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Operational & Strategic Risk Management

PMG630

Lecture 3

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This chapter describes several common techniques and a principle used in managing operational risks. The techniques are Preliminary Hazard Analysis (PHA), Hazard and Operability Analysis (HAZOP), Job Safety Analysis (JSA), Failure Mode and Effects Analysis (FMEA), Fault Tree Analysis (FTA), and Cause and Consequences Analysis (CCA). Their basic descriptions are summarized in Tables 3.1a.

Table 3.1a. Summary descriptions of six common tools

PHA
• Initial assessment of the hazards and their corresponding accidents • Identifies hazards, hazardous situations, and events for a given activity, facility, or system
HAZOP
• Structured and systematic technique for system examination and risk management • Identifies and evaluates problems that may represent risks to personnel, equipment, and operation
JSA
• Emphasizes job safety by analyzing workplace hazards • Identifies hazards associated with each step of any job or task that has the potential to cause serious injury

FMEA

- Design tool for the systematic analysis of component failures and their effects on system operations
- Identifies potential design and process failures before they occur and proposes changes to design or operational procedures

FTA

- Uses deductive top-down modeling technique to analyze how an unwanted event or a failure can occur
- Identifies linkages between segments in a causal chain of events

CCA

- Combines two different types of tree structures for analyzing consequence chains
- Shows the way in which various factors may combine to cause a hazardous event along with event trees to show the various possible outcomes

Preliminary Hazard analysis

The PHA is suitable as an initial risk study at an early stage of a project and its results are used to:

- Compare main concepts,
- Focus on the important risk issues,
- Input for analysis of more detailed risks .



Preliminary Hazard analysis

- PHA used as an initial step in a detailed risk analysis of a system concept or an existing system.
- The purpose of the PHA is then to identify those hazardous events that should be subject to further and more detailed risk analysis.
- A PHA can be used to initiate the formation of a hazard log.

The tabular form or spreadsheet is the most widely used format for PHA. An example of a PHA worksheet for a simple system, an elevator door, is shown in Figure 3.1. The columns of the PHA table generally follow the key questions of the risk management process:

What can go wrong? What are the causes and consequences? What are the likelihood or chances of occurrence? And what can be done to detect, control, and manage them?

These questions provide a good guide to follow when completing a worksheet. The following are the descriptions of columns that correspond to the PHA worksheet shown in Figure 3.1.

- What can go wrong?

{ Column 1: Hazards that may lead to an accident

- What are the causes and consequences? What are the likelihood or chances of occurrence?

{ Column 2: Accidents that can occur from the hazards

{ Column 3: The potential causes that can bring about each accident

{ Column 4: The likelihood that a particular cause triggers the Accident.

{ Column 5: The severity of the consequences if the accident occurs

{ Column 6: The risk score based on the likelihood information entered in Column 4 and the severity information entered in Column 5

- What can be done to detect, control, and manage the hazards?

{ Column 7: Recommended preventive and control measures to address the hazards, the causes, and their consequences

PHA Format

System: elevator door		Description				Analyst date	
#	(1) Hazards	(2) Accidents	(3) Potential causes	(4) Likelihood (L) Rating scale	(5) Severity (S) Rating scale	(6) Risk score	(7) Possible controls, preventive actions, mitigation
	<i>What are the possible hazards</i>	<i>What could be the harm of the hazard</i>	<i>How might the accident occur</i>	<i>What are the likelihood or chances of occurrence</i>	<i>How significant is the harm</i>	<i>L × S Ranking</i>	<i>What can be done</i>
1	Elevator door closing on obstruction	Body or body part trapped or pinned by the door which can result in bodily injury, hospitalization, or death	Obstruction is not detected	4	5	20	Door should be able to check pathway for obstruction • Install sensors • Implement regular testing and maintenance of sensors • Implement emergency plan and protocols
			Door mechanism is not working, that is, mechanism does not stop door from closing	2	5	10	An alternative mechanism to bypass standard controls should be available • Install emergency override switch • Implement system testing and maintenance • Implement emergency plan and protocols

Generalized steps for PHA

1. Define the system and scope of study.
2. Identify possible hazards.
3. Describe the accidents that can be caused by the hazards, as well as their consequences.
4. Identify potential causes of how might the accidents identified in step 3 can occur.

