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A PRACTICAL APPROACH TO HAZARD IDENTIFICATION
For Operations and Maintenance Workers
This book is one in a series of process safety guidelines and concept books published by the Center for Chemical Process Safety (CCPS). Please go to www.wiley.com/go/ccps for a full list of titles in this series.

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A PRACTICAL APPROACH TO HAZARD IDENTIFICATION
For Operations and Maintenance Workers

Center for Chemical Process Safety
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The ability to recognize and respond to hazards at the field level is important to the safety of workers at any facility. While hazard identification may be viewed as a first step towards formal risk analysis, some situations require immediate action if serious incidents are to be avoided. This book is about identifying, ranking and addressing workplace hazards so that all workers can return home safely at the end of a work day.

As an experienced process operator or maintenance technician, you have acquired considerable skills and knowledge. Some of this knowledge makes you aware of workplace hazards such as pinch points, moving machine parts or objects falling from elevated heights. That knowledge was likely gained with time through minor encounters resulting in the wisdom of “common sense”. Process or chemical hazards, though relatively safe when they are enclosed within equipment, can result in fires, explosions or toxic effects when they escape to the open air. You may not be aware of your exposure to these during normal work. Process hazards are less obvious than physical hazards and cannot always be detected at first glance. Consequently, some additional effort and different strategies may be required to identify process hazards so that they are addressed appropriately.

This book contains many photographs of hazards, abnormal situations and consequences of incidents. It explains what was learned and how you might use this information along with your skills and senses to improve workplace safety. We hope that you are able to apply the material provided here to better anticipate and prevent problems from occurring. In the future, if you find yourself effectively managing a hazardous situation with the help of this book, then we will have succeeded in our endeavor. The photographs and figures presented in this book were either (a) taken from public sources, (b) contributed by subcommittee members, or (c) created specifically for this book. CCPS is grateful for the contribution of photographs and figures.
The Center for Chemical Process Safety (CCPS) has published over 90 reference textbooks dealing with various aspects of process safety since 1989. Many of these were written from a technical perspective to help with program implementation. This concept book is our first CCPS publication intended for field use and we hope it will provide value to all users.
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ITEMS ON THE CD ACCOMPANYING THIS BOOK

Folder: Pictures
A Practical Approach to Hazard Identification Paper
CCPS A Practical Approach to Hazard Identification Presentation
CCPS Hazard Identification Logo
CCPS Hazard Identification
Contractor Job Site Audit
Facility Siting Human Factors Checklist
Haz ID Loss Event List
Hazard Awareness Training Presentation
Hazard Hunter
Hazard Presentation
MOC Risk Level Checklist
NOAA Output
Observation Card
Process Safety PGI
Reaction Matrix
Risk Based Decisions
Spot the Hazard
Task Analysis Worksheet
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INTRODUCTION

History suggests that incidents tend to repeat themselves (Ref. 1-1). Even with tightened safety regulations, process industries continue to be plagued with incidents that result in personnel injury, community impact, environmental impact, damage to the facility, and production downtime. Most of these incidents are the result of hazards that exist in our workplace.

Many incidents are similar to those that have previously occurred in industry. These events provide us with the ability to better recognize hazards and prevent recurrence. How can we learn to manage these hazards and reduce the risk at our facilities?

The pictures below illustrate the results of hazards that were not identified or controlled.
In simple terms, a “hazard” is a source of harm. Hazardous conditions or situations can cause harm to people and damage to property and environment when the hazards are not controlled. The term “dangerous” is sometimes used in a similar manner, but generally describes a more imminent situation, where the likelihood of harm is greater. Dangerous situations may even require an operation to be suddenly shut down for a temporary period of time, whereas hazardous conditions may be present during normal operations.

