1 INTRODUCTION

Since its founding in 1985, the Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers (AIChE) has promoted the enhanced management of chemical process safety. The CCPS has always recognized that good safety performance is achieved through a combination of technology and management excellence.

The management programs for the process safety, occupational safety and health, environmental, quality and security groups have developed separately in many organizations. CCPS recognizes that significant overall operational risk reduction occurs when these programs establish common management systems and metrics across the groups managing them. Hence, merging the similarities and common needs of these different programs will lead to more efficient and effective management within the organization. This guideline provides both small and large organizations with approaches to help identify and evaluate and leverage the common systems and metrics across the groups based on the hazards and risks being monitored for each group.

1.1 THE NEED FOR INTEGRATION

Many companies have overlapping regulatory, industry and trade association, and certification requirements that can consume significant resources and attention. Identifying synergies between these performance improvement systems will help ensure safe and reliable operations, will help streamline procedures and cross-system auditing, and will support regulatory and corporate compliance requirements. Since some of the systems and metrics are common to more than one function, a well-designed and implemented integrated management system will help reduce the load on the process safety, occupational safety and health, environmental, quality and security groups. In addition, an integrated system will help improve manufacturing efficiency and customer satisfaction. Integration of process safety, occupational safety and health, environmental, quality and security performance improvement systems have been noted in recent metrics-related themes at conferences, webinars, journals and books.

In almost every region and industrialized country, regulations have been introduced that require formal process safety, occupational safety and health, environmental and security management programs. Examples for process safety regulations include: the U.S. OSHA Process Safety Management (PSM) Standard and U.S. EPA Risk Management Program (RMP), the Canadian EPA Environmental Emergency Regulations, and the European Directive Seveso II. Detailed reference lists, included in Appendix A, provide a summary of U.S. regulations (Table A-1), international regulations (Table A-2), voluntary industry

standards (Table A-3), consensus codes (Table A-4) and organizations committing efforts to process safety (Table A-5).

Whether a facility is regulated or not, if it must handle hazardous materials and energies, a company's success will be impacted by how well it applies the fundamental elements of a process safety and risk management system and integrates metrics which affect process safety performance with its other risk reduction programs. As is shown in Table 1-1, the "business case" for process safety has been noted by several organizations (ACC 2013a, CCPS 2006) and was succinctly stated by Trevor Kletz decades ago, with many variations since then: "If you think process safety is expensive, wait until you have an accident." In addition to regulations, societal and political pressures from the public demand ever-better safety and environmental performance.

Every company needs to find ways to improve its operating efficiency and performance, reduce overall operating cost, and at the same time find ways to maintain and improve its competitive market position. Improving market position and customer satisfaction is inherent in an organization's quality management program. Although the management systems for process safety, occupational safety and health, environmental, quality and security may have developed separately, they have similar program-related expectations, such as being implemented with:

- Specific program-related record-keeping requirements, and
- Metrics used to demonstrate performance improvements of the program.

{*Note:* The management systems for process safety (S), occupational safety and health (H), environmental (E), quality (Q) and security (S) are sequenced for reference as "SHEQ&S" in this guideline.}

When the different SHEQ&S management systems are not well coordinated, the sometimes conflicting goals and demands on an operating facility may prompt program changes that inadvertently contribute to an increased process safety-related operating risk. Unfortunately evidence of such conflicts exists today since industry still experiences many preventable incidents due to inadequate hazardous materials management systems and programs. Examples include catastrophic equipment failures which resulted from inadequately designed, monitored and/or maintained equipment reliability programs. (Bloch 2012, US CSB 2003, and US CSB 2011b).

Other benefits for successful integration include reduced operating costs and more effective use of staff managing the programs, reducing duplication of effort across an organization. The history of successful business cost reductions is reflected in the improved results for organizations that implemented quality management programs. Some of the benefits for integrating programs using metrics which affect process safety performance and a quality management system approach are summarized in Table 1-1. This guideline is written to address the need for integration between the process safety, occupational safety and health, environmental, quality and security

management programs. Each of these programs has similar risk reduction goals that, once combined, will help a company become more efficient and effective when managing its overall operational risk.

