2 packages	
16	Self-stick removable (Post-it) Notes 34.9 mm × 47.6 mm (1½” × 2”), blue	2 packages	
17	Self-stick removable (Post-it) Notes Arrows	2 packages	
18	Dry-erase pen (medium tip), blue	2	
19	Dry-erase pen (wide tip), blue	2	
20	Dry-erase pen (medium tip), black	2	
21	Dry-erase pen (wide tip), black	2	
22	Dry-erase pen (medium tip), red	2	
23	Dry-erase pen (wide tip), red	2	
24	Highlighter (wide tip), yellow	2	
25	Highlighter (wide tip), green	2	
26	Highlighter (wide tip), blue	2	
27	Highlighter (wide tip), pink	2	
28	Graph paper A4 (8½” × 11”)	2 pads	
29	Lined paper A4 (8½” × 11”)	2 pads	
30	Isometric graph paper	1 pad	
31	Binder clips, small	1 box	
32	Binder clips, medium	1 box	
33	Binder clips, large	5	
34	Rubber bands	Various	
35	Mechanical pencil	2	
36	“Lead” suitable for mechanical pencil	1 container	
37	Large eraser	1	
38	Ballpoint pen, blue	2	
39	Ballpoint pen, red	2	
40	Ballpoint pen, black	3	

Investigation Tools Checklist (continued)

Item No.	Description	Quantity	Packed?
41	Permanent felt-tipped pen (medium tip), blue	2	
42	Permanent felt-tipped pen (medium tip), red	2	
43	Permanent felt-tipped pen (medium tip), black	2	
44	Blank adhesive labels 50 mm × 90 mm (2” × 3½”) for floppy disks	20	
45	Flip chart paper, folded	10 sheets	
46	Assorted pieces of felt (for picture taking): white, beige, black	Large & Small	
47	Small Scissors	1	
48	Small mirror, folding	1	
49	Small mirror (e.g., Boy Scout mirror)	1	
50	Stapler with additional staples	1	
51	Tape measure 30 m (100 ft)*	1	
52	Retractable tape measure 7.5 m (25 ft)*	1	
53	Straight-edged ruler 150 mm (6-inch), plastic	1	
54	Straight-edged ruler 150 mm (6-inch), metal	1	
55	Package of large latex gloves*	2 packages	
56	Heavy work gloves*	2 pair	
57	Clear plastic evidence bags, large – 1 liter (2.5 gallon) self-closing plastic bags*	10	
58	Clear plastic evidence bags, medium – 0.5 liter (1 gallon) self-closing plastic bags*	10	
59	Masking tape	1 roll	
60	Transparent tape	1 roll	
61	Multipurpose clipboard, plastic*	1	
62	75 mm (3-inch) blade pocket knife	1	
63	Calipers (inside and outside measurements)	1	
64	Waist pack, black	1	
65	Flashlight (explosion proof), 3 cell with grommet for lanyard*	2	
66	Batteries for flashlight (D size)*	4 sets of 2	
67	Breakaway lanyards for clipboard and flashlight*	3	

Investigation Tools Checklist (continued)

Item No.	Description	Quantity	Packed?
68	Incident investigation data/evidence tags*	20 (w/ties)	
69	Investigator's Business cards	20 each	
70	Software – ABS Incident Investigation Root Cause Analysis Software – Excel templates for causal factor charts and fault trees	 1 each 1 each	

*Items in field bag, all others in rolling bag
**Items in clipboards

Checklist completed by: ________________________________ *Date completed:* _______/_______/_______

Simple Investigation Plan Form

Incident Number		Incident Date and Time	/ /		
Incident Title					
Budget		Charge No.		Report Due	/ /
Team Leader		Phone No.		Fax No.	

Role	Individual	Notes
Team leader		
Investigation techniques		
Navigation/Operations expertise		
Machinery/Engineering expertise		
Maintenance (mechanical, electrical, instrumentation and controls)		
Structural engineering/support		
Chartering issues/customer interface		

Simple Investigation Plan Form (continued)

Role	Individual	Notes
Regulatory interface		
Media interface		
Restart/voyage resumption interface		
Others/consultants		

Notes:

Date: _____/________/_______

Page ___*of*___

Detailed Investigation Plan Form

Incident Number		Incident Date and Time	/ /	
Incident Title				

Legal Issues Are legal issues a potential concern? If so, what kind (e.g., liability to public, liability to employees, insurance, regulatory, criminal)?

Regulatory Impacts Are there regulatory impacts? Is so, what kind (e.g., agencies involved and specific regulations)?

Secure the incident scene Work with emergency response personnel and incident response teams to stabilize the scene
Notes:

Vessel Status What is the current status of the vessel? Total Loss? Fit to proceed? Unfit to proceed? What were the events leading up to this?

Restart/ Resume Criteria Restart or voyage resumption issues – what are the short-term and long-term concerns?

Investigation Team Select a team leader and team members based on the specifics of the incident.

Name	Role	Contact

Continued on next page

Detailed Investigation Plan Form (continued)

Supplies

Acquire MaRCAT toolkit and other supplies

Changes

Have any of the following occurred:

- Changes in operations – such as control systems, capacities, materials, locations, equipment, route
- Changes in systems that are related to the failure – support systems, auxiliary systems, bridge systems, machinery failures
- Changes in personnel – newly hired, newly transferred
- Changes in design, suppliers, maintenance practices

Logisitics

Ensure that investigation team members have the required training and identification(safety briefing, personal protective equipment, respiratory protection, company identification etc.) to allow unescorted access to the investigation scene and team room

Identify a team room where appropriate:

- secure so investigation materials can be left in the room
- wall for causal factor chart and fault tree, etc.
- flipchart paper, flipchart/easel, white board
- phone/fax/copier

Determine locations for interviews separate from the team room, if needed away from the incident scene

Develop a list of team members (with titles and contact information) and their previous incident investigation training

Note: Team members should be committed to the investigation on a full-time basis. If they are not, the investigation will be significantly impaired

Obtain overview of the operation, machinery, equipment etc involved.

Conduct a brief tour of the incident scene with escort if required.

Identify the need for any additional experts such as:

– metallurgist, combustion issues, vendor representatives, marine chemists

---

Data to Collect Immediately

Logs

Vessel/operations logs

Chief Engineers's log

Computer logs for the last 24 hours (for printing if need be)

Continued on next page

Detailed Investigation Plan Form (continued)

Data to Collect Immediately (continued) People	List of potential witnesses (personnel should be available for interviews) List of other personnel involved/related to the incident (personnel should be available for interviews) List of personnel assigned to the vessel/operation/process etc. (personnel should be available for interviews) List of emergency response personnel (personnel should be available for interviews)
Vessel/ Machinery/ Operations	Log of operational and safety system alarms Flow, temperature, pressure and other parameter trends Operational sequence documentation Navigational information (charts, radar records, communications data, etc.)
Maintenance Status	Work permits and their status Inspection reports and maintenance logs
Materials	Composition reports Analysis reports Manifests Welding procedures Repair records Product and intermediate specifications
Photography	General photographs of the incident scene Failed or damaged machinery/equipment/structures from multiple angles Any indications of failure or damage Stains, residues, foreign materials

Continued on next page

Detailed Investigation Plan Form (continued)

Overview of Approach Introduction	Overview of the incident Current status of the investigation Current status of data gathering Set up team room
Initial tour	Complete safety briefings and other administrative requirements See checklist for Initial Site Tour
Data Analysis	Begin fault tree (or why tree) and/or causal factor charting. Supplement with change analysis, if desired Use root cause analysis map
Interviews	*Note*: Interviews/data gathering will be mixed into analysis technique usage Company/vessel/facility personnel should conduct the interviews (ask the questions) One person does the interview while another takes notes but asks no questions Interview guidelines ♦ be respectful ♦ be quiet ♦ no leading questions, no accusing questions ♦ tell me what you did, tell me what happened
Test Plans	Physical parts analysis or sample/chemical analysis Consider test plans for each item
Reports	Begin report development from the beginning of the investigation Schedule/process for completing the report

Team Leader Responsibilities Checklist

Incident Number		Incident Date and Time	/ /	
Incident Title				

Direct and manage the team

- Obtains clear objectives for the investigation
- Ensures that objectives of the investigation are accomplished
- Ensures that the investigation is completed on schedule

Control incident site access

Identify, control and if necessary, modify the restricted access zone.

Safety

Ensure safety work practices are used at incident site during investigation.:

Establish protocols

Establish administrative protocols for the investigation for:

- Gathering data activities
- Preserving data.

Spokes person

Serve as the team's spokesperson and point of contact for other groups and organizations

Reporting

Keep others informed through status reports and other interim reports.

- May make periodic verbal reports to management and staff, as required
- Prepares interim written reports, as required

Investigation Activities

Organizes team work for investigation activities

- Assigns individuals to tasks and coordinates work with non-team members
- Establishes schedules
- Leads team meetings.

Continued on next page

Team Leader Responsibilities Checklist (continued)

Integrity	Ensure team members maintain objectivity and commitment to the investigation
Management of Resources	Obtains resources necessary for investigation ▪ Processes required procurement documents or assigns a team member to this task ▪ Initiates formal requests for: ▪ Information, interviews, test results, technical or administrative support
Controls impact	Minimizes the impact of the investigation on other activities
Confidentiality	Protect proprietary and other sensitive information
Final Report	Ensures that the final report if properly reviewed: ▪ Factual accuracy of report for internal and external reports ▪ Report is prepared for audience. ▪ Review by legal department ▪ Review by public relations department ▪ Proprietary information protected.

Meeting Notes Form

Details Date / / Time

Place

Attendees

Name	Role/Company	Contact Info

Meeting purpose

Topics discussed

Continued on next page

Meeting Notes Form (continued)

Decisions made

Topic	Decision

Actions

Topic	Who is Responsible	Deadline

Next Meeting

Investigator's Log Form

Incident Number		Incident Date and Time	/ /	
Incident Title				
Investigator				

Date	Start Time	End Time	Activity	Others Involved

Date: ____/____/________

Page____of____

Investigator's Log Form (continued)

Incident Number		Incident Date and Time	/ /	
Incident Title				
Investigator				

Date	Start Time	End Time	Activity	Others Involved

Date: ____/____/________ *Page*____*of*____

Initial Call Checklist

Incident Number		Incident Date and Time	/ /	
Incident Title:				
Investigator				
Company Name		Call Date and Time	/ /	
Name of Vessel/ Facility				
Caller's Name:				
Caller's Phone Number 1		Caller's Phone Number 2:		
Caller's Fax Number		Caller's E-Mail Address		

Item No.	Data Need	Response
1	Synopsis of incident	
2	Current status of vessel/ installation • Equipment destroyed • Equipment shut down; awaiting restart • Reduced capacity • Normal operations • Schedule impacts	
3	Current status of invest-igation • Emergency response? • Scene secured? • Initial witness statements obtained? • Initial investigation team commissioned? • Attorney/client privilege invoked?	

Initial Call Checklist (continued)

Item No.	Data Need	Response
4	Name/phone numbers of primary point of contact (POC) at vessel/installation (if different)	
5	Name and phone numbers of other points-of-contact	
6	Current location of vessel/ installation	
	Physical address, if appropriate	
7	Two nearest commercial airports nearest to incident location	
8	Recommended lodging arrangements (if needed)	
9	Driving directions to port/ location from both of the nearest commercial airports	
10	Expected arrival time at location for first meeting	
11	Badging, security and safety procedures to enter location	
12	Other information and notes	

Data Needs Form

Incident Number		Incident Date and Time	/ /	
Incident Title				
Investigator				

People		Position		Physical (components, chemicals)		Paper/Electronic (documentation, computer data)	
✓ or X	Item	✓ or X	Item	✓ or X	Item	✓ or X	Item

- Keeping too much data is better than not keeping enough
- Label all pieces of data and log them. This includes notes from interviews, procedures, computer disks, etc.