Risk is the combination of likelihood and consequence of an event that can cause harm. Identifying hazards is crucial to managing risk at a facility. To properly identify hazards, it is important to realize the following concepts:

- Hazards are conditions that can directly cause harm to people and/or damage to the environment and equipment.
- Hazards may occur naturally, may be inherent to the nature of material, or may be the result of some poorly designed or poorly managed process or activity.
- Hazards in the workplace are associated with chemicals, process equipment, operating conditions, physical activities and the general work environment.

Hazards are all around us. The challenge is to recognize hazards and then to do something about them!

Hazards become more of a concern when people or property can be impacted by the hazard. A snake in the grass will only pose a risk to humans if they come close to the snake (Figure 1-1).
Common workplace hazards and their effects on people are summarized in Table 1-1.

Table 1-1. Common hazards and their effects on people

<table>
<thead>
<tr>
<th>Hazard Types</th>
<th>Example</th>
<th>Potential Impact to People</th>
</tr>
</thead>
</table>
| Heat         | Touching hot pipe  
              | Excessive ambient temperature (heat stress)  
              | Over-exertion  
              | Working near hot equipment | Burn  
              | Heat stress or heat stroke  
              | Fatality |
| Cold         | Brittle fracture causing equipment failure  
              | Low ambient temperatures  
              | High pressure gas release | Frostbite  
              | Touch-freeze adhesion of skin  
              | Hypothermia  
              | Fatality |
| Electrical   | Touching live wire/terminal  
              | Equipment not grounded | Burn  
              | Electrical shock  
              | Fatality |
| Impact       | Motor vehicle impact  
              | Falling ice  
              | Dropped objects  
              | Projectiles | Broken bones  
              | Head injury  
              | Fatality |
| Noise        | High pitch sound  
              | Equipment noise  
              | Excessive noise levels | Reduced hearing ability  
              | Loss of hearing |
| Chemical     | Mixing reactive chemicals  
              | Spill | Chemical burn  
              | Exposure to vapors  
              | Respiratory damage  
              | Fatality |
### Table 1-1. Common hazards and their effects on people (continued)

<table>
<thead>
<tr>
<th>Hazard Types</th>
<th>Example</th>
<th>Potential Impact to People</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration</td>
<td>Whole body (extended driving over unpaved road, working on a compressor deck, etc.) Extremities (use of power tool)</td>
<td>Muscular sprain Circulation problems Raynaud’s disease</td>
</tr>
<tr>
<td>Radiation</td>
<td>Glare Lighting Laser exposure X-ray exposure</td>
<td>Burn Temporary loss of sight Permanent loss of sight Cancer Fatality</td>
</tr>
<tr>
<td>Biological</td>
<td>Sampling water cooling towers Drinking non-potable water Stepping on a sharp object Rotting or decaying materials Bird droppings</td>
<td>Sickness Disease Fatality</td>
</tr>
<tr>
<td>Rotation</td>
<td>Turning valves Reaching for valve Entanglement with rotating shaft Rotating equipment</td>
<td>Muscular sprain Dismemberment</td>
</tr>
<tr>
<td>Airborne particulates</td>
<td>Dust Asbestos dust Sandblasting Changing filter element</td>
<td>Respiratory damage Particles in eyes</td>
</tr>
<tr>
<td>Excavation</td>
<td>Trench collapse Damage to underground pipeline resulting in release of process materials</td>
<td>Body injury Suffocation Exposure to hazardous material</td>
</tr>
<tr>
<td>Asphyxiation</td>
<td>Inadequate oxygen Inert entry (nitrogen) Improper confined space protocols Improper rescue of co-worker Improper connection to air supply</td>
<td>Loss of consciousness Fatality</td>
</tr>
</tbody>
</table>

This table is provided for illustrative purposes only and describes some common industry hazards and their effects on people.

Although this table focuses on occupational or personnel hazards, process hazards that cause equipment failure and release of toxic or flammable material can also have a significant impact on workers at the site and will be discussed in further detail in Chapter 5.
Chapter 1 – Introduction

The motivation for identifying and managing hazards is simple:

- We want ourselves, our friends, and coworkers to go home safely every day.
- We want to keep our jobs; the economic impact of major process incidents can cause a plant or facility to shut down.
- We want to protect our community and neighbors; process incidents can have consequences for communities located around them.
- We all share the environment and irreversible events can cause long-term damage to the environment and the living things that coexist in the same spaces.

