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A Practical Approach to Hazard Identification

. . . for operations and maintenance workers

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INTRODUCTION

Hazard identification has long been recognized as a mechanism for improving safety and reducing incidents. The Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers (AIChE) is developing a new Concept Book that illustrates and extends existing hazard recognition practices and programs to identify process hazards. This new Concept Book will focus on providing operations and maintenance personnel with tools to enhance the hazard recognition process as part of their everyday observations.

The motivation for identifying and managing hazards is simple:

- Everyone wants themselves, their friends, and coworkers to go home safely every day
- Everyone wants to keep their job and process incidents can cause a company to be shutdown
- Process incidents can have consequences for communities located around them. Worker's families and friends often live in these communities.
- We all share the environment and events can cause long-term damage to the environment and the living things that coexist in the same spaces.

An effective hazard identification and control program should instill a culture at the facility where personnel are motivated to accept personal responsibility and manage their own safety. Personnel should be empowered to immediately stop any situations or behaviors that could put people and equipment in danger. To achieve this objective, employees must be empowered to recognize hazards throughout the facility and providing solutions to correct them.

HAZARD IDENTIFICATION IS NOT OPTIONAL.
IT'S AN ESSENTIAL PART OF DAY TO DAY ACCTIVITIES.

The goal is to establish a workplace built on a sense of achievement, recognition, responsibility, group decision making, and job enrichment. By building motivation into the work environment, people will become more involved and take ownership in the hazard management objectives.

The new Concept Book provides guidance for identifying and controlling hazards in the workplace to help:

- Improve your ability to detect hazards
- Prevent injuries and accidents
- Raise hazard recognition awareness
- Empower you to take action and follow-up

This book is primarily intended to provide operations and maintenance personnel with practical methods for identifying and addressing physical and process hazards.

This book should also provide benefit for those persons who:

- Are planning on participating in a formal process hazards analysis or safety review
- Occasionally enter a process facility and have not received formal training
- Implement new designs in an existing operating facility
- Are new employees

- Are responsible for providing resources for hazard control and elimination

Failure to identify hazards can lead to unforeseen consequences. Risk reduction begins with hazard identification. However, this is just the first step - multiple tools (methods and techniques) must be used to broaden and deepen hazard awareness and control.

There are many books already published on identifying physical hazards. This book extends hazard recognition practices and techniques to include identification and mitigation of *process hazards*. Process hazards are above and beyond occupational hazards because they have the potential to impact more than one person and the community. Process hazards are typically the result of equipment or systems operating outside their intended purpose.

The process for addressing risk through hazard identification and elimination/mitigation include the following steps:

- Understanding basic concepts
- Training employees to recognize hazards
- Using tools to identify hazards
- Understanding different types of hazards and their severity
- Evaluating the risk of physical and process hazards
- Providing resources and solutions to eliminate or mitigate the hazard or risk
- Ensuring we learn from past mistakes
- Implementing a hazard management program and making it part of a facility's culture

This paper will highlight the approaches to eliminate or mitigate the hazard or risk.

HAZARD RECOGNITION

Identifying hazards often depends on our ability to recognize the hazard. Hazards are most often recognized using our basic senses:

- Sight
- Sound
- Smell
- Touch

The Concept Book will provide guidance on how our senses are used to detect hazards in the workplace – as well as the limitations of our senses.

IDENTIFYING AND ASSESSING HAZARDS

There are a number of hazard identification methods that have been developed in the process industry over the last 20 years. They can be categorized into three groups:

1. Field Surveys: Tools that are designed to collect data in the field either through walk-through surveys using custom-designed checklists, or through the observation of personnel as they perform operations or maintenance tasks.
2. Pre-job Assessments: Tools that are designed to evaluate the job site to identify hazards in the area of interest.
3. Plant Assessments: Tools that are designed to identify hazards either before the plant is designed or in an existing plant with the thought of improving the design of facilities or equipment.

