1 Introduction

"A society grows great when old people plant trees whose shade they know they shall never sit in." Greek proverb

1.1 What Is Process Safety Knowledge Management (PSKM)?

This chapter introduces the key definitions for Process Safety Knowledge and Knowledge Management. Process Safety Knowledge Management (PSKM) is a subset of Knowledge Management focusing on building, disseminating, and sustaining Process Safety Knowledge (PSK) in an organization.

Knowledge Management has been defined by many authors over the years as collected and published by Girard and Girard [4]. One of the classic and most cited definitions of Knowledge Management is by O'Dell and Grayson [5]:

> *"Knowledge Management is a conscious strategy of getting the right knowledge to the right people at the right time and helping people share and put information into action in ways that strive to improve organizational performance."*

CCPS defines Process Safety Knowledge (PSK) as follows [1]:

> *"Knowledge related to information, which is often associated with policies, and other rule-based facts. It includes work activities to gather, organize, maintain, and provide information to other process safety elements. Process Safety Knowledge primarily consists of written documents such as hazard information, process technology information and equipment-specific information."*

Hence, Process Safety Knowledge Management (PSKM) is defined as:

> "*A system for capturing, organizing, maintaining, and providing the right Process Safety Knowledge to the right people at the right time to improve process safety in an organization."*

PSKM includes methodologies, tools, processes, organizational structures, and human capital management strategies used to convert data to information, information to knowledge and knowledge to wisdom.

Process Safety Knowledge Management (PSKM) systems cover the entire life cycle of Process Safety Knowledge including development, implementation, and maintenance. The knowledge management system must ensure Process Safety Knowledge is easily accessible and understandable to the people who need it,

and that the knowledge shared is consistent, current, and accurate. We note that there is a special case with regards to Contractors and other outside entities which could impact this stated goal. A brief discussion is included in Section 4.5.

1.2 Purpose and Scope of this Book

This book is intended to be a resource for sharing industry-leading best practices on PSKM and for providing a blueprint for developing an effective PSKM program for companies. This book is divided into three sections:

1. Business case for an effective PSKM program and its relationship to PSM elements (Chapters 2 and 3)
2. Setting up a successful PSKM system and sustaining it (Chapters 4 and 5)
3. Sharing case studies illustrating the importance of an adequate and effective PSKM system (Chapter 6)

The principles of PSKM are transferable across industries. Examples contained within this book will provide guidance on how the knowledge obtained from past incidents, and current best practices from industry leaders, can be applied to many different organizations.

1.3 Historical Development of PSKM

Historically, the terms Process Safety Information (PSI) and Process Safety Knowledge (PSK) have been used interchangeably [6], [7]. As companies' maturity level in Process Safety Management (PSM) improves, there is a continuing focus in the industry to transition from information to knowledge.

Before the 1990's, the PSK resided in the organization as a core competency of chemical or process engineers. Analysis of serious process safety events such as the methyl isocyanate release at Bhopal, India in 1984 and explosions at a chemical complex at Pasadena, Texas in 1989, showed that while PSI resided within an organization, it did not consistently turn into knowledge at the operational level. Hence, the right knowledge was not available to the right people.

With the establishment of the US PSM Standard by Occupational Safety and Health Administration (OSHA) in 1992, the importance of PSI and informing all affected employees of PSI became a key requirement in US facilities. Regulation, however, left the importance of Process Safety Information at the information level without extending it to knowledge.

Risk Based Process Safety incorporates four pillars: Commitment to Process Safety, Understand Hazards and Risk, Manage Risks and Learn from Experience. The Center for Chemical Process Safety (CCPS) thoroughly describes these pillars and 20 associated elements in its publication, Guidelines for Risk Based Process Safety (RBPS) [7]. One of the elements under the second RBPS pillar (Understand Hazards and Risk) is Process Knowledge Management. Process Safety Knowledge Management (PSKM) is different from the Process Knowledge Management (PKM) element. It directly impacts the four pillars of RBPS while operating within and beyond the limits of the individual elements of each pillar. In fact, PSKM is an expansion of PKM whereby it is actively used and maintained. PSKM is not just a catalog of information, but instead knowledge that is used to safely manage a process.