An effective hazard identification and risk assessment program should motivate workers to accept personal responsibility and manage their own safety. Workers should be empowered to immediately stop any situations or behaviors that present hazards to people, the environment and equipment. To achieve this objective, employees must be trained to recognize hazards throughout the facility and provide solutions to correct them.

HAZARD IDENTIFICATION IS NOT OPTIONAL – IT’S AN ESSENTIAL PART OF DAY-TO-DAY ACTIVITIES.

While a hazard identification program is not a replacement for a formal Process Hazard Analysis (PHA), it is another important component of risk management. It should be recognized that some “hidden” hazards are not easily detectable by front-line workers and others will be created by the workers themselves. Therefore, there is a strong incentive to closely examine processes and equipment both before and during work to identify hazards and reduce the risk of an incident.

The goal of an effective hazard identification program is to establish a workplace built on a sense of achievement, recognition, responsibility, group decision-making, and job enrichment. By instilling a strong safety culture into the work environment, people will become more involved and take ownership of the hazard management objectives.
An effective hazard identification program will help prevent incidents, like the one discussed below:

A process operator in a gas plant wanted to vent gas from a 6" diameter jump-over line. Recognizing that the gas contained hydrogen sulfide, the operator suited up with a self-contained breathing apparatus. This proved to be a wise move. When the operator turned the 6" valve handle one-quarter revolution, the bonnet blew off the valve body, just missing his face. He was later able to safely isolate the line from another location.

A formal investigation revealed that wet sour gas had penetrated the packing and leaked into the cavity between the bonnet and the packing. Severe corrosion was evident on the inner bonnet and on the bolts that secured it in place. The slight torquing of the valve stem was enough to cause the bolts to fail, releasing the bonnet and packing under pressure.

It is important to regularly inspect valves in sour or corrosive service. If there is any sign of corrosion on the threads or casing, a closer examination may be warranted.

Some people would consider themselves lucky to survive such an event and then focus on fixing the failed valve. However, next time the worker, or his colleague, may not be so lucky. Any high energy release associated with the abrupt failure of a piece of equipment can cause serious injury or death. Incidents such as this should trigger a formal investigation to determine how and why the equipment failed.

How far reaching is the problem and what can be done to prevent similar incidents in the future?

Were there any external symptoms that might have been detected in the field to alert workers of the immediate hazard?

Or was this a “hidden” hazard?
Chapter 1 – Introduction

This book provides guidance for identifying and controlling hazards in the workplace to help:

- Raise hazard recognition awareness
- Improve your ability to detect hazards
- Empower you to take action and follow-up
- Prevent injuries and accidents
- Pass this safety culture on to new employees

Even though industry’s focus has become hazard elimination and management through inherently safer design, the nature of a process facility makes it difficult to design-out all hazards. The characteristics of materials/products that make them hazardous are often what make them valuable (e.g., the flammability of gasoline).

Inherently safer design is an approach to hazard elimination and minimization (See Chapter 6.3.1). Hazards exist in the flammable and toxic materials that are processed, in the equipment used to perform work, and in the work conditions and environment.

A process for effectively recognizing and addressing hazards is illustrated in Figure 1-2. The core of the figure describes the types of hazards associated with a process facility. The outer band illustrates the steps in identifying hazards, evaluating their risk, making risk-based decisions for risk reduction, and implementing a hazard management program to mitigate the hazards and risks. This figure will reappear throughout the book to describe how each Chapter builds part of the hazard management process. The process for addressing risk through hazard identification and elimination/mitigation includes the following steps:

- Understanding basic concepts (Chapter 2)
- Identifying hazards (Chapter 3)
- Understanding different types of hazards and their severity (Chapter 4)
- Evaluating hazards (Chapter 5)
- Making risk-based decisions (Chapter 6)
- Implementing a hazard management program and making it part of a facility’s culture (Chapter 7)
- Ensuring we learn from past mistakes (Chapter 8)
There are two essential elements in establishing an effective hazard management program:

- Management commitment to providing the resources, empowering personnel, and measuring and managing the process.
- Employee ownership of the program to ensure that it is effectively implemented and maintained.

