Course Learning Outcomes for Unit VI

Upon completion of this unit, students should be able to:

5. Examine the role of hazard analysis in system safety efforts.
   5.1 Discuss the use of accident investigations in safety analysis.

7. Evaluate risk management tools related to system safety management.
   7.1 Describe the different data sources available for risk management.
   7.2 Discuss employee training as an administrative control tool for risk management.

Course/Unit Learning Outcomes	Learning Activity
5.1	Assessment, Lesson, Required Reading
7.1	Assessment, Lesson, Required Reading
7.2	Assessment, Lesson, Required Reading

Reading Assignment

Chapter 10: Data Sources and Training

Chapter 11: Accident Reporting, Investigation, Documentation, and Communication

Unit Lesson

In the last two units, you investigated and evaluated many different system safety tools as you continued to design out hazards from work systems and monitored those work systems with a continuous improvement focus. As you may recall from our Unit II work, the textbook clearly laid out the elements of a safety management system (SMS) and points back to that SMS design in Chapter 11. To this point in the course, you have focused largely on understanding the work system through the use of process flow diagrams such as those on page 173 and page 193. Focus has also been on learning to identify potential hazards within the system; learning to recognize where to design in engineering controls between components of a work system, such as control valves like CV-1 and CV-2 between the pump and the anhydrous ammonia nitrogen ready tank as seen in Figure 6.2 on page 193, to disrupt the hazard pathways to reduce potential risks; and analyzing the safety-designed work system for statistical forecasting of risks.

What we have yet to discuss in detail are two administrative controls that are actually the ground work impacting all four parts of the SMS: work system employee training and accident investigations. Training the entire organization to the safety-designed work system is fundamental in operationalizing a safe work system. Accident investigations are fundamental in understanding individual component failure of the safety-designed work system that led to the overall work system failure resulting in an incident such as a near miss or an accident such as an injury (Bahr, 2015). In this unit, you will be learning to finalize the design of a work system using these two administrative controls.

As a step immediately following the design of the SMS, an interactive and dynamically-updated knowledge-based safety knowledge management system (SKMS) should be designed (Bahr, 2015). This includes the design of the work system, assessments, hazard identification and evaluation, compliance verification, and a history log of the safety and failures of the system. The idea is that the entire organization's staff, at each respective affected level of work and management, is then trained to the SKMS. As you read through Chapter 10, you will notice the suggestions for using electronic (global Internet and company intranet) databases, government databases and sources, and peer-reviewed academic literature. Collectively, we could anticipate the resulting SKMS design to be as robust, comprehensive, defensible, and effective as possible. Now we just need to effectively train the organization to the SKMS knowledge base as an administrative control technique for the work system prior to putting the safety-designed work system online and operating for the organization. Bahr (2015) presents several strategies for effectively training an organization to the SKMS and even includes an example training course outline for consideration. Now let's spend some time discussing the use of accident investigations as an administrative control.

At this point in your program, you may have already been introduced to several different formal theories of accident causation. Among those formal theories, Bahr (2015) first describes the anatomy of an accident, then uses Reason's Swiss cheese model as a demonstration of how a system safety engineer can use formal models to identify independent variables that are causally related to an accident even before an accident occurs. By the time that you complete this graduate program, you will have studied many different models that can be used to achieve the same result; however, as the role of system safety engineering is one of continuous improvement, accidents may still occur from time to time. While we can design out the hazards of a work system, you simply cannot remove all associated risks. As such, the actual disruption of these critical independent variables is only accomplished through the use of an accident investigation. Bahr (2015) describes this process by first forming an accident investigation board, then explaining how to best conduct an initial accident report. Finally, you are provided a five-step process for investigating an accident. Using the information provided in Chapter 11, let's actually conduct an abridged accident investigation together.

Practice Scenario of an Accident

Again consider the anhydrous ammonia nitrogen (NH_3) fill station scenario on page 193 of the textbook. Imagine that the human component in this process is the pump operator working alone at the fill station. The line between the pneumatic pump and the control valve (CV-1) has been compromised by weather and has failed. When the operator actuated the pump, NH_3 product vapor vented through the hose, and the operator inhaled some product vapor for about two seconds prior to shutting the valve from the airline to the pump. If you have been around anhydrous ammonia, you may agree that it only takes seconds to realize when you are in inhalation contact with even the product vapor.

Closely following the five-step process laid out in the textbook, let's conduct an accident investigation on this scenario. As a reminder, this is just to serve as an example of how to use the five steps. This will not be as in-depth or detailed in this example as would be for an actual situation.

Step 1 Preparing for the investigation: First, you have read the initial accident that has been reported, the first report of accident document, and filed with the accident investigation board, and you have been informed that the operator is safe and unharmed. The operator has declined any medical treatment, has personally considered the inhalation exposure as minimal compared to what the product safety data sheet (SDS) describes as potential risks, and has conveyed a readiness to return to plant duties. The bulk tank has been gauged, and the product released to the atmosphere has been recorded.