- Keep control of all evidence. Identify appropriate storage locations for all data
- Use Chain of Custody forms for all data, even when no legal issues are anticipated

Date: ____/____/________ Page____of____

Data Needs Checklist

People	Position	Physical	Paper/Electronic
▪ Deck personnel ▪ Engineering personnel ▪ Steward department personnel ▪ Operators - on-watch - off-watch ▪ Personnel from other vessels ▪ Personnel from other organizations such as - stevadores - dock workers - terminal operators - chandlers - agents - pilots ▪ Maintenance personnel ▪ Emergency responders ▪ Warehouse personnel ▪ Quality control personnel ▪ Chartering representatives ▪ Manufacturer's representatives ▪ Purchasing agents ▪ Chemists ▪ Metallurgists	❖ Document the position of: People – participants – observers – victims Physical – operating equipment – safety equipment – stains and residues – levels – instrument needles – chart recorder needles – switch positions – valve positions – relief devices – scattered objects – impact marks and scratches – burn/flame/scorch marks – layers of debris – environmental conditions (weather/seas) ❖ Document and photograph what is on top of what in a pile of debris ❖ Document and photograph the position of all equipment, switches, dials, etc. ❖ Map and photograph all items before removal	❖ Document the physical aspects of: ▪ Operating components ▪ Safety devices ▪ Support equipment ▪ Structural components ▪ Chemical samples – tanks – spills – raw materials – cargo ▪ Retained samples ▪ Stains ▪ Residues ▪ Foreign objects ▪ Damaged equipment ▪ Portable and temporary equipment ▪ Instrumentation system components ▪ Electrical switchgear ▪ Security camera tapes ❖ Use sealable plastic bags ❖ Use durable tags to mark items that cannot be placed in a bag ❖ Watch for incompatibility of sample containers and the samples	❖ Perform computer data capture as soon as possible ❖ Document relevant information related to: ▪ Procedures ▪ Logs: bridge log, engine room log, cargo log, bell log ▪ Computer records ▪ Hazard and risk assessments ▪ Policies and programs ▪ Purchasing records ▪ Design specifications and calculations ▪ Training records/manuals ▪ Management of change records ▪ Maintenance and repair records ▪ Previous incident reports ▪ MSDS ▪ Critical limits/setpoints ▪ Software logic ▪ Permits ▪ Meteorological data ▪ News media video ▪ Vessel loading plans and records ▪ Strip an wheel chart recorder plots ▪ Work permits ▪ Instrumentation loop and interlock drawings ▪ Phone logs ▪ Email printouts ▪ Vessel general arrangement plans ▪ Terminal plan ▪ Charts ▪ Depth recorder ▪ Automatic radar plotting aid (ARPA)

Initial Incident Scene Tour Checklist

Incident Number		Incident Date and Time		
Incident Title:				
Investigator				

✓	Item	Step
	1	The tour should be completed as soon as possible.
	2	Obtain appropriate work permits ▪ Hot work permits for photography
	3	Follow all safe work practices identified by the incident scene commander or other safety personnel.
	4	Don't be in a rush to get to the center of the scene ▪ Observe the big picture first ▪ Walk through the entire area first.
	5	Look not only at what is there, but what is NOT there
	6	DO NOT MOVE ANYTHING unless absolutely necessary
	7	Take notes ▪ Positions of equipment/items/structures/outfitting ▪ Distances, dimensions – measure and sketch or photograph ▪ Orientations of equipment – measure and sketch or photograph ▪ Scale, magnitude and extent of damage – note what is NOT damaged ▪ Plan sample collection needs
	8	Anticipate logistical challenges ▪ Decide and arrange for long-term data/evidence storage ▪ Plan for coordination with clean-up/remediation.

Notes:

Date: ____/____/________

NOTE: If outside agencies are involved in investigating the incident, the initial site tour may need to be coordinated with these groups

Post-Tour Checklist

Incident Number		Incident Date and Time	/ /	
Incident Title				
Investigator				

✓	Item	Step
	1	Develop a detailed investigation plan ▪ Review Simple or Detailed Investigation Plan (MARCAT Toolkit) ▪ Develop detailed data needs (see Data Needs Form in MARCAT Toolkit).
	2	Arrange for additional internal experts or personnel resources from other departments, organizations, vessels, as required ▪ Legal assistance ▪ Media interface assistance ▪ Regulatory interface assistance.
	3	Arrange for additional outside specialists or resources, as required, including: ▪ Metallurgists ▪ Structural engineers ▪ Chemists ▪ Explosion experts ▪ Computer experts.
	4	Establish data collection control procedures and assign personnel to: ▪ Collect data ▪ Inventory data ▪ Control data.

Notes:

Date: ____/____/________

Open Issues Log Form

Incident Number		Incident Date and Time	/ /	
Incident Title				
Investigator				

Issue Number	Issue	Assigned to	Date Assigned	Date Completed	Resolution
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	

Date: ____/____/________ *Page*____*of*____

Open Issues Log Form (continued)

Incident Number		Incident Date and Time	/ /	
Incident Title				
Investigator				

Issue Number	Issue	Assigned to	Date Assigned	Date Completed	Resolution
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	
			/ /	/ /	

Date: ____/____/________ *Page*____*of*____

Contacts Form

Incident Number		Incident Date and Time	/ /	
Incident Title				
Investigator				

Name	Title	Company	Phone/E-mail	Other

Date: ____/____/________

Page____of____

Contacts Form (continued)

Name	Title	Company	Phone/E-mail	Other

Date: ____/____/________

Page____of____

Meeting Attendees Form

Incident Number		Incident Date and Time	/ /	
Incident Title				
Meeting Date and Time	/ /			

Name	Title	Company	Phone/E-mail	Other

Date: ____/____/________ *Page*____*of*____

Meeting Attendees Form (continued)

Name	Title	Company	Phone/E-mail	Other

Date: ____/____/________

*Page*____*of*____

Interview Scheduling Form

Incident Number		Incident Date and Time	/ /	
Incident Title				
Investigator				

Interviewee (name and position)	Interviewer (name and position)	Expected Information	Priority	Scheduled	Completed

Date: ____/____/________ *Page*____*of*____

Interview Scheduling Form (continued)

Interviewee (name and position)	Interviewer (name and position)	Expected Information	Priority	Scheduled	Completed

Date: ____/____/____ *Page* ____ *of* ____

Initial Witness Statement Form

Incident Date and Time	/ /		
Type of Incident	☐ Accident or ☐ Near Miss		
Your Name			
Title		License or Certificate	
Work Location			
Work Telephone			

Please write your view of what happened as soon as possible after the incident. Your cooperation in completing this form is appreciated and is an important part of the organization's health, safety, environmental, reliability and quality programs.

Assignment of blame and fault finding are NOT part of the investigation process. Punishment of individuals will ONLY occur in cases of illegal activity such as theft, use of illegal drugs, sabotage, etc.

Please provide information about what you know about incident: Follow the **WHO, WHAT, WHEN, WHERE, WHY** thought process.

1. Names of other people involved or in the area.

   ____

   ____

   ____

2. Weather conditions.

   ____

   ____

   ____

3. Anything moved or repositioned following the incident.

   ____

   ____

   ____

4. Training and preparation issues.

   ____

   ____

   ____

Initial Witness Statement Form (continued)

5. What happened? Please include each of the following:
   - Timing of events (record sequentially and in as much detail as possible)
   - Location of personnel
   - Any indicators of the conditions that existed
   - Actions of other people
   - Emergency response activities

Return this document to the Incident Investigator.

Date: ____/____/________ *Page___ of ____*

Interview Preparation Guidelines

The following are typical questions that you may want to ask during an interview:

✓	Item	Question
	1	What was happening at or around the time of the incident? (i.e., initial conditions)
	2	What were you doing just before the incident?
	3	What were you doing during the incident? (i.e., timing of events)
	4	What indications did you have of the incident?
	5	How did you know what to do when you saw …?
	6	What communications did you have with others in the area?
	7	What other individuals were in the area? ▪ where were they? ▪ what were they doing?
	8	What were the environmental conditions?
	9	What was different this time?
	10	Did you notice any equipment that didn't operate properly?
	11	Any training or preparation issues?
	12	Emergency response: ▪ What were the initial conditions when you arrived? ▪ Did you or others move or reposition anything? ▪ What emergency response activities did you perform?
	13	Have there been similar events in the past?
	14	Who else should we talk to? Who else might have information?
	15	What are your opinions, beliefs and conclusions related to causes and recommendations
	16	Is there anything else you wish to tell me? Is there anything else I should have asked?

Notes:

Date: ____/____/________

Interview Guidelines

✓	Item	Guideline
	1	Use the Initial Witness Statement form to quickly capture people data ▪ Review the Initial Witness Statements before the interview to help prepare for the interview ▪ Don't directly confront the witness with differences between the initial witness statement and statements made during the interview, but explore these differences
	2	Use the Data Needs form and the Interview Scheduling form (if needed)
	3	Keep witnesses separated.
	4	Conduct interviews promptly.
	5	Use data analysis techniques (fault trees, 5-Whys technique and causal factor charting) to develop a core set of questions.
	6	Be respectful and be quiet. ▪ Conduct interviews in neutral locations with as few distractions as possible ▪ Interviews at the incident scene may also be appropriate ▪ Perform interviews one-on-one or two-on-one ▪ Never lead, accuse, blame or threaten the witness ▪ Follow up on general comments to obtain clarifications and details
	7	Document witness interviews
	8	Review the notes from the interview with the witness
	9	Assure confidentiality only if you can guarantee it.

Notes:

Date: ____/____/________　　　　*Page___ of ____*

Interview Documentation Form

Interview Number		Interview Date and Time	/ /	
Interviewer				
Person being Interviewed				
Others Present (Name/Company)				

Page___ of ____

Interview Documentation Form (continued)

Interview Number		Interview Date and Time	/ /	
Person being Interviewed				

Page___ of ____

Data Log Form

Incident Number		Incident Date and Time	/ /	
Incident Title:				
Investigator				

Data Type/Data Number					
Document	Electronic File	Component	Chemical	Description	Storage Location

Date: ____/____/________

Page____of____

Data Log Form (continued)

Data Type/Data Number				Description	Storage Location
Document	Electronic File	Component	Chemical		

Date: ____/____/________ *Page*____*of*____

Data Correspondence Log Form

Incident Number		Incident Date and Time		
Incident Title:				
Investigator				

Document Number	Document Name	Sent to:		Sent by:	Date Sent:	Form Sent (paper, e-mail, floppy disk, CD, fax)
		Group	Person			

Date: ____/____/________

*Page*____*of*____

Data Correspondence Log Form (continued)

Document Number	Document Name	Sent to: Group	Sent to: Person	Sent by:	Date Sent:	Form Sent (paper, e-mail, floppy disk, CD, fax)

Date: ____/____/______ *Page*_____*of*____

Data Checkout Log Form

Incident Number		Incident Date and Time		
Incident Title:				
Investigator				

Item Number	Description	Checked Out by	Checked Out	Returned	Initials

Date: ____/____/________ *Page*____*of*____

Data Checkout Log Form (continued)

Item Number	Description	Checked Out by	Checked Out	Returned	Initials

Date: ____/____/________ *Page*____*of*____

Test Plan Form — Parts Analysis

Test Plan Number		Date and Time for Test	/ /	
Test Plan for				
Photos of Equipment				

Purpose of Test
Provide a brief description of the purpose of the test and the information that the test will provide. Explain how this is related to the events and conditions on the causal factor chart, 5-Whys or fault tree.

____

____

____

Initial Preservation

Persons performing data preservation		JSA Needed?	❑ yes ❑ no
Location of Activity			
Scheduled Date and Time	/ /		

Visual Examination

Persons performing visual examination		JSA Needed?	❑ yes ❑ no
Location of Examination			
Scheduled Date and Time	/ /		

Operational Tests

Persons performing operational tests		JSA Needed?	❑ yes ❑ no
Location of Operational Test			
Scheduled Date and Time	/ /		

Test Plan Form — Parts Analysis (continued)

Field Disassembly

Persons performing disassembly		JSA Needed?	❑ yes ❑ no
Location of Disassembly			
Scheduled Date and Time	/ /		

Sampling (see Sample/Chemical Analysis Test Plan)

Shop/Bench Testing, Shop Disassembly

Persons performing shop testing/ disassembly		JSA Needed?	❑ yes ❑ no
Location of shop testing/disassembly			
Scheduled Date and Time	/ /		

Simulation

Persons performing simulation		JSA Needed?	❑ yes ❑ no
Location of simulation			
Scheduled Date and Time	/ /		

Testing (destructive and nondestructive)

Persons performing testing		JSA Needed?	❑ yes ❑ no
Location of simulation			
Scheduled Date and Time	/ /		

Test Plan Form — Parts Analysis (continued)

Long-term Preservation

Persons performing long-term preservation		JSA Needed?	❑ yes ❑ no
Location of Long-term preservation			
Scheduled Date and Time	/ /		

Approvals

Test plan written by:		Title	
Date and Time	/ /		

Test Plan Approved By	Title of Approver	Date Approved
		/ /
		/ /
		/ /
		/ /
		/ /
		/ /
		/ /
		/ /

Page __ of ___

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Test Plan Form — Sample/Chemical Analysis

Test Plan Number		Date and Time for Test	/ /	
Test Plan for Sampling				
Photos of Sampling Equipment/ Sample Point				

Purpose of Test

Provide a brief description of the purpose of the test and the information that the test will provide. Explain how this is related to the events and conditions on the causal factor chart, 5-Whys or fault tree.