We’ve all heard the words “Safety Takes No Vacation” or “Safety Doesn’t Take a Holiday”, yet incidents in industry continue to remind us that hazard identification and risk management require vigilance and continuous improvement (Figure 1-3).
Chapter 1 – Introduction

Fires and explosions that occur in manufacturing facilities can have widespread, devastating consequences.

1.1 INTENDED AUDIENCE

This book is primarily intended to provide industrial plant operations and maintenance workers with practical methods for identifying and managing physical and process hazards. This book should also provide benefit for people who:

- Are planning on participating in a formal Process Hazards Analysis (PHA) or safety review
- Occasionally enter a process facility and have not received formal training
- Implement new designs or review/approve Management of Changes in an existing operating facility
- Are responsible for providing resources for hazard control and elimination
- Are safety inspectors or regulators
- Are safety professionals
- Are new to the workforce

Figure 1-3. The need for prevention
This book will help you identify and manage workplace hazards (Figure 1-4).

Construction and maintenance activities can create new and unique hazards. For example, overhead loads suspended by a crane create potential energy hazards, while entry into confined spaces and vessels may create asphyxiation hazards.

The activities pictured above are common on a construction site and represent a high level of energy. Heavy loads and moving equipment can easily distract a worker and direct his or her attention from the work at hand. Construction hazards are particularly critical when modifications are made on an operating plant site. A vehicle impact or collapsing crane boom can damage delicate process equipment, releasing the contents to atmosphere. This may cause further injuries.
1.2 HOW TO USE THIS BOOK

Failure to identify hazards can lead to undesirable 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.

While other books cover physical or occupational hazards, this book extends hazard recognition practices and techniques to include identification and mitigation of process hazards. One way in which process hazards differ from physical or occupational hazards is that process hazards have the potential to impact more people and the surrounding community. Process hazards are frequently the result of equipment or process systems operating outside their design intent.

Each Chapter provides practical examples that can be used in the field.

Throughout this text, tables, illustrations and photographs have been used to describe various hazards and their effects.

While it may appear useful to have highlighted all of the possible hazards and associated consequences in each and every case, this has not been done. In certain cases, the most common hazards have been explored in detail. In others, more subtle hazards and their potential consequences have been described. However, in all cases the reader is encouraged to identify hazards and consequences beyond those provided in the book.

Be a leader, and do not assume others have already identified the hazards around you.
The interpretation of specific hazards will vary across industry and is generally a function of the types of processes employed, the materials used, and the safeguards in place. For example, the presence of water in a steel mill may be deemed an extreme hazard if it comes into contact with hot or molten metal.

It is difficult to compile a complete listing of all hazards and their range of effects given the wide audience for which this book is intended. Examples of hazards, their effects, and potential consequences are suggested throughout the book to provide examples and to encourage the reader to think beyond one single hazard for each photograph, and one single consequence for each hazard.

To enable your organization to gain the most benefit from this book, a few suggestions for use follow:

- Introduce “hazard recognition” as a standard agenda item at operations safety team meetings.
- Have a supervisor, trainer or worker read the book and then select specific topics for review or training with operations and maintenance staff.
- Select examples from the book to discuss at shift change and other important work group meetings.
- Select a specific hazard to focus on at shift change, tailgate, and similar meetings.
- Flag a page or example in the book and then pass around the control room with a sign-off sheet.

### 1.3 REFERENCES

1-1 Recommendations for Addressing Recurring Chemical Incidents at the U.S. Department of Energy.