The Guidelines for Risk Based Process Safety (RBPS) book as published by CCPS in 2007 [7] highlighted the need for PSK and its inclusion in a wider management system. This work linked the PSK to the risk assessment and other risk management tools.

Initially, PSKM was based on word of mouth such as limited passing of anecdotal stories handed down from one to another almost like apprentices in trades. With the extension of PSI to PSK, there is an intentional and systematic processing of facts, records, and information management. It is important to understand the reasoning behind the action and not simply to replicate it.

1.4 Knowledge Pyramid

PSKM can be approached from the continuous improvement perspective of the Plan-Do-Check-Act (PDCA) cycle associated with other management systems. Using the PDCA cycle within the context of PSKM facilitates movement from simply providing information to people who operate and maintain processes to transferring knowledge and developing wisdom in these very same people.

The transition from data to wisdom can be represented by the Data-Information-Knowledge-Wisdom (DIKW) pyramid [8] (Figure 1-1).

Figure 1-1 Data-Information-Knowledge-Wisdom (DIKW) pyramid

Data: There are millions of data items in a process facility. Data is a collection of *name-value* pairs. An example of a *name-value* pair is the "Normal Operating Pressure" as the name and "100 psig" as the *value*. When these name-value pairs are collected over time, they form data. For example, the Unit is Isomerization, Time Step is 5, and the Normal Operating Pressure is 100 psig. Data can usually be represented in a tabular format, either on paper or electronically.

Information: This is a grouping of data items, describing their interrelationships, along with suitable narratives. Examples of *information* include drawings (e.g., Process Flow Diagrams - PFDs, Piping, and Instrumentation Diagram - P&IDs), procedures (e.g., normal shutdown procedure, start-up procedure), equipment files (e.g., pump curves, tank design specifications), and inspection reports (e.g., wall thickness measurements, vibration tests, etc.). Information can be presented in tabular, graphical, or textual formats, either on paper or electronically.

Knowledge: When information is assimilated by a person it becomes *knowledge*. Reading and viewing information is a common way for people to acquire knowledge. Training is an organized approach to assure that information has been transformed into knowledge in specified individuals. Knowledge can be further categorized in two dimensions: explicit and tacit [9]. *Explicit knowledge* consists of facts, rules, relationships, and policies that can be faithfully codified in paper or electronic form and shared without need for discussion. *Tacit knowledge* represents knowledge based on the experience of individuals [10]. Tacit knowledge is knowledge housed in the human brain, such as expertise, understanding, or professional insight formed because of experience. Tacit knowledge is highly personal, context-specific, and therefore hard to formalize and communicate. Tacit knowledge in an organization is human capital, whereas explicit knowledge is structural capital.

Wisdom: The experience gained by applying knowledge in practice provides a deeper understanding of the knowledge, leading to competency and enhanced expertise and, when providing exceptional value, is normally termed "*wisdom*." Wisdom relates to the ability to effectively choose and apply appropriate knowledge in each situation. Wisdom is an action-oriented concept. Knowledge is required but insufficient for wise action. Organizational wisdom is the collection, transference, and integration of individuals' wisdom and the use of institutional and social processes (e.g., structure, culture, leadership), in understanding how a company makes best use of its knowledge [11].

Organizations that operate at the bottom of the pyramid tend to be very reactive. As they move up the pyramid, from information-based to knowledge-based, the organization becomes more independent and more proactive since it has developed personal and/or group knowledge it can use to operate more efficiently. The final move to organizational wisdom transforms the organizational culture to interdependence where understanding of process operations is deep and more effective.