The Concept Book will contain:

- A full description of each of the tools
- Literature references for published tools
- An overview of how each of the tools could be improved

Field Surveys

Identifying hazards can be a difficult task when there is less information available. Typically, workplace hazards are identified from incident records and near miss reports. Plants with good safety performance typically have fewer incidents, so there is less to learn from.

Field surveys and worker observations can fill this void since they can be conducted as many times as necessary to identify hazardous situations. This section reviews field survey methods that are published and have been produced by process industries.

Behavior Observation

Behavior is defined as what workers do or say - i.e., their actions - not what they think or feel. Thus, behavior is an objective observable concept. This section, reviews the use of behavior observation as a method of identifying workplace hazards.

Observing the behavior of operators can provide insight on:

- Errors that are committed during the performance of the task
- Time required to perform each activity
- Difficulty or ease with which the task is performed
- Improved ways of performing the task or alternative tools that could be used to perform more safely or efficiently
- Quality of procedures

Observations are typically performed in three different ways:

- Direct observation: Where an observer deliberately observes another person (or persons) performing a task. This is arguably the most frequent method used and is key to behavior-based safety programs.
- Indirect observation: Where those being observed do not know they are being observed. Traffic and pedestrian surveys fall into this category.
- Participatory observers: Where the observer is the one performing the task.

For each type of observation scheme, preparation is the key. Some items to consider during preparation include:

- *What activities will be observed?*
- *What is the instrument that is used for observation?*
- *Who is being observed?*
- *Who is making the observations?*
- *What data are being collected?*

Facility Walkthrough Checklists

Facility walkthroughs are a common method of looking for hazards and are typically conducted by operations and supervisor/management:

- Operations plant rounds - Plant rounds are conducted by operators several times per shift to monitor equipment operation and observe that the equipment is operating satisfactorily, e.g., no leaks, no vibration. The rounds may be guided by a data collection sheet on which values of process variables are recorded.
- Plant management walkthroughs - Plant walkthroughs can also be conducted by plant management to look for safety hazards such as broken insulation, steam leaks, tripping hazards, water on grade, hot water dripping on walkways, poor housekeeping, broken equipment, broken lighting, etc.

Checklists have a history of being poorly designed and poorly used. Often the words on a checklist are ambiguous or misleading. For example, “Valve actuator is potentially hazardous” leaves a great deal to interpretation. Is the actuator positioned too high or too low? Is it difficult to turn? Is it difficult to access? Many times, the checklist user is not familiar with checklist terms. And, often, the checklist is not asking the right questions, e.g., “List the gauge pressure _____ bar” (when in fact the gauge is reading psi).

Table 1. Example Plant Walkthrough Hazard Identification Checklist

Checklist Question	Illustration	Present (√)	Responsible Group			Potential Mitigation
			Maint.	Oper.	Design	
Potential adverse outcome from inadvertent leaning against control panel, switches, etc.?						
Labels on critical switches, valves, piping and vessels inadequate?						
Valve access inadequate?						
Electrical connections and enclosures loose or open?						
Insulation inadequate?						

Checklist Question	Illustration	Present (√)	Responsible Group			Potential Mitigation
			Maint.	Oper.	Design	
Sample point inaccessible?						
Eye-wash station is obstructed and difficult to access?						
Corrosion leading to failure?						

Pre-Job Assessments

Job Hazard Analysis

A Job Hazard Analysis (JHA) is a technique that is used to identify and assess the hazards in a job before they occur. The JHA focuses on a specific job and examines the:

- Steps required to perform the job
- The relationship between the job and the worker(s), the tools used by the worker(s) and the work environment
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It evaluates the risk of injury involved in the task and specifies interventions to reduce the risk. Other terms used to describe this technique are Job Safety Analysis (JSA) and Job Hazard Breakdown (JHB).