Generalized steps for PHA

5. Evaluate each cause according to the likelihood that it can occur and the severity of consequences.
6. Rank hazards in terms of step 5.
7. Determine recommended preventive and control measures to address the hazards, the causes, and their consequences

Generalized steps for PHA

Step 1 defines the system and clearly distinguishes the scope of the PHA. As an example, consider an elevator door as a system of interest. For the succeeding steps, refer to the PHA worksheet in Figure 3.1.

Step 2 identifies possible hazards. Recall from Chapter 1, a hazard is defined to refer to objects, actions, processes, or conditions that may contribute toward the occurrence of an accident. For an elevator door, a possible hazard is the door closing on an obstruction. This information is entered in Column 1 of the PHA worksheet.

Generalized steps for PHA

Step 3 describes the potential accident caused by the hazard. What could be the harm of the door closing on an obstruction? If the obstruction was a body or body part, then getting pinned or trapped is a potential accident that may result in bodily injury, dismemberment, or even death. This information is entered in Column 2 of the PHA worksheet.

Generalized steps for PHA

Step 4 examines the possible causes of how the accident can occur. For the elevator door closing on an obstruction, two potential causes can be identified: (1) the obstruction is not detected and (2) the door mechanism is not working. This information is entered in Column 3 of the PHA worksheet.

Generalized steps for PHA

Step 5 evaluates the likelihood and severity for each potential cause. A rating scale such as Tables 2.2 and 2.3 in Chapter 2 is typically adopted. For the elevator door PHA, suppose the number of accidents occurring from the obstruction not being detected is on average one per year, then the likelihood is rated at 4 (see Table 2.3). The absence of sensors on the elevator door accounts for this high likelihood of accidents. For the door mechanism not working, the number of accidents occurs only once per 100 years due to the high quality of the door mechanisms.

Generalized steps for PHA

Step 5 evaluates the likelihood and severity for each potential cause. A rating scale such as Tables 2.2 and 2.3 in Chapter 2 is typically adopted. For the elevator door PHA, suppose the number of accidents occurring from the obstruction not being detected is on average one per year, then the likelihood is rated at 4 (see Table 2.3). The absence of sensors on the elevator door accounts for this high likelihood of accidents. For the door mechanism not working, the number of accidents occurs only once per 100 years due to the high quality of the door mechanisms.

Generalized steps for PHA

Step 6 facilitates the ranking of the hazards and potential causes by determining an overall risk score for each entry. For the elevator door PHA, this is done by multiplying likelihood and severity ($L \times S$). This information is entered in Column 6 of the PHA worksheet. The risk of an accident from the obstruction not being detected is more significant than the risk from the door mechanism not working, with a risk score of 20 and 10, respectively. Thus, addressing the detection of an obstruction should be prioritized.

Generalized steps for PHA

Step 7 develops recommended measures to prevent, control, or mitigate the hazards and its consequences as it relates to each potential cause. For the elevator door example, proposed measures such as the installment of sensors to detect obstructions is entered in Column 7 of the PHA worksheet.

Hazard and Operability analysis

- HAZOP, or a Hazard and Operability Study, is a systematic way to identify possible hazards in a work process.
- In this approach, the process is broken down into steps, and every variation in work parameters is considered for each step.

Hazard and Operability analysis

HAZOP is a top-down qualitative approach, as opposed to semi quantitative approach such as PHA.

HAZOP is used to determine potential hazards in a process, operation, or system. In particular, it systematically identifies possible deviations from the design and operating intent and determines how these deviations may eventually become hazards.

1 . WHERE AND WHEN TO USE HAZOP

HAZOP was originally intended for analyzing accidents that affect human health and safety. It has since been adopted as a general-purpose risk management tool. It is applicable to various types of systems, especially those with highly monitored performance and detailed design requirements found in the chemical, petroleum, food industries, and the like.

1 . WHERE AND WHEN TO USE HAZOP

Similar to PHA, it is applicable during the design phase of a project, product, or system development to determine specifications. It is also often applied to existing systems to improve safety and minimize operational risk. It is, in fact, useful for periodic review throughout the life of a system to accommodate changes within the system and its environment. It can also be used as supporting documentation for hazard logs.