____

____

____

Drawing the Sample

Persons drawing the sample		JSA Needed?	❑ yes ❑ no
Location of sample equipment/point			
Scheduled Date and Time	/ /		

Note: All equipment used in drawing the sample should be clean to prevent contamination of the sample.

Equipment needed for drawing sample (lines, hoses, containers, etc.):

____

____

____

Safety equipment (including personal protective equipment) required for drawing sample:

____

____

____

Description of sampling process (include container requirements, flushing times, volume of samples, etc.). Attach JSA/procedure, if needed.

____

____

____

____

Test Plan Form — Sample/Chemical Analysis (continued)

Visual Examination of Sample Drawn/Collected

Persons performing visual examination		JSA Needed?	❑ yes ❑ no
Location of Visual Examination			
Scheduled Date and Time	/ /		

Marking of Containers

Mark the containers with the following information; also record the information below.

	Container Number			
	1	2	3	4
Sample number				
Container (size, material, color, etc.)				
Time and date of sample	/ /	/ /	/ /	/ /
Description of what was sampled				

Transport/Storage of Samples

Persons ______________________________

	Container Number			
	1	2	3	4
Person involved				
Storage location (if required)				
Analysis to be performed on sample (refer to procedure number if appropriate)				
Chain of custody form	❑ yes ❑ no	❑ yes ❑ no	❑ yes ❑ no	❑ yes ❑ no
*Analysis Report Number				

* **Results** (attach report to this form)

Test Plan Form — Sample/Chemical Analysis (continued)

Approvals

Test plan written by:		Title	
Date and Time	/ /		

Test Plan Approved By	Title of Approver	Date Approved
		/ /
		/ /
		/ /
		/ /
		/ /
		/ /
		/ /
		/ /

Page __ of ___

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Paper Chart Data Collection Guidelines

✓	Item	Guideline
	1	Identify all charts (strip charts, disk charts, etc.) that should be collected
	2	Add all items to the list of paper data on the Data Log Form
	3	DO NOT REMOVE THE PAPER FROM THE EQUIPMENT YET
	4	Initial marking ▪ Mark the name of the chart on the paper ▪ Mark the parameter the chart is recording ▪ *Note*: For multiple pen recorders, indicate the color and line associated with each parameter so that the association between the parameter and the trend data will still be possible with black and white copies ▪ Mark the current time/date at the current location of the marker (to determine the speed of the recorder and provide a common reference across the various charts)
	5	DO NOT REMOVE THE CHART YET
	6	Wait a half-hour to an hour before proceeding to: ▪ Mark the current time/date at the current location of the marker ▪ The difference between the initial time/date mark and this second mark will allow you to determine the speed of the recorder
	7	Remove the chart from the equipment and place in data storage

Notes:

Date: ____/____/________ *Page* ____ *of* ______

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Position Data Form

Incident Number		Incident Date and Time		
Incident Title				
Investigator				

Object Number	Description	Reference Point	Distance	Direction	Notes

Date: ____/____/________

Page____of____

Position Data Form (continued)

Object Number	Description	Reference Point	Distance	Direction	Notes

Date: ____/____/____ *Page*____*of*____

Photography Guidelines – Stills

Item	Guideline
1	Obtain hot work permits if necessary
2	Notify personnel in the area just before you take a photo using a flash. ▪ Bright flashes of light are generally a cause for alarm. Warning personnel ahead of time will help address this issue.
3	Type of photos to use ▪ Digital photography is acceptable for most investigations. ▪ Digital photographs are usually not admissible in court proceedings. Standard film should be used in addition to any digital photos taken. ▪ Instant photos can be used to assist the team in their investigation, but digital/film photos should also be taken of the same items.
4	Setting up the camera ▪ Use automatic date and time stamping on each photograph if the camera has that capability. ▪ Ensure that the date and time are properly set on the camera. ▪ Use the highest resolution settings for the camera. ▪ A camera with wide-angle and zoom capabilities is useful.
5	Setting up the Shot Plan the shot ▪ Determine what you are trying to capture with the photo and plan the shot accordingly. Provide reference items in your photos ▪ Use cardboard arrows, fluorescent tape, Post-it® Notes, pens or people to point out and highlight items of interest in the photograph. ▪ Provide an item of known dimension in the photograph – use a ruler (preferable) or other item of known dimension. ▪ Provide reference points – an arrow pointing up, starboard or north in every photograph. Take photos from multiple angles ▪ Begin with general views of the area. This will be helpful to put the more detailed photographs in context and show the relationship between each photo. ▪ Include angles from witness locations to show what they would have seen during the incident. ▪ Consider taking photographs at the same time of the day as the incident to reproduce the lighting conditions experienced by the witness. Use a non-reflecting background ▪ Use of a cloth or felt background often helps to highlight the object in the photo and eliminates glare. ▪ A selection of black, white and tan backgrounds usually works for most objects. ▪ Before using the cloth/felt background, consider the potential contamination of the object from lint from the material.

Photography Guidelines – Stills (continued)

Item	Guideline
6	Document the photographs using the photographic log ▪ Date and time of photo ▪ Type of film used ▪ Shutter speed (if known) ▪ Key item of interest in the photograph (why it was taken) ▪ Reference to drawing or document showing item ▪ Direction of shot Examples Looking north from Hatch 4 Back side of control panel from boiler end Passageway 4-2 from aft entrance doorway ▪ Distance from object of interest (if not readily identified by other objects in the photo).
7	Identity of photographer and recorder ▪ Sign each documentation form ▪ Initial each role of film.
8	Other considerations ▪ Ensure you have extra sets of batteries available for the camera ▪ Periodically checking of the batteries may be required to ensure the batteries are fresh.

Photography Guidelines – Video

Item	Guideline
1	Videotapes can be useful for: ▪ seeing the relationship of one location to another ▪ getting the big picture ▪ capturing action, such as during the dismantlement of a component or during a simulation or test.
2	Do not count on videos to show details of components.
3	Start with an overview before zooming in on an object.
4	Do not move the camera too quickly – Pan/zoom/move twice as slowly as you think you need to.
5	Document the video using a voiceover on the tape to describe: ▪ Date and time of video ▪ Key item of interest in the photograph (why it was taken) ▪ Direction of shot ▪ Identity of photographer and recorder - Sign each documentation form - Initial each cassette - Provide reference items in your video.
6	Take videos from multiple angles.

Photographic Record Form

Incident Number		Incident Date and Time		
Incident Title:				
Investigator				
Lighting		Film Roll		

Number	Description	Time		Orientation	Paper Reference (documentation, drawing)
		Date	Time		

Date: ____/____/________ *Page____of____*

Photographic Record Form (continued)

Lighting		Film Roll	

Number	Description	Time		Orientation	Paper Reference (documentation, drawing)
		Date	Time		

Date: ____/____/________ *Page*____*of*____

5 Whys Worksheet

Incident Number		Incident Date and Time	/ /	
Incident Title				
Investigator				
Causal Factor Number and Description				
Background:				
Why:				
Why:				
Why:				
Why:				
Why:				
Recommendations:				

Date: ____/____/________ *Page* __ *of* ___

5 Whys Worksheet (continued)

Causal Factor Number and Description	
Background:	
Why:	
Why:	
Why:	
Why:	
Why:	
Recommendations:	

Date: ____/____/________

Page __ of ___

Root Cause Summary Table Form

Incident Number		Incident Date and Time	/ /	
Incident Title:				
Investigator				

Causal Factor #	Paths Through Root Cause Map™	Recommendations
Description: **Background:**		

Date: ____/____/________

Page __ of ___

Root Cause Summary Table Form (continued)

Causal Factor #	Paths Through Root Cause Map™	Recommendations
Description: **Background:**		

Date: ____/____/________ *Page __ of ___*

Causal Factor, Root Cause and Recommendation Checklist

Incident Number		Incident Date and Time	/ /	
Incident Title				
Investigator				

✓	Item	Guideline
Causal Factors		
	1	Oftentimes, it is a human error, usually committed by front-line personnel, though the causal factor could also be a structure, machinery/equipment, outfitting or external problem.
	2	It is something we want to prevent from occurring in the future
	3	Elimination or correction of the item will prevent the incident or reduce the consequences
	4	Item is NOT a root cause
Date this section was completed:		
Root Causes		
	1	A management system weakness
	2	Addresses something over which management has control
	3	Represents as deep a level of cause as is practical to correct through recommendations
	4	Directly tied to a causal factor
Date this section was completed:		
Recommendations		
	1	Directly tied to a root cause
	2	Addresses options for reducing frequency and/or reducing the consequences of one or more root causes
	3	Intended action clearly stated
	4	Describes specific actions to be taken by management
	5	Completion of the recommendation can be determined by reviewing data
	6	Practical, feasible and achievable
	7	Does not pose other undesirable and/or unforeseen risks
		Short-term, medium-term and long-term recommendations addressed for each causal factor
		Recommendations made at the highest level possible ▪ Eliminate the possibility of recurrence - eliminate the hazard ▪ Reduce the probability of occurrence - make the system inherently safer/more reliable or prevent the occurrence of the event ▪ Reduce the consequences of the event - detect and mitigate the loss, contain the damage or perform emergency response
		Four levels of recommendations considered for each root cause ▪ Address the causal factor ▪ Address the specific problem ▪ Fix similar problems ▪ Correct the process that creates these problems
		Each recommendation has an assigned responsibility and a date for completion
Date this section was completed:		

Recommendation Tracking Summary

Investigation for: ____________________

Investigation/report #: ____________________

Recommendation Number	Action	Responsible Person	Target Completion Date	Status

Date: ____/____/________ *Page*____*of*____

Management Resolution of Recommendations

Incident #: ______________________________ Date __________

Recommendation #(s): ______________________________

Item(s): ______________________________

____

____

✓	Recommendation Resolution	Person Responsible for Implementation
	Approved as recommended	
	Approved with modifications as documented [1,2,3]	
	Returned to investigation team for additional information [1]	
	Rejected because implementation of the recommendation would increase the overall risk of facility operations [1,3]	
	Rejected because the recommendation is no longer valid [1,3]	
	Rejected because implementation of other team recommendations adequately addresses this recommendation [1,3]	
	Rejected because the risk reduction associated with this item can be accomplished by a more effective (less costly, less complicated or greater risk reduction) action [1,2,3]	
	Rejected because the recommendation is not necessary to protect the health and safety of personnel [1,3]	
	Rejected because the recommendation is infeasible [1,2,3]	

[1]Explanation: ______________________________

____

____

____

____

[2]Alternative action: ______________________________

____

____

____

____

[3]Decision communicated to investigation team:

Prepared by: ______________________

Approved by: ______________________

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Change Analysis Worksheet

Incident Number		Incident Date and Time	/ /	
Incident Title:				
Investigator				
Problem Situation (Describe)				
Problem-free Situation (Describe)				

Check mark type of analysis being performed:	☐ **Actual**	☐ **Test**	☐ **Procedure**	☐ **Ideal**	☐ **Experience**	☐ **Future**	**Other Specify**

Conditions Found in Problem Situation	Conditions Found in Problem-free Situation	Differences Between the Two Situations	Resulting Effects on Problem

Date: ____/____/________ *Page*____*of*____

Change Analysis Worksheet (continued)

Check mark type of analysis being performed:	☐ Actual ☐ Test ☐ Procedure	☐ Ideal ☐ Experience	☐ Future Other Specify
Conditions Found in Problem Situation	**Conditions Found in Problem-free Situation**	**Differences Between the Two Situations**	**Resulting Effects on Problem**