The following items (in order of robustness) provide measures for hazard control:

1. Inherently Safer Designs
2. Engineering Controls
3. Management (Administrative) Controls
4. Personal Protective Equipment

Pre-Job Planning and Permitting

In most plants, hazard identification, recognition and analysis includes many different programs that are conducted to meet varying needs. The Job Hazard Analysis that is described above, for example, is conducted to identify hazards associated with process tasks. The JHA is often used to review jobs before they are performed to familiarize plant personnel with the generic hazards. This is often part of a pre-job planning session.

Pre-job planning can be performed for every task that is performed in the plant. Often, however, it is conducted for those jobs that:

- Are non-routine
- Require a work-permit

If the job already has a JHA/JSA written for it, pre-job planning merely involves the work team and supervisor reviewing the JHA/JSA to ensure that the precautions noted in the analysis are implemented. These could include:

- PPE in addition to routine equipment, e.g., fall protection
- Hot or cold work permits
- Special equipment, such as cranes or barricades
- Special precautions, e.g., fire truck onsite

If the job does not have a JHA/JSA, then one must be prepared by the work team to ensure that all hazards are identified and preparations and precautions are implemented.

Ad-Hoc Risk Assessment

Once personnel arrive at the job site, they will often find that the work conditions that were assumed when the JHA/JSA was developed have changed. The site could be rain or snow covered, construction could be ongoing in the area, and minor changes could have been made to the equipment. Consequently, the JHA/JSA might not identify all the hazards on the job site.

The type of risk assessment is carried out by the individuals who are performing the onsite work. The assessment is conducted at the job site just before performing work. The objectives of the process are to:

1. Improve operators' hazard recognition and awareness abilities
2. Retain awareness of the local hazards throughout the task
3. Reduce the number and severity of incidents and illnesses in all onsite activities
4. Over the long term, to change operators' mindset such that the ad-hoc risk assessments are done automatically without the need for a paper-based system

The ad-hoc risk assessment works best if:

- Operators (including contractors):
  - Take responsibility for their safety and the safety of those they are working with
  - Consistently follow the LMHRA process for all onsite permitted jobs (especially for non-routine, high risk operations)

- Supervisors support the operators by:
  - Training all operators and contractors in the technique
  - Encouraging operators to complete ad-hoc worksite risk assessments to convince them that the technique is beneficial in reducing accidents and to promote a "want to do" approach rather than a "have to do"
  - Encouraging the completion of ad-hoc worksite risk assessment to a consistently high standard
  - Committing to lead by example
  - Ensuring compliance by review and follow-up

- Plant management supports the program by:
  - Providing funding to enable the ad-hoc risk assessment to be implemented
  - Stewarding the progress of the program
  - Ensuring that compliance is consistent across shifts

Here are some suggestions to ensure that ad-hoc risk assessments are effectively conducted at the worksite:

- Ensure that all work site hazards are identified
- Provide enough time for the workers to complete the assessments
- Ensure that the workers memorize the hazards

Plant Assessments

Critical Task Identification and Analysis

Critical Task Identification Analysis (CTIA) is a systematic method of identifying critical tasks within a process plant, prioritizing their importance, analyzing those tasks that are considered most critical and identifying appropriate interventions to mitigate the risk. Critical in this context means high risk. The tasks that may have the potential for personal injury, equipment or facility loss, environmental release, community exposure, or business interruption are defined as "critical". These tasks represent a hazard and the goal is to identify the hazards and correct them before they turn into incidents.

Experience has shown that the analysis is best conducted by a small group of process personnel (site team) who, together, have the knowledge necessary to complete the task. The suggested site team consists of:

- Process Technician
- Maintenance Technician
- Plant Engineer
- Health and Safety Specialist
- Human Factors Specialist

Step 1 – Create Process Flow Diagram. The analysis starts by specifying the plant processes and equipment and creating a process flow diagram.