GENERALIZED STEPS FOR HAZOP

1. Define the system and scope of study.
2. Divide the system into nodes and define each node's design intent.
3. For each node, identify node elements such as material, input, process step, or operation.

GENERALIZED STEPS FOR HAZOP

4. Define the element's relation to the design intent, performance measure, and acceptable range of performance (parameters).
5. Define the deviation by selecting a process guideword and pair with parameter.

GENERALIZED STEPS FOR HAZOP

6. Establish the causality of the deviation with potential hazards.
7. Describe the consequences of each hazard.

GENERALIZED STEPS FOR HAZOP

8. Identify existing preventive and control measures to address the hazard.
9. Determine recommendations for additional controls to address the hazard.

GENERALIZED STEPS FOR HAZOP

Step 1 defines the scope of the analysis and system of study. As an example for HAZOP, consider a cooling water facility for a production plant as a system of interest.

GENERALIZED STEPS FOR HAZOP

Step 2 divides the system into nodes. Part of the cooling water facility is the water cooling circuit pipework as shown in Figure 3.2. This represents a node in an overall HAZOP study of a cooling water facility. To begin the analysis of each node, the design intent of the node and its corresponding parameters are defined. For the water cooling pipework, its purpose is to continuously circulate cooling water.

GENERALIZED STEPS FOR HAZOP

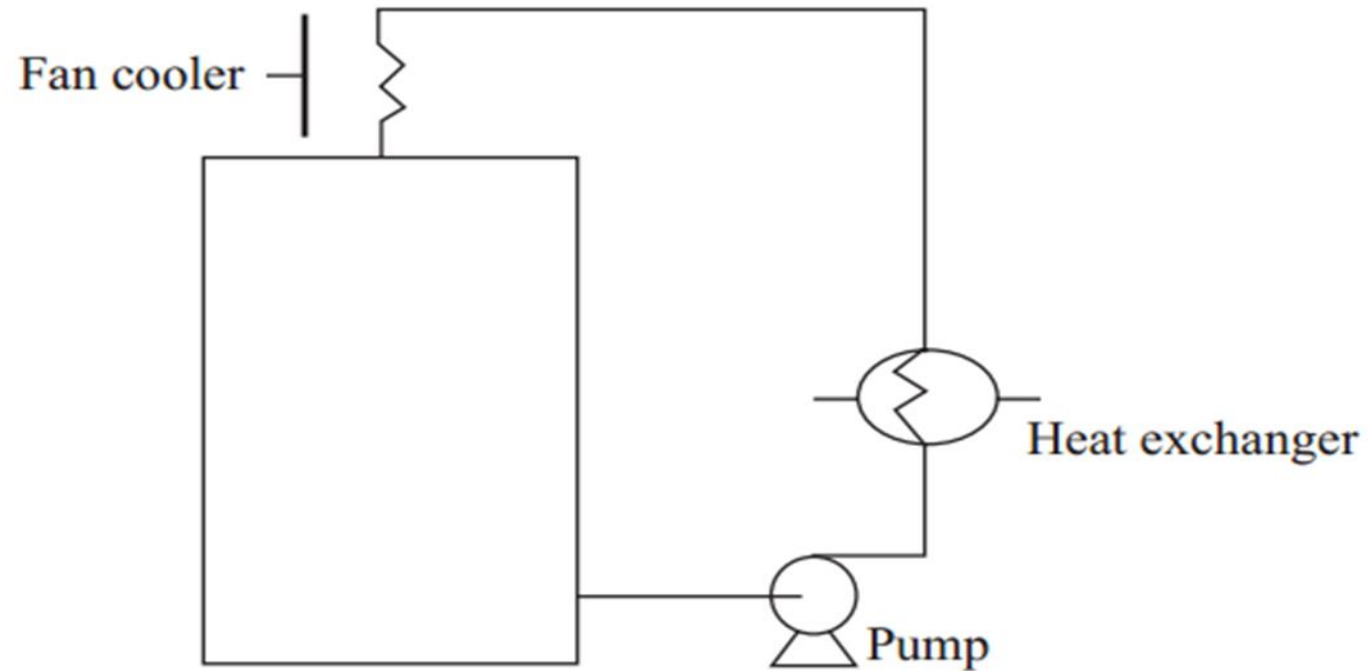


Figure 3.2. PFD of water cooling circuit pipework.⁴

GENERALIZED STEPS FOR HAZOP

Step 3 identifies the node elements. Elements are described in terms of its materials, inputs, components, and process steps and entered in Column 1 of the HAZOP worksheet. For the water cooling pipework, the key processes are circulation and cooling.

GENERALIZED STEPS FOR HAZOP

Step 4 defines process parameters for each element as it relates to the design intent. As defined in Step 2, the purpose of water cooling pipework is to continuously circulate cooling water and a key process identified in Step 3 is circulation. How does circulation then achieve the system's design intent? To continuously circulate water, the system is designed to flow at a rate of 75.5 m/min.

GENERALIZED STEPS FOR HAZOP

Step 5 defines the deviation. It follows then that for the water cooling pipework, a deviation or departure from the design intent would be a lack of adequate circulation. In HAZOP, the term less flow rate or no flow describes this deviation. This information is entered in Column 2 of the HAZOP worksheet.

GENERALIZED STEPS FOR HAZOP

Step 6 identifies the causes (i.e., the hazards) that can cause the deviation to occur. For the deviation no flow, failure of the pump may be one of the potential causes. This information is entered in Column 3 of the HAZOP worksheet. Note that the failure of the pump is described as a cause, not a deviation. Also note that in HAZOP, the identified causes are analogous to what PHA identifies as hazards.