Date: ____/____/________ *Page*____*of*____

HAZOP Worksheet

Incident Number		Incident Date and Time	/ /	
Incident Title:				
Investigator				
Procedure		Intent		
Step		References		

	Deviation	Causes	Consequences	Safeguards	Recommendations

Date: ____/____/________

Page____of____

HAZOP Worksheet (continued)

	Deviation	Causes	Consequences	Safeguards	Recommendations

Date: ___/___/___ Page____ of___

Incident Investigation Report Form

General	
Vessel Name	
Incident Type	☐ Near Miss or ☐ Accident
Official No.	
IMO No.	
Incident Title	
Initial Event (Grounding, Collision, etc)	
Incident Date	/ /
Incident Time	
Report Date	/ /
Report Number	
Reported By	
Class Affected?	☐ Yes or ☐ No
Third Party Involved?	☐ Yes or ☐ No

Vessel Info	
Call Sign	
Flag Name	
Port Of Registry	
Classification Society	
Registered Owner	
Managing Company	
Contact	
Address	
Tel No.	
Mobile No.	
E-Mail	
Other	
Vessel Type	
Vessel Function	
Length Overall	
Gross Tonnage (ITC)	
Net Tonnage (ITC)	
Design Deadweight	
Prime Mover	
Maneuvering System	
Propulsion System	
Hull Material	
Hull Construction	
Delivery Date	
Major Conversion Date	/ /
Builder	

Incident Investigation Report Form (continued)

Preliminary Data	
Damage Details:	
Emergency Response Measures:	
Item-Failure Type and Failure Description	

Consequence Summary	
Damage to Vessel	
	☐ Fit to proceed ☐ Unfit to Proceed ☐ Total Loss
Damage to People	
No. of Dead/Missing Crew:	
No. of Dead/Missing Passengers:	
No. of other Dead/Missing People:	
No. of Seriously Injured Crew:	
No. of Seriously Injured Passengers:	
No. of other Seriously Injured People:	
Damage to Environment	
Bunker Spills (specify type and units*)	
▪ Heavy fuel	
▪ Diesel	
▪ Lube oils	
▪ Other	
▪ Oil Cargo Spills	
▪ Crude Oil	
▪ Persistent Refined Oil Products	
▪ Non-Persistent Refined Oil Products	
*Specify Units next to each entry or pick one below to apply to all ☐ Liters, ☐ Barrels, ☐ US Gallons, ☐ Imperial Gallons, ☐ Other (specify):	
Chemicals In Bulk Spills	☐ kilos ☐ lbs ☐ Other: ______
Lost Dangerous Goods In Packaged Form	☐ kilos ☐ lbs ☐ Other: ______

Incident Investigation Report Form (continued)

People	
No. of Crew	
No. of Passengers	
Pilot Onboard	☐ Yes or ☐ No
People Involved In Incident	
Name	
Company	
Role*:	
Status (Dead, Missing, Injured, Uninjured)	
Statement	☐ Yes - Append statements to the end of the report ☐ No
Name	
Company	
Role*:	
Status (Dead, Missing, Injured, Uninjured)	
Statement	☐ Yes - Append statements to the end of the report ☐ No
Name	
Company	
Role*:	
Status (Dead, Missing, Injured, Uninjured)	
Statement	☐ Yes - Append statements to the end of the report ☐ No
Name	
Company	
Role*:	
Status (Dead, Missing, Injured, Uninjured)	
Statement	☐ Yes - Append statements to the end of the report ☐ No
Name	
Company	
Role*	
Status (Dead, Missing, Injured, Uninjured)	
Statement	☐ Yes - Append statements to the end of the report ☐ No
Name	
Company	
Role*	
Status (Dead, Missing, Injured, Uninjured)	
Statement	☐ Yes - Append statements to the end of the report ☐ No
Name	
Company	
Role*	
Status (Dead, Missing, Injured, Uninjured)	
Statement	☐ Yes - Append statements to the end of the report ☐ No

* Choose one of following for Role: (Person(s) in Charge, Engineer of the Watch, Officer of the Watch, Crew, Witness Only, Pilot, Investigation Team, Passenger, Other)

Incident Investigation Report Form (continued)

People Details	
Name:	
Role*	[Field Contents]
Status with regard to vessel:	☐ Crew member ☐ On Duty ☐ Off Duty ☐ Not a crew member ☐ Not applicable
Company:	
Job Title	
License/Certificate:	
Date of Birth:	
Nationality	
Contact Details	
Address	
E-mail:	
Tel No.	
Mobile No.:	
Other	
Injury Details	
Type of Injury:	
Body Part Involved:	
Heath Condition:	
Where injury occurred:	
Equipment/Substance Involved:	
No. of Hrs worked before Incident:	
Duration of last off duty period	

* Choose one of following for Role: (Person(s) in Charge, Engineer of the Watch, Officer of the Watch, Crew, Witness Only, Pilot, Investigation Team, Passenger, Other)

Incident Investigation Report Form (continued)

Statement Details	
Date of Statement	
Place Statement Given	
Taken by:	
Statement:	
Remarks	

Incident Investigation Report Form (continued)

Voyage Conditions	
Location	
In Port	
▪ Port	
▪ Country	
At Sea	
▪ Latitude	
▪ Longitude	
▪ Place	
▪ Departure Date:	/ /
▪ Departure Time:	
▪ To:	
▪ From:	
Operations	
▪ Operational Status	
▪ Voyage Phase:	
▪ Underway Course True	
▪ Underway Speed Knots	
▪ As Loaded Draft (fwd):	☐ m or ☐ ft
▪ As Loaded Draft (aft):	☐ m or ☐ ft
Visibility	
	☐ Good ☐ Fair ☐ Poor
▪ Nautical Miles	
▪ Ambient Outdoor Light	
Atmospheric/Sea Conditions	
▪ Sea State:	
▪ Wind Speed:	
▪ Wind Direction:	
▪ Bottom Depth Under Keel:	☐ m or ☐ ft
▪ Currents/Tides:	
▪ Ice Conditions:	
▪ Other:	

Incident Investigation Report Form (continued)

Analysis	
Event description/Sequence	
Root Cause Analysis Map paths	
Principal findings	
Attachments (This includes Causal factor charts, Fault or 5-Whys Trees)	☐Yes or ☐No

Continuous Improvement	
Investigate further?	☐Yes or ☐ No
Recommendations to prevent recurrences	

Incident Investigation Report Form (continued)

Notes
Notes:

Report Checklist

Incident Number		Incident Date and Time	/ /	
Incident Title:				
Investigator				

✓	Item	Guideline
Interim Reports		
	1	All pages marked DRAFT – PRELIMINARY – BUSINESS CONFIDENTIAL or other appropriate markings
	2	Report date, version number and pages marked "Page x of y"
	3	Line numbering used to help with comment resolution
	4	Controlled distribution of all copies with each copy marked with copy number
	5	Cover page indicates that facts, causes, conclusions and recommendations are preliminary and may change
	6	All copies returned after review
Final Reports		
	1	All pages marked BUSINESS CONFIDENTIAL or other appropriate markings
	2	Report date, version number and pages marked "Page x of y"
	3	Completed approval form attached
All Reports		
	1	Executive summary including a summary of the event, consequences (actual and potential), causal factors, observations, root causes and recommendations Note: completing a standard report form meets this requirement
	2	Causal factor chart or fault tree for more complex events. 5-Whys for simpler events
	3	Description of the incident – sufficient for the target reader to understand the incident – reference to a causal factor chart or fault tree can significantly reduce the text description Initial conditions, personnel involved (by position only, no names), consequences of the incident and significance of the incident to the stakeholders
	4	Causal factors ▪ Human errors and equipment failures ▪ Failures to prevent the incident and failure to mitigate the consequences
	5	Successful safeguards that significantly impacted the consequences identified.
	6	No names used in the report – use sufficient identification of individuals to understand incident
	7	Suppositions, opinions and conclusions clearly identified

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Report Comment Form

Incident Number		Incident Date and Time	/ /	
Incident Title:				
Investigator				
Report Date	/ /	Report Version		

Reviewer's Initials	Section	Page Number		Line Number		Comment (use multiple lines if needed)	Resolution
		Start	End	Start	End		

Page __ of __

Report Comment Form (continued)

Reviewer's Initials	Section	Page Number		Line Number		Comment (use multiple lines if needed)	Resolution
		Start	End	Start	End		

Page __ of __

Report Routing Form

I acknowledge that the findings and corrective actions related to Incident Report #: ____________________
have been reviewed with me.

Employee/Contractor			
Name (please print)	**Signature**	**Position**	**Date**

Return completed form (i.e., signed) to the Safety Manager.

Date: ____/____/________ *Page___ of ____*

Investigation Checklist

Incident Number		Incident Date and Time	/ /	
Incident Title:				
Investigator				

✓	Item
	All items on Data Needs form addressed (collected or decision made not to collect)
	All items on the Open Issues Log addressed (resolved or decision made not to resolve)
	Fault tree, 5-Whys and/or Causal factor chart complete ▪ All questions answered or decision made not to resolve ▪ All causal factors identified
	Root causes identified for all causal factors
	Recommendations developed for all root causes
	Responsibilities and completion dates assigned for all recommendations
	Report written and reviewed by all appropriate personnel
	Report findings distributed at appropriate level of detail to all those involved in the event and in follow-up activities
	Stakeholder meeting conducted

Completed by: ____

Date: ____/____/______

Incident Investigation/Root Cause Analysis Program Evaluation Checklist

Item Number	Data collection method*	Incident Investigation Analysis Program Evaluation Checklist	Comments
1		**General**	
1.1	RR	Is a written procedure in place to define the incident investigation process?	
1.2	RR	Does the program identify the organization's objectives for performing incident investigation?	
1.3	RR	Does the organization have specific definitions of the following: • Causal factor (human errors and equipment failures) • Root cause • Recommendation • Item of note or observation	
1.4	RR	Are the definitions for causal factor, root cause, recommendation and item of note or observation used consistently in the application and use of the program?	
1.5	I-PTM I-SRQM	What are the definitions of causal factor, root cause and item-of-note (or observation)?	
1.6	I-PTM	What are the team member's responsibilities outlined in the investigation program?	
1.7	I-SRQM	What are the safety/quality/reliability manager's responsibilities outlined in the investigation program?	
2.1		**Incident Identification**	
2.1.1	RR	Does the incident investigation program specifically define the types of incidents that should be analyzed? Are examples of each type of incident included in the program?	
2.1.2	RR	Do investigation procedures define the various levels of investigations (i.e., major loss, minor loss, near miss)?	
2.1.3	RR	Do the investigation procedures describe the process and level of effort associated with each level of analysis?	
2.1.4	RR	Does the investigation program specifically assign the task of incident reporting to someone?	

Incident Investigation/Root Cause Analysis Program Evaluation Checklist (continued)

Item Number	Data collection method*	Incident Investigation Analysis Program Evaluation Checklist	Comments
2.1.5	I-SRQM	Are there documented thresholds for reporting incidents?	
2.1.6	I-PTM I-GM I-SRQM	How is an incident investigation initiated (i.e., who is called, when, which type of form is used)?	
2.1.7	I-GE	How do you report an incident?	
2.2		Initiating the Investigation	
2.2.1	RR I-ERM	Are emergency response activities performed with no interference from the II/RCA team?	
2.2.2	RR I-PTM	Is an incident classification methodology used to allocate resources to investigations?	
2.2.3	I-SRQM	Are there documented thresholds for reporting incidents?	
2.2.4	RR	Is the classification methodology based on a measure of the ability to learn from the incident?	
2.2.5	RR I-SRQM	Is the classification scheme is used?	
2.2.6	RR	For acute events, have incident investigations been initiated as promptly as possible and always within 48 hours?	
2.2.7	I-PTM I-SRQM I-GM	How soon must an investigation be conducted following a report of an incident?	
2.2.8	RR I-PTM	Was the subject and scope of each investigation clearly defined by the commissioning body?	
2.2.9	RR	Have incident investigation teams been established in accordance with the written incident investigation program?	
2.2.10	RR	Do the teams contain at least one person knowledgeable in the process/system/equipment involved in the loss and other members with appropriate knowledge and experience to thoroughly investigate and analyze the events?	