Table 1-1. The "Business Case" for Process Safety

Business Value[1,2] - Reduced incident costs	
Ethical	Corporate responsibility
Employee	Fatalities, injuries, emergency response
Environment	Cleanup, material disposal, environmental remediation
Equipment	Repairs or replacement of failed component or damaged equipment as a result of subsequent fire or explosion
Financial	Flexibility, sustained value, business opportunity, business interruption, feedstock/product losses, loss of profits, obtaining or operating temporary facilities, obtaining replacement products to meet customer demand [e.g., from a sister facility at another location]
Business value[3] - Integrating management systems across groups	
Ethical	Distributed across the value chain and government entities and stakeholders
Community relations	Improved communications through Community Advisory Panels
Liability protection	Reduced insurance premiums, reduced terrorist liability [the Security Code meets Department of Homeland Security (DHS) requirements through the SAFETY Act as a Qualified Anti-terrorism Technology]
Organizational efficiency	Improve efficiency by taking advantage of and by combining existing management systems, encourages teamwork by bringing together diverse staff from multiple management teams (Groups: environmental, health, and safety; operations, maintenance, community relations; shipping; security; regulatory compliance; and purchasing)
Competitive advantage	Continuous improvement activity aligning environmental, health, safety, security, product stewardship and value chain performance
Business considerations[4] - Fundamental principles	
Humanist	Protecting the safety and health of employees and surrounding communities is the humanitarian thing to do - a company's moral obligation - regardless of legal obligation.
Employee / Labor relations	Employee involvement is a major tool in achieving quality safety and health. Consider areas in which employees can have a positive impact on safety performance.
Public Perception	Public perceptions about a company's attitude towards its employees can affect the market for its products.
Regulatory / Legal	Regulatory agencies aggressively enforce regulations; they can impose fines and cause operational interruptions. Companies and individuals may be held criminally liable for violations. The cost of litigating citations and proposed penalties against the company should also be considered. If found in violation, the company can lose some flexibility in how it allocates its resources. For uncontested violations, abatement must occur within the mutually agreed upon time period.
Financial	Consider the short- and long-term costs of adopting effective safety and health standards versus the increased cost of workers' compensation claims, lost time and other direct and indirect costs associated with a less effective program.

[1] CCPS, The Business Case for Process Safety, Second Edition, AIChE, 2006.
[2] CCPS, from the definition of "Direct Cost" in Process Safety Leading and Lagging Metrics, Revised: January 2011
[3] American Chemical Council (ACC), Business Value of Responsible Care©, http://responsiblecare.americanchemistry.com/Business-Value (accessed 18-September-2013)
[4] National Safety Council (NSC), 14 Elements of a Successful Safety and Health Program, (1994).

1.2 THE PURPOSE OF THIS GUIDELINE

One major goal of this guideline is to help an organization reduce its overall operational risk by integrating its monitoring-related work across groups, focusing on common high-risk metrics which affect process safety performance. The purpose of this guideline is to present a process through which an organization could develop or improve the ties between its existing process safety, occupational safety and health, environmental, quality and security management programs. Many metrics are common to more than one group, such that a well-designed and implemented integrated management system will reduce the work load on the process safety, safety and health, environmental, quality and security groups, and help improve manufacturing efficiency and customer satisfaction, as well.

The process described in this guideline uses parts of quality management approaches, such as Total Quality Management (TQM) or the ISO 9000/14000 series, providing an integrated management system that can be tailored to be consistent with a company's culture and management style (Albrecht 1990, ACC 2013b, Caropreso 1990, Juran 1964, Kane 1968, Scherkenbach 1986, Scholtes 1988).

1.3 THE SCOPE OF THIS GUIDELINE

The scope of this guideline focuses on the process for identifying common metrics between the process safety, occupational safety and health, environmental, quality and security management programs. Since some of the metrics which affect process safety performance are common across groups and recent reviews on the types of process safety metrics have been published, this guideline has been written to capture the latest approach to help reduce an organization's overall operating risks. Although a quality management system may form the basic foundation for these risk management programs, it is beyond the scope of this guideline to detail the different types of quality management programs.

1.4 THE APPROACH USED IN THIS GUIDELINE

The existing business and SHEQ&S management systems that are integrated into the SHEQ&S program are shown schematically in Figure 1-1. For the purposes of this guideline, the "SHEQ&S program" is defined as the set of SHEQ&S management systems which monitor meaningful metrics to indicate process safety conditions. Metrics common to these groups are shown schematically in Figure 1-2, where the different SHEQ&S management systems have overlapping areas. Some metrics are common to different SHEQ&S groups, as is represented by the intersections in Figure 1-2. Please note that the Safety systems include the two distinct process safety and personnel safety efforts essential for safe and reliable

operations. The personnel safety efforts, in particular, are a part of the existing occupational safety and health programs.

Unfortunately, some metrics used for monitoring and tracking occupational safety and health programs have proven to be inadequate as the only measure for the real condition of the organization's process safety programs (see additional discussion in Section 1.8). Hence, the goal of this guideline is to help an organization identify the common metrics which affect process safety performance across the different SHEQ&S groups, as is represented by the "center" area of the intersection between management systems in Figure 1-2. When appropriate indicators are selected, tracked and monitored, an organization can reduce its overall operating risk across the different groups.

This guideline recognizes that companies may combine their risk reduction efforts into several different groups, with different combinations of the Safety (both process and occupational), Health, Environmental, Quality and Security groups (e.g., SH&E, HS&E, H&S, etc.). However, no matter what a company's organizational chart looks like, this guideline assumes that each group monitors group-specific metrics to ensure that its group's particular risks are reduced.

