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Methods in Chemical Process Safety

Serial Editor

Faisal Khan

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METHODS IN CHEMICAL PROCESS SAFETY

Edited by

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PREFACE

Chemical Process Safety is an area of growing importance within the chemical, oil and gas, and allied industries. Worldwide, the chemical sector alone represents a $5 trillion industry[a] and directly employs millions. The chemical sector is a fast-developing industry due to the growing dependence of society on energy resources and the rapid development of exploration and production technologies. The need for safe, well-managed processes within the industry has been highlighted by several recent disasters including the Deepwater Horizon oil spill in 2010 (caused by poor safety systems and cost cutting measures, according to a White House report) and the Tianjin disaster in China in 2015. These disasters not only cost human life but had a huge impact on the local environment and represent major financial losses for the companies involved.

The chemical, oil and gas, and allied industries are inherently risk-laden sectors. The continued occurrence of major process incidents has increased the awareness within the process industry about the importance of making development and operational decisions based on a thorough assessment of the associated risks to identify measures that can be taken to prevent potential losses. This increased awareness has shaped and influenced process safety science. Chemical process safety is a rapidly evolving area and is moving to more dynamic and adaptive methods of design and management to improve health and safety across the industry.

This book is the first volume of the *Methods in Chemical Process Safety* book series. This book series intends to be a one-stop resource for both academic researchers and professional practitioners. It aims to publish fundamentals of process safety science leading state-of-the-art advances occurring in the field while maintaining a practical approach for their application to the industries. An international editorial board and authorship ensures that this book series depicts the latest research developments from around the globe. Each volume will cover fully commissioned methods across the field of process safety, risk assessment and management, and loss prevention. This first volume discusses the Fundamentals of Process Safety from a practical perspective to make the book applicable for practitioners working within the industry.

[a] http://www.statista.com/statistics/302081/revenue-of-global-chemical-industry/.

This volume presents six chapters. Chapter 1 provides an overview of process safety regulatory and technological evolutions. It also provides examples of different Methods in Chemical Process Safety, including methods to identify process hazards and to implement, measure, evaluate, monitor, and manage safety of hazardous processes. Chapter 2 reviews the process safety incidents in the last decades and highlights the importance of learning from both major incidents and near misses. Main elements and foundational blocks of process safety are discussed in Chapter 3. This chapter helps safety practitioners to design and implement elements, which are required to optimize process safety management performance, efficiency, and effectiveness. Human error is frequently used to describe a cause of losses. Chapter 4 discusses the role of human factor in process safety and the importance of improving safety system designs rather than focusing on human failure as the root cause of accidents. Chapter 5 introduces the concept of risk-based process safety and the importance of considering both probability and consequences of process safety incidents in decision making. Finally, the process safety regulatory context is discussed in Chapter 6.

I am indebted to all members of the editorial and the contributory authors; this book could not have been published without their dedication, time, and commitment. On behalf of everyone who contributed in this volume, I hope that this book contributes to a safer future by serving as a source of knowledge in the field of chemical process safety. It is personally a great pleasure for me to bring together experts and compiling their contribution. I am imperfect and still learning and improving, I sincerely apology in advance for potential errors and misses in this volume. I encourage readers to share them with me for my self-learning and also to serve the community better. I look forward to learning from your feedback.

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CHAPTER ONE

Introduction

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1. BACKGROUND

1.1 Major Accidents Are Still Occurring

The growing dependence of society on energy resources has resulted in extensive exploration of hydrocarbon resources and the rapid development of the process industry. But, has process safety technology developed proportionally to the growth of the process industry? This needs to be investigated but what is clear is that major accidents are still occurring. Does this mean that we do not know what is the right thing to do? Or, do we know

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but have failed to act? Considering the alarming rate of the continued occurrence of major accidents in the oil and gas industry, the answer to both questions is "Yes," at least partially. Until we can answer "No" to these questions with confidence, if the future is similar to the past, unfortunately we should expect more accidents. For those who have been in the industry for very long, this is a given assumption.

1.2 People or Systems? Where Does the Blame Lie?

The answer to this question seems obvious. Crowl and Louvar reviewed the causes of the largest hydrocarbon and chemical plant accidents from Marsh's 100 largest losses report in the period from 1972 to 2001 and came to this conclusion: "Human error is frequently used to describe a cause of losses. Almost all accidents, except those caused by natural hazards, can be attributed to human error. For instance, mechanical failures could all be due to human error as a result of improper maintenance or inspection" (Crowl & Louvar, 2011). This conclusion is also aligned with Kletz's statement in his work titled "Still Going Wrong!" that: "Missing from this book is a chapter on human error. This is because all accidents are due to human error" (Kletz, 2004).