Incident Investigation/Root Cause Analysis Program Evaluation Checklist (continued)

Item Number	Data collection method*	Incident Investigation Analysis Program Evaluation Checklist	Comments
2.2.11	RR	Does each team contain personnel that are knowledgeable in the actual performance of the task and the desired performance of the task?	
2.2.12	RR	Is the makeup of each investigation team consistent with the classification guidance?	
2.2.13	I-PTM I-GM I-SRQM	How are incident investigation teams selected? Do the teams contain at least one person knowledgeable in the process and other persons with appropriate knowledge and experience to thoroughly investigate the incident?	
2.2.14	RR I-PTM	Are adequate resources and skills made available to the incident investigation teams, depending on the complexity or seriousness of the incidents?	
2.2.15	I-PTM I-SRQM	Do team members need any special skills and/or knowledge?	
2.2.16	I-PTM I-SRQM	Is any type of training provided to employees in incident investigation skills and techniques?	
2.2.17	RR I-SRQM	Do procedures allow for third-party participation in investigations and identify under what circumstances third parties might be required?	
3		**Data Collection, Preservation and Analysis**	
3.1	RR	Do guidelines exist for data preservation?	
3.2	RR	Do guidelines exist for data collection (interviews, electronic data, photographs, videotapes, test plans, etc.)?	

Incident Investigation/Root Cause Analysis Program Evaluation Checklist (continued)

Item Number	Data collection method*	Incident Investigation Analysis Program Evaluation Checklist	Comments
3.4	RR	Was data properly preserved for the team?	
3.5	I-PTM	Was access to the site restricted to prevent inadvertent alteration of the data?	
3.6	RR	Were photographs taken promptly, prior to alteration of the data?	
3.7	RR	Were data needs driven by the analysis needs?	
3.8	RR	Was a list of needed data developed and tracked?	
3.9	RR	Were data collection efforts prioritized by fragility of the data?	
3.10	RR I-PTM I-SRQM	Were appropriate physical, people, paper/electronic and position data examined by the team?	
3.11	RR I-GE	Were interviews conducted using questions that were: • Open-ended • Neutral • Non-threatening • Not leading	
3.12	RR	Did appropriate personnel perform interviews?	
3.13	RR	Were physical data analyzed in a controlled manner, using test plans as appropriate?	
3.14	RR	Was calibration data documented for any instruments used?	
3.15	RR	Was a chain-of-custody documented for all physical, paper and electronic data?	
3.16	RR	Were paper/electronic data identified by revision and inventoried?	
3.17	RR	Were photos properly marked and annotated and subsequently cataloged?	
3.18	RR	Were photos annotated to indicate relevant information (see specific photography guidelines in the MaRCAT Toolkit)?	
3.19	RR	Do photos show orientation and relative size?	

Incident Investigation/Root Cause Analysis Program Evaluation Checklist (continued)

Item Number	Data collection method*	Incident Investigation Analysis Program Evaluation Checklist	Comments
4		**Data Analysis Techniques**	
4.1	RR	Does the program identify specific techniques to determine the causes of incidents and to establish corrective actions to prevent recurrence?	
4.2	I-PTM	Is there a structured approach to incident investigation and near-miss investigation? Are there specific investigation methods that are used?	
4.3	RR	Are the methods consistently used when performing analyses?	
4.4	RR	Is a system used to ensure that logic questions are asked during the analysis?	
4.5	RR	Is logic used to ensure all required conditions and events are considered?	
4.6	RR	Are multiple causes explicitly considered by the methodologies?	
4.7	RR	Are the data specific to who, what, where, when, how?	
4.8	RR	Is the origin of data identified to allow assessment of its level of certainty – guess, hearsay, opinion, logical conclusion, "fact"?	
4.9	RR	Are multiple levels of causes identified?	
4.10	RR	Is each level of cause specifically and logically connected to the next level of cause?	
4.11	RR	Are data used to verify and refute hypotheses when using a fault tree approach?	
4.12	RR	Are logic tests used in addition to the time-based prompts for time-based approaches?	

Incident Investigation/Root Cause Analysis Program Evaluation Checklist (continued)

Item Number	Data collection method*	Incident Investigation Analysis Program Evaluation Checklist	Comments
5		**Root Cause Identification** Note: Some methods do not specifically identify root causes. They are just deeper causes in a continuum of causes	
5.1	RR	Does each root cause identify: • Something that management can control (so a recommendation can be written to address the cause)? • A basic, underlying cause?	
5.2	RR	Is each root cause associated with a causal factor or observation?	
5.3	RR	Are root causes associated with management system issues?	
5.4	RR	Are multiple root causes identified?	
5.5	I-PTM	What is a root cause? Can you provide some examples?	
6		**Developing Recommendations**	
6.1	RR	Is each recommendation tied to a cause (causal factor and/or root cause)?	
6.2	RR	Are recommendations developed to address all four levels of recommendations (as appropriate)?	
6.3	RR	Are recommendations developed at the highest level practical in the recommendation hierarchy?	
6.4	RR	Are recommendations assigned to specific individuals for implementation? Are specific completion dates assigned?	
6.5	I-SRQM	After an incident is investigated, how are human factors deficiencies corrected at the point of the event? At other locations?	

Incident Investigation/Root Cause Analysis Program Evaluation Checklist (continued)

Item Number	Data collection method*	Incident Investigation Analysis Program Evaluation Checklist	Comments
7		**Completing the Investigation**	
7.1	RR	Reports should include key information • Date and time of the incident • Date and time the investigation began • Description of event • Causal factors (factors that contributed to the incident) • Underlying causes (root causes) • Recommendations	
7.2	I-PTM	What items are addressed/included in the report? Are there specific items that should be excluded from the report?	
7.3	RR	Are the analysis tools (CFC, 5-Whys and FTA) used to reduce the effort required to write the report?	
7.4	RR	Are the report-writing guidelines and report checklist in the MaRCAT Toolkit used?	
7.5	RR	Is the effectiveness of selected recommendations assessed by monitoring a leading indicator?	
7.6	RR	Is the investigation process periodically critiqued?	
7.7	RR	Do analyses result in a signed-off report and recommendations?	
7.8	I-PTM	What type of report is generated following an incident investigation?	
7.9	RR I-SRQM	How long does it take for a typical investigation to be completed?	
7.10	RR	Has a system been established to promptly address and resolve the incident investigation report findings and recommendations?	

Incident Investigation/Root Cause Analysis Program Evaluation Checklist (continued)

Item Number	Data collection method*	Incident Investigation Analysis Program Evaluation Checklist	Comments
7.11	RR	Have resolutions and corrective actions from incident investigation reports been documented? Who is assigned the responsibility of maintaining these records?	
7.12	I-PTM	Is documentation maintained regarding the resolution of incident investigation findings? If so, how, where? Can you find one for me?	
7.13	RR I-SRQM	Are recommendations reviewed in accordance with the organization's management of change process? Does the health and safety organization review the recommendations for potential impact on worker safety, facility safety and environmental impact? Are recommendations reviewed by the quality organization for potential impact on customer satisfaction?	
7.14	RR	Are recommendations completed in accordance with the assigned completion dates? How many times are completion dates revised before a recommendation is completed?	
7.15	I-GE	Are corrective actions completed in a timely manner following completion of analyses?	
7.16	I-SRQM	Are there enforced time limits for completing recommendations from incident investigations?	
7.17	RR	Are investigation records available to employees and safety, quality and/or reliability committee members?	
7.18	RR	Have incident investigation reports been reviewed with all affected personnel whose job tasks are relevant to the investigation findings, including contract employees, where applicable? • Are there minutes of meetings or other evidence of communicating the results of incident investigation reports to affected personnel?	

Incident Investigation/Root Cause Analysis Program Evaluation Checklist (continued)

Item Number	Data collection method*	Incident Investigation Analysis Program Evaluation Checklist	Comments
7.19	I-PTM	How are lessons learned disseminated throughout the company? Are there requirements?	
7.20	I-EA	How do affected personnel find out about the results of incident investigations?	
7.21	RR I-SRQM	Are incident investigation reports and recommendations communicated to the safety, health and quality organizations?	
7.22	I-GE	How do you find out about the results of incident investigations that occur in your work area?	
7.23	I-GE	Are the findings uncovered during incident investigations addressed in a timely manner?	
7.24	I-PTM	Are incident investigation reports maintained for any specific period of time? If so, how long?	
7.25	I-SRQM	Are reporting statistics highly publicized?	
8		**Selecting Problems for Analysis**	
8.1	RR	Are personnel encouraged to report problems and unsafe conditions? • Is there any fear of reprisal? • Is there a proactive management philosophy of not placing blame for incidents in order to ensure openness, cooperation and volunteering of information from employees?	
8.2	I-GE	Were you ever involved in an accident or incident? If so: • Did you report it? Why or why not? • Was the incident investigated?	

Incident Investigation/Root Cause Analysis Program Evaluation Checklist (continued)

Item Number	Data collection method*	Incident Investigation Analysis Program Evaluation Checklist	Comments
8.3	I-GE	Are you reluctant to seek medical treatment for a minor injury? Why?	
8.4	I-GE	Are you reluctant to report problems you see? Why?	
8.5	I-GE	Is there training on how to report?	
8.6	I-GE	What major problems have you seen here?	
8.7	I-GE	What near-miss incidents have you witnessed or heard about?	
8.8	I-GE	Are loss events and near misses investigated?	
8.9	I-GE	What is your definition of a near miss?	
8.10	I-SRQM	How are personnel encouraged to report?	
8.11	I-SRQM	Is there training on how to report?	
8.12	I-SRQM	Who is accountable for incident investigation and near-miss reporting?	
8.13	I-SRQM	What criteria and procedures exist for reporting and investigating accidents and near misses?	
8.14	I-SRQM	Are they followed consistently?	
8.15	RR	Does the organization have a documented method for selecting incidents for analysis (acute or chronic analysis)?	
8.16	I-SRQM	How is it decided to undertake a detailed investigation? Is the selection method used?	
8.17	RR	Have analyses of chronic problems been performed?	
8.18	RR	Is the near miss to incident ratio high (greater than 10)?	
8.19	I-SRQM	Are relevant statistics compiled from incident investigation reports?	
8.20	I-SRQM	Are reporting levels appropriate?	

Incident Investigation/Root Cause Analysis Program Evaluation Checklist (continued)

Item Number	Data collection method*	Incident Investigation Analysis Program Evaluation Checklist	Comments
9		**Trending**	
9.1	RR	Are methods in place to periodically review performance data to identify chronic problems? Are the review methods structured? Are the reviews scheduled? Have the reviews been completed in accordance with the schedule?	
9.2	RR	Does the company collect data related to each incident?	
9.3	RR	Is a database established for recording and analyzing incidents to develop trend information?	
9.4	I-SRQM	Are data on human errors collected and made available to managers? How is this information used?	
9.5	I-SRQM	What formal measures of safety/reliability/quality performance are tracked? Have the data been used as the basis for any management decisions?	
9.6	I-SRQM	What is the current safety/reliability/quality performance of the facility?	
9.7	I-SRQM	Is this record better or worse than your historical one?	
9.8	I-SRQM	Is this record better or worse than your goals?	
9.9	RR	Does the organization have a documented method for selecting chronic incidents for analysis?	
9.10	RR	Is the selection method used?	
9.11	RR	Is someone assigned the responsibility for analyzing data for chronic incidents?	
9.12	RR	Is chronic data analysis performed periodically?	
9.13	RR	Have selected recommendations been selected for results assessment?	
9.14	RR	Is someone assigned the responsibility of performing long-term results assessment?	
9.15	RR	Are analyses being performed to assess the effectiveness of recommendations?	
9.16	I-SRQM	Have the data from incident investigations been used as the basis for any management decisions?	