GENERALIZED STEPS FOR HAZOP

Step 7 defines the consequences for each hazard. Pump failure means water is not flowing or circulating and, therefore, not cooled to the requirements of the production facility. A consequence could be possible over-heating of equipment and interruption or delay in the production process if the work has to stop because of down equipment. This information is entered in Column 4 of the HAZOP worksheet.

GENERALIZED STEPS FOR HAZOP

Step 8 describes existing measures on how the deviations and the hazards are addressed. For the water cooling pipework, suppose a backup pump is in place, then its information is entered in Column 5 of the HAZOP worksheet.

GENERALIZED STEPS FOR HAZOP

Step 9 determines recommendations. An assessment has to be made as to whether existing measures are sufficient and effective. Part of the analysis is to identify additional safeguards or controls when and if needed. This information is entered in Column 6 of the HAZOP worksheet.

HAZOP Worksheet

**Node: water cooling circuit
pipework**

		Description				Analyst date
(1) Element	(2) Deviation	(3) Possible causes	(4) Consequences	(5) Safeguards (preventive)	(5) Safeguards (reactive)	(6) Actions required
<i>Describe what the guideword pertains to (material, input, process step, etc.)</i>	<i>What can go wrong (describe the deviation)</i>	<i>How can the deviation occur</i>	<i>What may happen if the deviation occurs</i>	<i>List controls that prevent the deviation from occurring</i>	<i>List controls that can address the deviation that is occurring</i>	<i>Identify any additional controls or actions required</i>
Flow process	Low flow rate No flow	Pump failure	Water backs up Production facility or equipment overheats and breaks down	Regular maintenance	Engage backup pump Replace or repair pump	Upgrade system with digital monitoring and alarm
		Broken circuit pipe	Water leak Production facility or equipment overheats and breaks down	Regular maintenance	Replace or repair pipe	Upgrade system with digital monitoring and alarm
Cooling process	High temperature	Temperature control failure	Water not cooled Production facility or equipment overheats and breaks down	Regular maintenance	Engage manual control Replace or repair controller	Upgrade system with digital monitoring and alarm
		Compressor failure	Water not cooled Production facility or equipment overheats and breaks down	Regular maintenance	Replace or repair compressor	Upgrade system with digital monitoring and alarm

Figure 3.3. HAZOP worksheet for water cooling circuit pipework.⁵

References

Resources:

Operational Risk Management

C. Ariel Pinto

Luna Mylene Magpili

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Chapter 3