There are multiple inputs and outputs for each of the DIKW pyramid sections. As shown in Table 1-1, as one moves up the pyramid the outputs of the previous stage become the inputs of the next stage – representing the development occurring within the organization as people transition from phase to phase.

Table 1-1 Example Inputs and Outputs of the DIKW Pyramid

	INPUTS	OUTPUTS
Data	Safety Data Sheets Test reports Equipment lists	P&ID Flow diagrams Process Safety Information Manuals Hazard Identification and Risk Analysis (HIRA)
Information	P&ID Flow diagrams PSI Manuals HIRA	Risk assessments Controls list Operating procedures Training Emergency plans
Knowledge	Risk assessments Controls list Operating procedures Training Emergency plans	Verification of understanding Validation of competency Revalidation plans Shared learnings External learnings
Wisdom	Verification of understanding Validation of competency Revalidation plans Shared learnings External learnings	Broader learnings Subject matter experts Knowledge sharing Knowledge retention Right decisions

1.5 Audience

This book is intended primarily for Engineering Managers and Process Safety Managers of all organizations who realize that a structured approach to Process Safety Knowledge Management can add value and improve safety. The intended audience also includes Process Safety Specialists, Plant Managers, Maintenance Managers, Operations Managers, and anyone else in the organization who has a role in improving process safety performance through a structured implementation of Process Safety Knowledge Management.

1.6 Elements Not Covered in This Book

The following elements are outside the scope of this book:

- Complete listing of all items of PSI to collect for a project or a facility
- Complete listing of all items of Process Knowledge to collect for a project or a facility
- Application of artificial intelligence and machine learning to development of PSK without human interaction
- Information security including cybersecurity
- Business knowledge management

This book relates directly to the Process Safety Knowledge Management (PSKM) instead of covering a more general topic of "Knowledge Management for any Chemical Business". As such, while business topics such as succession planning are touched upon in Chapters 4 and 5, this book is aimed specifically at understanding, implementing, and maintaining a PSKM System.

1.7 Content and Organization of this Book

The summaries provide an overview of the content and organization of this book, chapter-by-chapter, to enable the reader to quickly locate a particular area of interest.

This book is divided into three sections. The first section (Chapters 2 and 3) introduces the business case for Process Safety Knowledge Management along with its interaction with multiple elements of Risk Based Process Safety. The second section (Chapters 4 and 5) addresses how to set up and sustain a successful Process Safety Knowledge Management system. The last section (Chapter 6) provides case studies and lessons learned from various industries.

Chapter 2 – Business Case for Process Safety Knowledge Management: this chapter discusses the benefits of having an effective Process Safety Knowledge Management system in an organization.

Chapter 3 – Process Safety Knowledge Management and Risk Based Process Safety: this chapter further describes Process Safety Knowledge Management and its interaction with relevant elements of Risk Based Process Safety such as Hazard Identification and Risk Analysis, Management of Change, Incident Investigation, and others.

Chapter 4 – Developing and Implementing Process Safety Knowledge Management: this chapter discusses subjects about developing and implementing a Process Safety Knowledge Management system relevant to facility design, operations, and maintenance.

Chapter 5 – Maintaining and Improving Process Safety Knowledge Management: this chapter builds on Chapter 4 content to provide a summary of the applicable tools currently available for Process Safety Knowledge Management. In this chapter, various tools are introduced to illustrate the principles described in Chapter 4. This chapter also highlights available metrics related to managing Process Safety Knowledge that can be used for improvement, as well as their ongoing review for a sustainable PSKM system.

Chapter 6 – Case Studies and Lessons Learned: this chapter includes Case Studies from around the world and their relevance to Process Safety Knowledge Management. The Case Studies share general as well as specific information regarding Process Safety Knowledge, related to the events that have occurred both within and outside the chemical process industry. The Case Studies describe how these events were handled from the perspective of management of Process Safety Knowledge. Effective and inadequate examples of PSKM are included in concise summaries.