Incident Investigation/Root Cause Analysis Program Evaluation Checklist (continued)

Item Number	Data collection method*	Incident Investigation Analysis Program Evaluation Checklist	Comments
10		**Investigation Programs**	
10.1	RR	Does the incident investigation program address the interface with investigation of health, safety, reliability and quality problems?	
10.2	RR	Does the organization have established training and experience requirements for investigation team leader(s) and members? Do the training requirements address both initial and ongoing training?	
10.3	RR	Are training requirements established for all members of the organization (including those that do not perform incident investigations)? As a minimum, do these training requirements include the types of incidents to report and how to preserve evidence? Is ongoing training required for investigation team leaders?	
10.4	RR	Does the organization have assigned responsibilities for reporting and investigating incidents, selecting team members, following-up and closing out of action items and training/communicating the results of incident investigations?	
10.5	RR	Has the incident investigation program been revised recently? Are all the requirements current?	
10.6	RR	Has each incident been investigated that exceeded the thresholds defined in the incident investigation program?	
10.7	RR	Does the program meet all appropriate regulatory requirements?	
10.8	RR I-PTM I-SRQM	Has management taken an active role in ensuring the program is functional?	
10.9	I-PTM I-SRQM	What criteria does management use to evaluate an analysis?	

Incident Investigation/Root Cause Analysis Program Evaluation Checklist (continued)

Item Number	Data collection method*	Incident Investigation Analysis Program Evaluation Checklist	Comments
10.10	I-PTM I-SRQM	Has management defined a goal for the investigation program?	
10.11	I-PTM I-SRQM	Who is the organizational champion for the program?	
10.12	I-PTM	What are the perceived rewards and punishments for participating or leading an investigation team?	
10.13	RR	Has the role of the organization's legal department in investigations been defined?	
10.14	RR	Does the organization have someone assigned to address media requests related to an investigation?	
10.15	RR	Are reports written in a neutral, factual tone to avoid media and legal problems?	
10.16	I-GE	What do you think about the way incidents are investigated?	
10.17	I-GE	Have you been involved in an accident or near miss?	
10.18	RR	Are incident investigation reports retained until the next risk/reliability/safety assessment of the system?	
10.19	RR	How many incident investigations were performed in the last 3 years? Is the number of investigations increasing or decreasing?	
10.20	RR	Is management taking any actions to reduce the number of incidents? • If not, why not?	
10.21	I-SRQM	Do the investigations go into enough depth to identify the root causes of human errors and other failures?	

RR – Records Review
FV – Field Verification
I-PTM – Interview Members Of Past Investigation Teams
I-EE – Interview Employees Affected By Past Investigation Results
I-GE – Interview General Employees
I-SRQM – Interview Safety, Reliability and Quality Managers
I-ERM – Interview Emergency Response Team Manager

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APPENDIX 8 Cross References between ABS Root Cause Analysis Map and Industry Standards

This Appendix provides cross references between individual items on the ABS Marine Root Cause Analysis Map and a variety of marine standards. The purpose of this appendix is to give the reader a general idea of where different aspects of the various standards may relate to the items on the ABS Marine Root Cause Analysis Map. It should be noted that opinions may differ as to which aspects of the various standards relate to the different Root Cause Analysis Map Items. The tables below are provided as an aid rather than a definitive statement about the interrelationships of the standards and ABS Root Cause Analysis Map. The industry standards referenced in the table include:

TABLE 1 Referenced Standards

Document	*Referenced in Tables Below As:*
IMO's International Convention for the Safety of Life at Sea	SOLAS
IMO's SOLAS Chapter IX, Management for the Safe Operation of Ships (also known as International Safety Management Code)	ISM
IMO's Standards for Training, Certification and Watchkeeping Code	STCW
IMO'S SOLAS Chapter XI-2, Special Measures to Enhance Marine Safety (also known as International Ship and Port Facility Security Code)	ISPS
ISO 9001: 2000, Quality Management Systems – Requirements	9001
ISO 14001: 2004, Environmental management systems - Specification with guidelines for use	14001
OCIMF TMSA, Oil Companies International Marine Forum Tanker Management and Self Assessment: A Best Practice Guide for Ship Operators	TMSA
OHSAS 18001:1999 Occupational Health and Safety Management Systems. Specifications	OHSAS
API RP 75, Recommended Practice for Development of a Safety and Environmental Management Program for Offshore Operations and Facilities	SEMP
ABS Guide for Marine Health, Safety, Quality and Environmental Management	See ISM, ISO references

TABLE 2
Problem Types

Problem	*Map Item #*	*Standards Reference*
Structural	1	ISM 10
Machinery/Equipment	2	ISM 10
Outfitting	3	
Human	4	
External	5	

TABLE 3
Problem Categories

Problem Categories	*Map Item #*	*Standards Reference*
Design Problem	6	
Reliability Program Problem	7	ISM 10
Misuse/Overload Problem	8	ISM 7
Installation/Fabrication Problem	9	
Permanent/Returning Officers/Crew	10	
Newly Assigned/Contract/Temporary Officers/Crew	11	
Company Employee	12	
Other (Third Party Employee)	13	
Uncharted/Unknown Hazard to Navigation	14	
Sea/Weather Condition	15	
Sabotage/Terrorism/War	16	ISPS Code, SOLAS Chapter XI-2
Suicide/Homicide	17	
External Events	18	
Other	19	

TABLE 4
Design Input/Output Cause Category with Cause Types and Intermediate Causes

	Map Item #	ISM	STCW	ISO	TMSA	SEMP	OHSAS
Design Input/Output Cause Category	20			9001: 7.3	**6A:** 4.1 **10B:** 4.1	2.3.5., 3.3.2, 4.2.a, 8.3	
Design Input Issue	21			9001: 7.3			
• Design Scope Unclear	22			9001: 7.3			
• Design Input Obsolete	23			9001: 7.3			
• Design Input Incorrect	24			9001: 7.3			
• Necessary Design Input Not Available	25			9001: 7.3			
Design Output Issue	26			9001: 7.3			
• Design Output Not Clear	27			9001: 7.3			
• Design Output Incorrect	28			9001: 7.3			
• Design Output Inconsistent	29			9001: 7.3			
• Design Input Not Addressed in Design Output	30			9001: 7.3			

TABLE 5
Design Review/Verification Cause Category with Cause Types and Intermediate Causes

	Map Item #	ISM	STCW	ISO	TMSA	SEMP	Other
Design Review/Verification Cause Category	31			9001: 7.3		8.3, 9.1.a	
No Independent Review/Verification	32			9001: 7.3			
Review Verification Issue	33			9001: 7.3			

TABLE 6
Maintenance Program Design Cause Category with Cause Types and Intermediate Causes

	Map Item #	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Maintenance Program Design Type Cause Category	34	10		14001: 4.4.6	**4A:** 1.2 **12A:** 1.1, 1.2, 2.1, 2.2		4.4.6
No Program	35	10		14001: 4.4.6			4.4.6
Program Inadequacy	36	10		14001: 4.4.6	**4B:** 4.1 **10B:** 2.1	8.1, 8.5, 8.6.a	4.4.6
• Critical Equipment/System Not Identified	37	10.3		14001: 4.4.6	**4B**:1.1, 2.1		4.4.6
• Inappropriate Maintenance Type Applied	38	10		14001: 4.4.6			4.4.6
• Acceptance Criteria Inadequate	39	10		14001: 4.4.6			4.4.6

TABLE 7
Maintenance Program Implementation Cause Category with Cause Types and Intermediate Causes

	Map Item #	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Maintenance Program Implementation Cause Category	40	10		14001: 4.4.6	**4A**: 1.1, 1.2, 1.3, 2.2, 2.3, 2.5, 3.1, 3.2, 3.3, 4.1, 4.3 **4B**: 4.2, 4.3 **4C**: 1.1, 2.1, 3.1, 4.1 **5A**: 2.1	1.2.1.g, all of Sec 8	4.4.6
Planned Maintenance Issue	41	10.2		14001: 4.4.6	**4A:** 4.3 **4B:** 1.2, 3.1, 3.2 **6B:** 1.1, 1.2		4.4.6
• Scheduling Issue	42	10.2.1		14001: 4.4.6			4.4.6
• Scope Issue	43	10.1		14001: 4.4.6			4.4.6
• Implementation Issue	44	10.1		14001: 4.4.6			4.4.6

TABLE 7 (continued)
Maintenance Program Implementation Cause Category with Cause Types and Intermediate Causes

Maintenance Program Implementation Cause Category	*Map Item #*	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Condition Monitoring Maintenance Issue	45	10.2		14001: 4.4.6	**4A:** 4.3 **6B:** 1.2		4.4.6
• Scheduling Issue	46	10.2.1		14001: 4.4.6			4.4.6
• Detection Issue	47	10.2		14001: 4.4.6			4.4.6
• Monitoring Issue	48			9000: 8.2.3 14001: 4.5.1			4.5.1
• Troubleshooting/Corrective Action Issue	49	9		9001: 8.5.2 14001: 4.5.2			4.5.2
• Implementation Issue	50	10.1		14001: 4.4.6			4.4.6
Shore-based Maintenance Issue	51	10		14001: 4.4.6	**4A:** 4.3		4.4.6
• Event Specification Issue	52	10.2.1					
• Scheduling Issue	53	10.1					
• Scope Issue	54	10.1					
• Implementation Issue	55	10.1		14001: 4.4.6			4.4.6
Corrective Maintenance	56	10.2.2, 10.2.3			**4B**: 1.1		
• Troubleshooting/Corrective Action Issue	57	10.2.3					
• Repair Implementation Issue	58	10.2.3		9001: 8.2.3 14001: 4.5.1			4.5.1
Failure Finding Maintenance Issue	59	10.2.1, 10.3		9001: 8.2.3 14001: 4.5.1		8.5	4.5.1
• Scheduling Issue	60	10.4, 10.2.1		9001:. 8.2.3 14001: 4.5.1			4.5.1
• Scope Issue	61	10.1		9001: 8.2.3 14001: 4.5.1			4.5.1
• Troubleshooting/Corrective Action Issue	62	10.2.3					
• Implementation Issue	63	10.1		9001: 8.2.3 14001: 4.5.1	**4B:** 4.3 **12A:** All		4.5.1

TABLE 7 (continued)
Maintenance Program Implementation Cause Category with Cause Types and Intermediate Causes

Maintenance Program Implementation Cause Category	*Map Item #*	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Servicing and Routine Inspection Issue	64	10.2.1		9001: 8.2.3 14001: 4.5.1	**4A:** 4.3 **6A:** 2.2	8.5	4.5.1
• Scheduling/Frequency Issue	65	10.2.1		9001: 8.2.3 14001: 4.5.1			4.5.1
• Scope Issue	66	10.1		9001: 8.2.3 14001: 4.5.1			4.5.1
• Implementation Issue	67	10.1		9001: 8.2.3 14001: 4.5.1			4.5.1

TABLE 8
Equipment Records Cause Category with Cause Types and Intermediate Causes

	Map Item #	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Equipment Records Cause Category	68	11		9001: 4.2.1, 4.2.3 14001: 4.4.5	**4A:** 2.3 **4B**: 3.3 **6A:** 2.2, 2.3 **12A:** 3.2	2.3.1, 2.3.4, 4.2.f, 8.5.c	4.4.5
Equipment Design Records	69			9001: 7.3	**4B**: 3.4		
Manufacturers Manuals	70	11.2.1		9001: 4.2.1, 4.2.3 14001: 4.4.5			4.4.5
Equipment Operating/Maintenance History	71	11.1		9001: 4.2.1, 4.2.3 14001: 4.4.5	**4A:** 2.3, 2.5, 3.1, 3.2, 3.3, 4.1 **4B:** 3.3, **5A**: 2.1 **6B:** 1.2	4.1, 8.6.c, 13.3.f	4.4.5

TABLE 9
Management Systems Cause Category with Cause Types and Intermediate Causes

	Map Item #	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Management Systems Cause Category	72	7		9001: 4.2. 14001: 4.4.5		1.2	4.4.5
Health, Safety, Environment Issue	73	10.3			**1A:** 4.1 **1B:** 3.1, 4.1, 4.2, 4.3 **3A**: 2.5, 3.5 4.4 **3B:** 3.3 **5A:** 1.3, 2.2, 2.3, 4.1, 4.2 **6A:** 1.1, 1.3, **6B:** 3.1 **8B:** All **9A:** 3.3 **9B:** 1.1, 1.2, 1.3, 2.1, **10A:** 1.1, 1,2, 1.3, 2.3 **10B:** 1.1 thru 3.1, 3.3 **12B:** All	1.2.1 k, 5.2.d, 6.1, Section 11	
• No Program	74	10.3					
• Program Inadequate/Not Specific Enough	75	10.3					
• Management Inadequate	76	10.3			**9B:** 3.1, 3.2		
• Recordkeeping Issue	77	11			**6B:** 3.1 **9A:** 2.2	All of Sec.13	
• No/Poor/Spill/Emergency Contingency Plans	78	7			**11A:** All **11B:** All	1.2.1.i, 7.1, all of Sect 10, 13.3 i	
• No/Inadequate Job Safety Analyses	79	9			**6B:** 3.1 **7B:** 1.1, 3.2 **9A:** 2.1, 2.3, 2.4, 2.5, 3.2 **9B:** 1.4, 2.3		
• No/Inadequate Safe Work Practices	80	3.2			**9A:** 1.4	1.2.1.e, all of Sec. 6., 7.1, 8.5 a, 9.1 g	