Second, check the 40CFR tables and confirm that the amount of product released is well below the reportable quantity (RQ) values established by the U.S. Environmental Protection Agency (EPA), as well as the municipal local limits for fugitive emissions or plant upsets. As such, there is no need to report the incident to the municipal, state, or federal authorities.

Third, the accident investigation board has established an investigation outcome goal of understanding how the accident occurred and has communicated this to the operator to remove any potential fear of discipline. The operator is now standing with us at the fill station. Nothing has been disturbed since the accident.

Step 2 Gathering evidence and information: First, you video the area with a company camera and ask the operator to describe the sequence of work as well as the outcome. You construct a grid map of the scene and take measurements between the bulk tank, the compressed airline feeding the pneumatic pump, the break in the compromised product hose, and CV-1. The plant chemical engineer is present with a copy of the fill station piping and instrumentation diagram (P&ID) as well as a written copy of the standard operating procedure (SOP) for the work process.

Second, you compare the grid map to the P&ID and note that there seems to have been no process changes to the piping or hoses, as well as to the SOP. You ask the plant operator to read through the SOP and to trace the events again using the P&ID. Finally, you collect the fill station's operations log, maintenance log, and product hose from the scene.

Step 3 Analyzing the data: First, you review the operations log and maintenance log. Then you construct a timeline of activities starting from the last maintenance activities and extending all the way through the accident occurrence. Finally, you compare the measurements from field data collection to the P&IDs. You realize that the product hose between the pump and CV-1 is actually reported as being 12 inches longer on the P&ID as well as the SOP description than what was measured in the field. You also note that there was a hose maintenance activity reported vaguely in the maintenance records, just one day before the accident occurred. These are important observations from the collected qualitative and quantitative data.

Second, you use the what-if analysis described in Unit IV to determine the potential outcomes if there has been a change in product hoses between maintenance activities and operations activities. You have identified the following potential outcomes.

1. The wrong hose type (pressure or chemical rating) may have been used to replace the original product hose in the process.
2. A faulty hose may have been used to replace the original product hose in the process.
3. The hose may have been pulled too tightly as it is approximately one foot shorter than the original hose, and the resulting overall product hose integrity was compromised.

Third, you study the product hose and research the chemical rating stamped on the product hose with the product hose supplier. You learn that the chemical rating stamped on the product hose is not an appropriate match for anhydrous ammonia but for low temperature process wastewater. The hose supplier tells you that the product hose for either the wastewater or chemical hose can be effectively stretched for two full feet without compromising the integrity of these particular hoses. If anhydrous ammonia product passed through the replacement wastewater hose with pressure, the integrity of this wastewater hose simply cannot be expected to remain intact. It appears that the independent variable, causally related to the dependent variable, the accident, was the wrong type of replacement product hose used in the maintenance activities resulting in the replacement hose developing a break during pressurized line activities.

Step 4 Discussion of the findings, analysis, and conclusions: First, using the investigation report outline on pages 293–294 in the textbook, you develop an investigation report. You carefully report all of the findings from steps one through three of the accident investigation. You clearly demonstrate the use of the what-if analysis steps and outcomes. Finally, you describe the independent variable, the wrong replacement hose, that seems to have led to the accident.

Second, you describe your conclusions are that there seems to be a problem potentially related to root cause; however, the potential for root cause does not seem to be within the operations of the fill station. Instead, the data seems to suggest that you may ultimately find root cause from within the maintenance work system or purchasing work system. For some reason, maintenance staff used the wrong replacement hose, and purchasing staff may have purchased the wrong replacement hose.

Step 5 Recommendations: First, you suggest that the faulty product hose be replaced with a new, chemically-compatible product hose specified by the hose supplier. Second, you suggest that the root cause investigation activities be refocused to the maintenance and purchasing departments to include any affected personnel in both departments. Finally, you provide the hose vendor-supplied chemical-compatibility charts, the grid map, the P&IDs of the fill station, an intranet dynamic hyperlink to the electronic video file, and the field measurements from the scene as appendices to the investigation report document.

As you move to the next two units, this process will serve you well in learning how to effectively utilize accident investigations as administrative controls in managing hazards within work systems. Be sure that you fully understand how you completed every step, and realize how you did not confuse the accident investigation outcomes with any pending root cause analysis to later be conducted within the maintenance department and purchasing department. These points will be critical as you practice applying system safety engineering to evaluate work systems in Unit VII, as well as to help you more effectively learn to manage risks through engineered work systems in Unit VIII.

Reference

Bahr, N. J. (2015). *System safety engineering and risk assessment: A practical approach* (2nd ed.). Boca Raton, FL: CRC Press.

Learning Activities (Nongraded)

Nongraded Learning Activities are provided to aid students in their course of study. You do not have to submit them. If you have questions, contact your instructor for further guidance and information.

Studying a Work System with the Swiss Cheese Model

Carefully reread the Unit VI Lesson material related to Bahr's discussion of Reason's Swiss cheese model of accident causation on pages 283-284. Select a work system that you know well. Do your best to identify independent variables, potentially causal to an accident, and then apply the Swiss cheese model to demonstrate these relationships with a drawing. Feel free to send the drawing to your professor to evaluate and discuss with you.