Step 2 - Identify Process Significant Tasks. The Critical Task Identification process is a 'brainstorming' technique that is designed to encourage the site team to identify the 'critical' tasks that they could be required to perform in each area of the process plant. A critical task could occur during a process upset or other abnormal situation or it could be a task that is difficult to perform or performed frequently. At each block of the PFS, the team is asked to identify the 'critical' tasks that he or she performs by placing them into one of seven different categories including:

- Safety-critical tasks, e.g., responding to the failure of a pump flange
- Quality-critical tasks, e.g., responding to an out-of-limits lab analysis
- Production-critical tasks, e.g., responding to the loss of an exchanger which reduces output
- Most frequently performed tasks, e.g., filter changes
- Difficult to perform or complex tasks
- Time critical tasks, e.g. responding to tasks that, in a short period of time, will cause a larger upset. An example is a compressor shutdown.
- Environmentally-critical tasks, e.g., responding to an out-of-limit environmental deviation. For example, a high SO_2 reading on the stack of a fired heater.

Step 3 - Identify the Risk of a Loss Event. No company can afford to spend money and commit resources on issues that have little benefit to the operation. Thus, it is essential to identify the tasks which, when improved, will improve safety, reduce cost or improve the environment. The approach used at this stage is to estimate the risk associated with each task identified in the above exercise. Most companies have developed their own risk matrix. The next step in this exercise is to prioritize each 'critical' task in terms of its risk to the plant.

Step 4 - Identify Highest Risk Tasks. The tasks that most require analysis are those with the highest risk. A risk ranking matrix is typically used to categorize risk.

The final step in the process is to mitigate risk.

TYPES OF PROTECTION

Processing facilities require all types of strategies and approaches to keep the process risk at tolerable levels. By using diverse risk reduction measures, the chance of common safeguard systems weaknesses can be minimized and preparedness for loss events can be enhanced.

Hazard Elimination (Inherent Safety)

When possible, elimination of the hazard is the ultimate goal of hazard management. For example, many facilities who traditionally used one-ton cylinders of chlorine for water treatment at cooling towers have switched to sodium hypochlorite. Chlorine is immediately dangerous to life and health (IDLH) at 10 ppm. The Level 2 Emergency Response Planning Guideline (ERPG-2) is 3 ppm. A release of one ton of chlorine will produce a vapor cloud that will travel 3 miles and deliver concentrations that are hazardous to the community and require evacuation and/or shelter-in-place. Exposure to sodium hypochlorite can cause topical burns to exposed workers. Switching from chlorine to sodium hypochlorite provides substantial risk reduction.

Engineering

To manage and control risks, industry has incorporated many engineered safety systems into our processing facilities. When hazard elimination is not possible, the next best options are engineered solutions. These solutions can be either passive or active.

A passive approach uses safety solutions that do not require an action to be taken. Examples of passive solutions are curbs around equipment, fire or blast walls, or robust design of pressure vessels to handle the expected overpressure. Another example is an enclosure around a piece of noisy equipment to reduce the noise exposure to personnel.

Active approaches require that a physical action occur in response to a process event. An example is a Burner Management System (BMS) that does not allow lighting of a furnace until the firebox has been purged. Another example is a Safety Instrumented System (SIS) that brings a process to a safe state when a process deviation exceeds the safe operating conditions. Active solutions are generally less reliable than passive solutions.

Administrative

Administrative controls provide another layer of protection, but should not be solely relied on if there are engineered options that can also be put in place. Administrative approaches that require human action can increase the likelihood of human error. Examples of administrative controls are procedural checks, operator actions in response to an alarm, and emergency response following a loss event.

Many companies use administrative controls for operations that require personnel to follow specific steps. This could be for either operational or maintenance procedures.

Another example of administrative control is lockout/tagout, e.g., a car seal on the inlet of a pressure relief device that is car sealed open.

An administrative procedure can be used to control the amount of material in storage so that in the event of a release is not a sufficient quantity of material to cause an offsite issue with the community.