TABLE 9 (continued)
Management Systems Cause Category with Cause Types and Intermediate Causes

Management Systems Cause Category	*Map Item #*	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Human Resource Issue	81	6		9001: 6.2.1, 6.2.2 14001: 4.4.2	**2A:** 1.2, 1.3, 1.4, 2.2, 4.1, **3A:** 1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3, 3.4, 4.1, 4.2, 4.3, 4.5 **3B**: 1.1, 3.1, 3.2, 4.1, 4.2	4.3, 7.2.2	4.4.2
• Employee Screening/Hiring Issue	82	6.2		9001: 6.2.1, 6.2.2 14001: 4.4.2	**2A:** 1.3, 1.4		4.4.2
• Resource/Staffing Issue	83	6		9001: 6.2.1, 6.2.2 14001: 4.4.2	**2A:** 3.2 **3B**: 1.1, 1.2, 1.3, 4.1, 4.2	1.2.1h, 3.5	4.4.2
• Safety/Hazard/Risk/Security Review Issue	84	10.3			**5A**: 1.1, 2.2, 4.1, 4.2 **7B:** 1.1, 3.2 **9A:** 1.1, 1.2, 1.3, 2.1, 2.3, 2.5, 3.2, 4.1, 4.2 **9B:** 1.1, 1.4, 2.3	1.2.1b 2.2.2, 2.3.3, all of Sec. 3, 5.2.c, 6.3, 8.6.c, all of Sec. 9	
• Review Skipped or Incomplete	85					2.2.2	
• Recommendations Not Yet Implemented	86						
• Risk Acceptance Criteria Issue	87						
• Ineffective Review	88						
Problem Identification/Control Issue	89	12		9001: 8.5.2 14001: 4.4.2	**3A:** 3.3 **4A:** 1.3, 2.2, 2.4, 3.2 **4B:** 1.1 **5A:** 2.1, 2.2, 2.3, 4.1, 4.2 **9A:** 1.1, 1.2, 1.3, 2.5, 3.1, 3.4 **9B:** 1.2 **10A:** 3.1 **12A:** 3.2 **12B:** All	1.2.1k, 3.6, 7.5, 8.6.d	4.5.2 4.4.2
• Problem Reporting Issue	90	9.1, 10.2.2 9		14001: 4.4.3			4.4.3
• Problem Analysis Issue	91	9.1, 12.2.					

TABLE 9 (continued)
Management Systems Cause Category with Cause Types and Intermediate Causes

Management Systems Cause Category	*Map Item #*	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
• Audit Issue	92	12.1, 12.3		9001: 8.2.2 14001: 4.4.5	**4A:** 2.4 **9A:** 3.1, 3.4 **12B:** All	All of Sec.12	4.5.4 4.4.5
• Corrective Actions Ineffective	93	9.1, 10.2.3		9001: 8.5.2, 8.5.3 14001: 4.4.2			4.5.2 4.4.2
• Corrective Actions not Implemented	94	9.2, 12.3, 12.6		9001: 8.5.2, 8.5.3 14001: 4.4.2			4.5.2 4.4.2
Change Control Issue	95			9001: 7.3.7	**7A:** 1.1, 1.2, 2.1, 2.2, 2.3, 3.1, 3.2, 4.1, 4.2 **7B:** 1.1, 2.1, 3.1, 3.2, 4.1, 4.2	1.2.1c, 3.4, all of Sec. 4, 5.3, 7.4, 8.5.d, 8.6.e, 9.1.f,	
• Change Not Identified	96						
• Change Review Issue	97						
• Change Verification Issue	98						
• Change Not Documented	99	11		9001: 4.2 14001: 4.4.5	**7A:** 2.3 **7B:** 2.1	12.6	4.4.5
Document/Drawing Control Issue	100	11		9001: 4.2 14001: 4.4.5	**1B:** 1.1 **9A:** 2.2 **4A:** 2.1 **7A:** 3.1 **12B:** 3.1	1.2.1.1 2.2.1, 2.2.2, 2.3.1, 3.6, 9.1.c, all of Sec. 13	4.4.5
• Documentation Content Inaccurate or Incomplete	101	11		9001: 4.2 14001: 4.4.5			4.4.5
• Required Documents not Available or Missing	102	11.2.1		9001: 4.2 14001: 4.4.5			4.4.5
• Obsolete Documents being used	103	11.2.1, 11.2.3		9001: 4.2 14001: 4.4.5			4.4.5
• Change Review or Approval Not Performed	104	11.2.2		9001: 4.2 14001: 4.4.5			4.4.5

TABLE 9 (continued)
Management Systems Cause Category with Cause Types and Intermediate Causes

Management Systems Cause Category	*Map Item #*	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Vessel Spares/Stores Issue	105			9001: 7.5.4	**4A:** 3.1, 4.2 **10B:** 2.1		
• Handling Issue	106			9001: 7.5.2			
• Storage Issue	107			9001: 7.5.4			
• Packaging/Transport Issue	108			9001: 7.5.4			
• Substitution Issue	109						
• Inventory Issue	110	10		14001: 4.4.6		1.2.1.a	4.4.6
• Inspection Issue	111			9001: 7.5.3			
Purchasing Issue	112			Part of Operational Controls under 14001: 4.4.6 9001: 7.4.1	**5A:** 2.4	6.3, 8.2, 8.5.c, 13.3.g	4.4.6
• Purchasing Specification Issue	113			9001: 7.4.2			
• Changes to Purchasing Specifications	114			9001: 7.4			
• Supplier/Contractor Selection Issue	115			9001: 7.4.1	**10B:** 4.2	1.1.2, 6.1, 6.2, 6.4, 7.5, App. A	
• Inspection on Receipt Issue	116			9001: 7.4.3			
Charter/Contract Fulfillment Issue	117			9001: 5.5.6			
• Charter Requirements not Documented/ Communicated	118			9001: 5.5.6			
• Vessel Not Suitable for Charter Requirements	119			9001: 5.5.6			

TABLE 10
Procedures Cause Category with Cause Types and Intermediate Causes

	Map Item #	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Procedures Cause Category	120	7, 11.2.1		9001: 4.2 14001: 4.4.5	**1A:** 2.3 **1B:** 1.4, 2.1, 2.2, 3.2 **5A:** 1.1, 1.4, 3.4, **6A:** 1.1, 1.3, 2.1, 2.4, 3.1, 3.2 **6B**: 1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 3.2, 4.1 **7A:** 1.2, 3.4, 2.5, 3.2 **8A:** All **8B:** 3.1	1.2.1d 1.2.4, 3.3.2.e, all of Sec. 5, 6.3, 7.1, 7.2.2, 8.5.a, 9.1.b, Sec. 11	4.3.4 4.4.4 4.4.5
Not Used	121	11.2.1		9001: 4.2 14001: 4.4.5	**1B:** 1.3, 2.1 **8B:** 3.1	8.3	4.3.4 4.4.4 4.4.5
• No Procedure for Task or Operation	122	11.2.1		9001: 4.2 14001: 4.4.5	**6B:** 1.1, 1.3, 2.1, 2.2, 2.3, 3.2, 4.1 **7A**: 2.4, 2.5		4.3.4 4.4.4 4.4.5
• Procedure Not Readily Available or Inconvenient to Obtain	123	11.2.1		9001: 4.2 14001: 4.4.5	**1B**: 1.3		4.3.4 4.4.4 4.4.5
• Language Difficulty	124	6.6					
Misleading or Confusing	125				**1B**: 2.1		
• Format Confusing/Complex/Difficult to Use	126						
• Multiple Actions per Step	127						
• No Check off Space Provided but Should Be	128	7		9001: 7.5.1			4.4.6
• Content Issue	129	7		9001: 7.5.1			4.4.6
• Graphics/Drawing Issue	130						
• Ambiguous/Confusing Language/Wording Issue	131	5.1.3		9001: 7 14001: 4.5.1			4.4 4.5.1

TABLE 10 (continued)
Procedures Cause Category with Cause Types and Intermediate Causes

Procedures Cause Category	*Map Item #*	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
• Insufficient or Excessive References	132			9001: 7 14001: 4.5.1			4.4 4.5.1
• Too Much/Little Detail	133			9001: 7 14001: 4.5.1			4.4 4.5.1
• Procedure Difficult to Identify	134			9001: 7 14001: 4.5.1			4.4 4.5.1
Wrong/Incomplete	135			9001: 7 14001: 4.5.1	**1B**: 2.1		4.4 4.5.1
• Typographical Error	136			9001: 7 14001: 4.5.1			4.4 4.5.1
• Wrong Action Sequence	137			9001: 7 14001: 4.5.1			4.4 4.5.1
• Facts Wrong/Requirements Incorrect	138			9001: 7 14001: 4.5.1			4.4 4.5.1
• Obsolete Version Used	139	11.2.3		9001: 4.2 14001: 4.4.5			4.4 4.5.1
• Inconsistency between Requirements	140			9001: 7 14001: 4.5.1			4.4 4.5.1
• Incomplete/Situation Not Covered	141	11.2.3		9001: 4.2 14001: 4.4.5			4.4 4.5.1
• Overlap or Gaps between Procedures	142						

TABLE 11
Human Factors Cause Category with Cause Types and Intermediate Causes

	Map Item #	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Human Factors Cause Category	143					2.3.5, 6.1, 8.1	
Workload	144				**3B:** 1.2		
• Sustained High Workload/Fatigue	145		Section A-VIII/1				
• Excessive Action Requirements	146						
• Unrealistic Monitoring Requirements	147						
• Insufficient Time to Respond	148						
• High Transient Workload	149						
Situation Awareness	150						
• Information Incomplete/Unusable	151						
• Information Inaccurate	152						
• Information Inaccessible	153	11.2.1		9001: 4.2 14001: 4.4.5			4.3.4, 4.4.4, 4.4.5
• Information Unverified	154						
• Alarm/Signal Issue	155	10.3		9001: 7 14001: 4.5.1			4.4, 4.5.1
• Excessive Complex Calculations Required	156						
• Knowledge-based Decision Requirement	157						
Work Environment	158						
Ambient Conditions Issue	159						
Protective Clothing/Equipment Issue	160						
Slippery/Unsteady Work Surfaces	161						
Housekeeping Issues	162						
Tool Issue	163						
Other Excessive Workplace Stresses	164						

TABLE 11 (continued)
Human Factors Cause Category with Cause Types and Intermediate Causes

Human Factors Cause Category	*Map Item #*	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Workspace Layout	165						
• Individual Control/Displays/Alarm Issue	166					2.3.5, 8.1	
• Control/Display/Alarm Integration/ Arrangement Issue	167						
• Awkward/Inconvenient/Inaccessible Location of Control/Display/Alarm	168						
• Inconsistent/Mirrored Layout	169						
• Awkward/Inconvenient/Inaccessible Equipment Location	170				**5A:** 4.3		
• Poor/Illegible Labeling of Equipment or Space	171						
• Labeling Language Issue	172						
• Poor Accessibility	173						
• Inadequate Visibility/Line of Sight	174						
Intolerant System	175						
• Errors not Detectable	176						
• Errors can not be Corrected/Mitigated	177						

TABLE 12
Training/Personnel Qualifications Cause Category with Cause Types and Intermediate Causes