In 2005, an explosion at BP's Texas City refinery claimed 15 lives and caused much more injury and destruction. The company's vice president of North American refining testified in 2007 that: "Our people did not follow their start-up procedures [...] If they'd followed the start-up procedures, we wouldn't have had this accident" (Calkins & Fisk, 2007). Later, when it was found that the equipment was substandard, the company questioned managerial decisions to use it. Examples such as these are familiar in the field of professional safety, where expert investigators, managers, and the public respond to accidents by pointing to a "Bad Apple" tendency, and focusing on human failure as the root cause of accidents (Holden, 2009). Accordingly, the oil and gas industry has focused on making progress in process safety by protecting the system from unreliable employees/workers through selection, procedures, automation, training, and discipline.

However, it appears that outside the oil and gas industry, the situation is different, for example, in the aviation and nuclear energy sectors. Studies such as those by Dekker (2001) and Holden (2009) have referred to the "Bad Apple" approach of safety management (in industries such as oil and gas) as the "old view," according to which one "identifies bad apples (unreliable human components) somewhere in an organization, and gets rid of them or somehow constrains their activities" (Dekker, 2001). In contrast to the "old view" that posits human error as the cause of many accidents, the "new view" considers human error as a symptom of more complicated systematic issues (Holden, 2009). Perhaps this focus on flawed systems rather than human is one of the reasons behind the significantly fewer major accidents in the aviation and nuclear industries. Of course, humans, the creators of the systems, are involved in accidents, but they are not necessarily the sole or primary cause of losses. There is an emerging need for modern safety professionals to "reinvent" the understanding of human error more holistically by tracing the connections between human error and the tools through system-centered solutions. More discussions on the role of human factor in process safety are provided in the chapter "Role of Human Factor in Process Safety" by Mearns.

1.3 Learning From the Experience

Unfortunately, there is no shortage of new accident reports. Accident investigation reports are influential documents in the growth of process safety science. They are very beneficial in the light of what the industry currently knows—or assumes—about the nature of accidents (Lundberg, Rollenhagen, & Hollnagel, 2009). However, time, distance, and cultural challenges such as litigation, fear of adverse publicity, internal procedure, and disclosure of confidential information may influence how well the industry learns from its previous mistakes (Kletz, 2004). Usually, only those incidents that have had catastrophic consequences are publicized and used for developing new safety barriers. Moreover, some of the incident reports still describe only the immediate technical causes, failing to investigate the accident from different aspects.

The scope of improving process safety should also include learning from near misses. Near misses are symptoms of underlying process issues and provide valuable information to understand how systems work (Dahle et al., 2012). Learning from accidents and near misses requires a system-thinking approach to assess the interdependence of people, technology, and organizations rather than considering these elements in isolation (Dahle et al., 2012; Tjorhom & Aase, 2010; Wiig & Aase, 2007). The main assumption in system-thinking approach is that accidents do not occur solely because of incompetent operators, wrong procedures, poor techniques, faulty processes, or organizational failures. Instead, it is the combination of correlated, multicausal variables that interact to create the conditions in which accidents may occur. Failure to consider all aspects of organizational, cultural, technological, and human factors in accident investigation has usually resulted in the identification of lack of competence, experience, and risk awareness of operators as the primary cause of accidents (Dahle et al., 2012).

According to Lundberg et al. (2009), the causes found during investigations reflect the assumptions in the accident model following the principle of "What you look for is what you find." Moreover, the identified causes typically become specific problems to be solved during implementation of remedial actions, which follows the principle of "What you find is what you fix" (Lundberg, Rollenhagen, & Hollnagel, 2010). Therefore, the learning process from these experiences should focus on a bigger picture of causes of the wide range of accidents, using a holistic approach that includes all factors involved in accidents.

Another important issue relates to our ability—or lack of ability—to learn from positive results. There are several good examples of where the industry does appear to have learnt from incidents and has made improvements on a global basis (Marsh, 2016). However, in addition to focusing on "what went wrong," the oil and gas industry can benefit from asking "what went well," perhaps by examining the aviation, nuclear, and healthcare sectors. The chapter "Learning From the Experience" by Mannan is devoted to learning from the past success and failure experiences.

1.4 Are Major Accidents Black Swans?

"Black Swan" events are extreme and rare events, and in practice impossible to anticipate. Understanding and evaluating the potential exposure to "black swan" events has been a topic of discussion in recent years, particularly in the actuarial industry (Taleb, 2007). As expressed in Marsh's 100 Largest Losses report: "none of the losses listed in this document should be considered black swan events" (Marsh, 2016). Blowouts in drilling and well operations, flooding in distillation processes, runaway conditions in reactor systems, and other extremely dangerous process conditions are all inherent hazards of the process industry and are foreseeable. The disastrous Deepwater Horizon incident in the Gulf of Mexico in 2010, the largest oil spill in oil and gas history, was also not a "black swan" event. "On the day of the April 20 tragedy, no effective safeguards were in place to eliminate or minimize the consequences of a process safety incident" (CSB, 2014b).