	Map Item #	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Training/Personnel Qualifications Cause Category	178	6.1.1, 6.2. 6.3, 6.4, 6.5	All	9001: 6.2.1, 6.2.2 14001: 4.4.2	**1A:** 2.3 **2A:** 1.1, 2.2, 4.1, 4.4 **3B:** 1.3, 2.1, 3.4, 4.3 **5A:** 3.2, 3.3 **6A:** 3.2, 4.2 **7A:** 2.2, 3.2 **8B:** 1.1, 2.1, 4.1 **9B:** 2.3, 3.3	1.2.1 f 1.2.4, 3.5, 3.6, 5.3, 6.3, all of Sec. 7, 8.5.b, 9.1.e	4.4.2
No Training	179	6.3, 6.5	All	9001: 6.2.1, 6.2.2 14001: 4.4.2	**2A:** 2.2, 3.1 **3B:** 3.3 **8B:** 3.2		4.4.2
• Decision not to Train	180	6.3, 6.5	All	9001: 6.2.1, 6.2.2 14001: 4.4.2			4.4.2
• Management Systems (MS) Familiarization Not Provided	181	6.3					
• Training Requirements Not Fulfilled	182	6.5, 8.2		9001: 6.2.2 14001: 4.4.2			4.4.2
• Training Need not Identified	183	6.5		9001: 6.2.2 14001: 4.4.2	**3B:** 2.3		4.4.2
Training Records System Issue	184	6.5		9001: 6.2.2 14001: 4.4.2	**2A**: 2.3 **3B:** 2.2	13.3.c	4.4.2
• Training Records Incorrect	185			9001: 6.2.2			4.4.2
• Training Certificate/Endorsement Expired/ Invalid	186	6.2		9001: 6.2.2			4.4.2

TABLE 12 (continued)
Training/Personnel Qualifications Cause Category with Cause Types and Intermediate Causes

Training/Personnel Qualifications Cause Category	*Map Item #*	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Training Issue	187	6.2, 6.5	A-I/6 and applicable sections following A-I/6	9001: 6.2.2	**2A**: 2.2, 3.1, 4.3, 4.4 **3B:** 2.4, 3.3 **5A:**4.3 **8B:**3.2 **9B:** 4.3	7.2.2.d,f	4.4.2
• Training Program Design/Objectives Issue	188	6.5	A-I/6 and applicable sections following A-I/6	9001: 6.2.2			4.4.2
• Content Issue	189	6.5	A-I/6 and applicable sections following A-I/6	9001: 6.2.2			4.4.2
• On-the-Job Training Issue	190	6.5	A-I/6 and applicable sections following A-I/6	9001: 6.2.2			4.4.2
• Qualification Testing Issue	191	6.5	A-I/6 and applicable sections following A-I/6	9001: 6.2.2			4.4.2
• Continuing Training Issue	192				**2A**: 3.1		4.4.2
• Emergency Preparedness Training Issue	193				**9B:** 2.2 **11A:** 2.2	10.4	
• Special Operations Training Issue	194						4.4.2
Qualifications Issue	195	6.2			**2A**: 1.3, 1.4,	7.2.2	
• No license/certificate	196	6.2					
• Expired license/certificate	197	6.2					
• Forged Document	198	6.2					
• Unclear license/certificate/endorsement requirement	199	6.2					

TABLE 13
Responsibility/Authority Cause Category with Cause Types and Intermediate Causes

	Map Item #	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Responsibility/Authority Cause Category	200	3.2, 4, 5, 6.1.1, 6.2 3.2, 5.1, 5.2		9001: 5.5.2 14001: 4.4.1	**1B:** 3.3 **5A:** 1.2 **6A:** 1.2 **4A:** 4.1	5.2.a, 10.2	4.4.1
Responsibility/Authority Not Defined	201	3.2, 5.1, 5.2		14001: 4.4.1 9001: 5.5.2			4.4.1
Responsibility/Authority Unclear	202	3.2, 5.1, 5.2		9001: 5.5.2 14001: 4.4.1			4.4.1
• Ambiguous	203	3.2, 5.1, 5.2		9001: 5.5.2 14001: 4.4.1			4.4.1
• Conflicting/Overlapping	204	3.2, 5.1, 5.2		9001: 5.5.2 14001: 4.4.1			4.4.1
• Not Documented	205	3.2, 5.1, 5.2		9001: 5.5.2 14001: 4.4.1			4.4.1

TABLE 14
Human Factors Cause Category with Cause Types and Intermediate Causes

	Map Item #	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Operations/Job Supervision Cause Category	206	7	A-VIII/2 and 3	9001: 7.5.1	**3A:** 1.1	6.3	SOLAS Ch V: Reg. 15 OHSAS 4.4.6
Preparation	207	7		9001: 7.5.1			OHSAS 4.4.6
• Planning, Scheduling or Tracking of Work Activities Issue	208	7	A-VIII/2	9001: 7.5.1			OHSAS 4.4.6
• No Preparation	209	7	A-VIII/2	9001: 7.5.1			OHSAS 4.4.6
• Unclear Instructions to Personnel	210	7	A-VIII/3	9001: 7.5.1			OHSAS 4.4.6
• Ineffective Walk-through	211	7	A-VIII/3	9001: 7.5.1			OHSAS 4.4.6
• Scheduling/Rotation Issue	212				**2A**: 4.3		
• Personnel Selection/Assignment Issue	213	6.3	A-VIII/3	9001: .1 14001: 4.4.2	**3A:** 1.1 **4B:** 3.4 **5A:** 1.2		OHSAS 4.4.2
Supervision During Work	214	5	A-VIII/3	9001: 5.5.2 14001: 4.4.1		7.5	OHSAS 4.4.1
• Insufficient Supervision	215	5	A-VIII/3	9001: 5.5.2 14001: 4.4.1			OHSAS 4.4.1
• Improper Performance Not Corrected	216	9	A-VIII/3	9001: 8.3 14001: 4.5.2			OHSAS 4.4.7
• Crew Coordination Issue	217		A-VIII/3				
• Fatigue Management Issue	218		A-VIII/3				
• Ineffective Teamwork	219		A-VIII/3				

TABLE 15
Communications Cause Category with Cause Types and Intermediate Causes

	Map Item #	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Communications Cause Category	220			9001: 5.5.3 14001: 4.4.3	**8A:** 1.1	1.2.4, 3.6	4.4.3
No Communications or Untimely	221			9001: 5.5.3 14001: 4.4.3	**1A:** 2.3 **7A:** 3.1 **9B:** 4.1, 4.2		4.4.3
• Method Unavailable or Inadequate	222			9001: 5.5.3 14001: 4.4.3			4.4.3
• Communication between Work Parties Issue	223			9001: 5.5.3 14001: 4.4.3			4.4.3
• Communication between Vessel and Owner Issue	224			9001: 5.5.3 14001: 4.4.3			4.4.3
• Communication with other Vessels	225			9001: 5.5.3 14001: 4.4.3			4.4.3
• Communication with Charterer Issue	226			9001: 5.5.3 14001: 4.4.3			4.4.3
• Communication with Parties Ashore Issue	227			9001: 5.5.3 14001: 4.4.3	**1A:** 2.3		4.4.3
Communication Misunderstood/Incorrect	228			9001: 5.5.3 14001: 4.4.3			4.4.3
• Standard Terminology Not Used	229	6.7					
• Language/Translation Issue	230	6.6		9001: 6.2.1			4.4.2
• Verification or Repeat-back Not Used	231	6.7					
• Long Message	232						
• Garbled Message	233						
• Wrong Instructions	234						

TABLE 15 (continued)
Communications Cause Category with Cause Types and Intermediate Causes

Communications Cause Category	*Map Item #*	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Bridge Team Management	235	7	A-VIII/3	9001: 7.5.1 14001: 4.4.6	**5A:** 1.1. 3.4		SOLAS Ch V: Reg. 15 OHSAS 4.4.3
• Unclear Communications	236		A-VIII/3	14001: 4.4.3			SOLAS Ch V: Reg. 15 OHSAS 4.4.3
• Information not Communicated	237		A-VIII/3				SOLAS Ch V: Reg. 15
• Information Ignored	238		A-VIII/3				SOLAS Ch V: Reg. 15
• Ambiguous Information	239		A-VIII/3				SOLAS Ch V: Reg. 15
• Communication with Pilot	240		A-VIII/3				SOLAS Ch V: Reg. 15
Duty/Watch Handover Issue	241		A-VIII/3	9001: 7.5.1 14001: 4.4.6			SOLAS Ch V: Reg. 15 OSHAS 4.4.6
• Communication within Watch Issue	242		A-VIII/3				SOLAS Ch V: Reg. 15
• Communication at Watch Turnover Issue	243		A-VIII/3				SOLAS Ch V: Reg. 15
• Personnel Change/Relief Procedure Issue	244		A-VIII/3				SOLAS Ch V: Reg. 15

TABLE 16
Communications Cause Category with Cause Types and Intermediate Causes

	Map Item #	*ISM*	*STCW*	*ISO*	*TMSA*	*SEMP*	*OHSAS*
Personnel Performance Cause Category	245			9001: 7.5.1	**2A**: 2.1, 4.2 **3A:** 2.1, 2.2, 3.1, 3.2		4.4.6
Company Issue	246				**2A**: 1.2		
• Inadequate Problem Detection/Situational Awareness	247	3					
• Rewards/Incentives Issue	248				**2A**: 4.1		
Individual Issue	249						
❋ Inadequate Sensory/Perceptual Abilities	250	6.2					
❋ Poor Reasoning	251						
❋ Inadequate Motor/Physical Capabilities	252	6.2					
❋ Disregard for Company Procedures/Policies	253						
❋ Inadequate Rest/Sleep (Fatigue)	254						
❋ Personal Medication Use/Abuse	255						

❋ These items are for descriptive purposes only. Code only to *Personnel Performance – Individual Issue*

TABLE 17
Company Standards, Policies or Administrative Controls (SPACs) Root Cause Types and Root Causes

	Map Item #	*Standards Reference*
Company Standards, Policies or Administrative Controls (SPACs) Issue	256	TMSA: **1A** **1B**: 1.2 **3A**: 4.3 **9B**: 3.1, 3.2 **10A**: 1.4, 2.1, 2.2, 3.2, 4.1, 4.2, 4.3 SEMP: 1.2.3, 1.4, 2.2.3
• No SPACs/Issue Not Addressed	257	-
• Not Strict Enough	258	-
• Confusing, Contradictory or Incomplete	259	-
• Technical Error	260	-

TABLE 18
Company Standards, Policies or Administrative Controls (SPACs) Not Used Root Cause Types and Root Causes

	Map Item #	*Standards Reference*
Company Standards, Policies or Administrative Controls (SPACs) Not Used	261	TMSA: **1A**: 2.1, 2.2, 3.1, 3.3, 4.1, 4.2, 4.3
• Tolerable Risk	262	-
• Unaware of SPACs	263	-
• Recently Changed SPACs	264	-
• Enforcement Issue	265	TMSA: **1A**:1.2

TABLE 19
Industry Standards Root Cause Types and Root Causes

	Map Item #	*Standards Reference*
Industry Standar Issue	266	TMSA: **10B:** 3.2 SEMP : 1.2.3, 1.5, 2.3.2, 2.3.3
• Situation Not Addressed by Standard	267	Not Applicable
• Standard Confusing, Contradictory (Internal or External) or Incomplete	268	Not Applicable
• Technical Concern with Standard	269	Not Applicable
• Inappropriate Standard Applied	270	Not Applicable

Guidance Notes on Investigation of Marine Incidents

We value your opinion regarding the ABS *Guidance Notes on Investigation of Marine Incidents*. Your input will be helpful for the future development of this document and other ABS publications. After you have had an opportunity to review these Guidance Notes, we would be grateful if you would take a few moments to complete and return this form.

Your assessment of these Guidance Notes:

1) Are the criteria or other guidance in these Guidance Notes presented in a clear, concise manner?
   Yes **No**

2) Does the content of these Guidance Notes adequately address your needs? **Yes** **No**

3) Is the format, layout and presentation of the criteria contained in these Guidance Notes well presented, clear and readable? **Yes** **No**

4) If you answered no to any of the above questions, please explain why and suggest improvements (please use additional space if necessary):____________________________________

5) Are there any health, safety, environmental or security topics, which were not addressed in these Guidance Notes that you would like to have addressed in future revisions? ______________________

Please tell us about yourself (or affix your business card):

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If you would like additional copies of these Guidance Notes, they can be downloaded from the ABS Internet site at http://www.eagle.org/rules/downloads.html. Select Publication 142 – ABS *Guidance Notes on the Investigation of Marine Incidents*.

Please feel free to contact us with any comments, questions or concerns regarding these Guidance Notes, and thank you very much for your time.

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