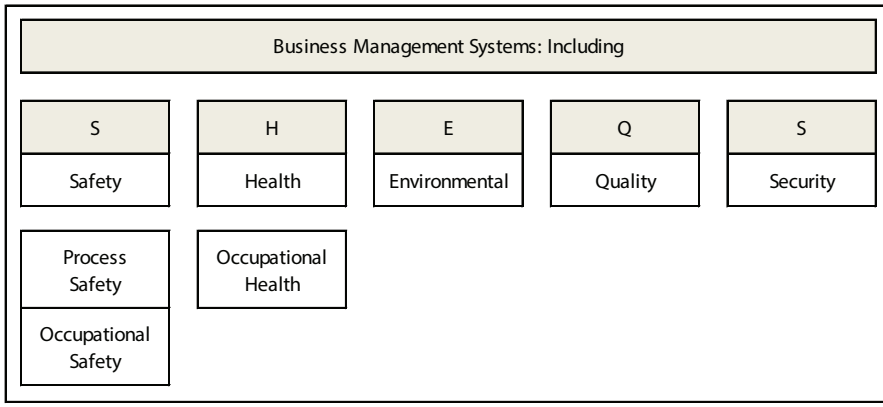

Figure 1-1. The Management Systems in the SHEQ&S Program

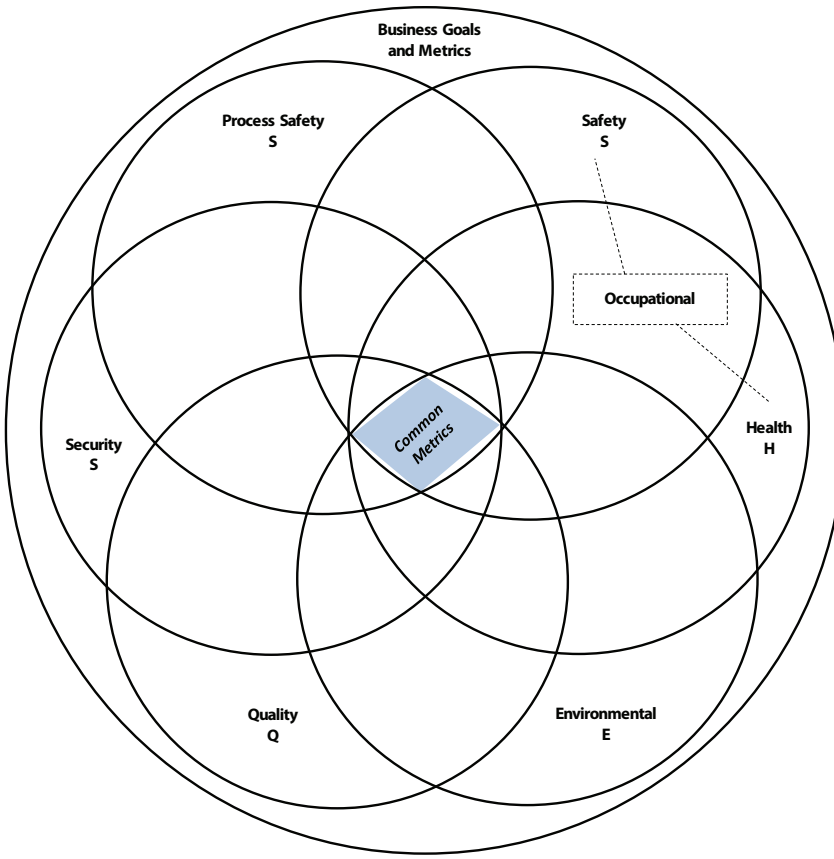

Figure 1-2. Metrics Common to the SHEQ&S Management Systems

The framework for organizing the material presented in each chapter combines the SHEQ&S program "Life cycle" phases and the "Plan, Do, Check, Act (PDCA)" approach as is shown in Figure 1-3. Each phase is briefly described below for Chapters 2 through 7:

Phase 1) The "Plan" intent for the SHEQ&S program:

The SHEQ&S program design begins at the initial "plan" phase (the program's creation or birth); with the understanding that reviews and gap analyses may change the program's design during its life as the programs mature and grow beyond their infancy.

The “Plan” phase chapters are:

Chapter 2. Secure Leadership Support across Groups

Chapter 3. Evaluate Hazards and Risks across Groups

Chapter 4. Identify Common Metrics across Groups

Phase 2) The “Do” intent for the SHEQ&S program:

The “do” phase is the day-to-day day application of each of the SHEQ&S systems. S uccess hinges on these systems being in place and adhered to by everyone, from those working in the field to those in senior management making decisions that affect the resources required to effectively implement the management systems. Safe, highly reliable organizations understand and apply the principles of conduct of operations and operational discipline.

The “Do” phase chapter:

Chapter 5. Implement the SHEQ&S Program

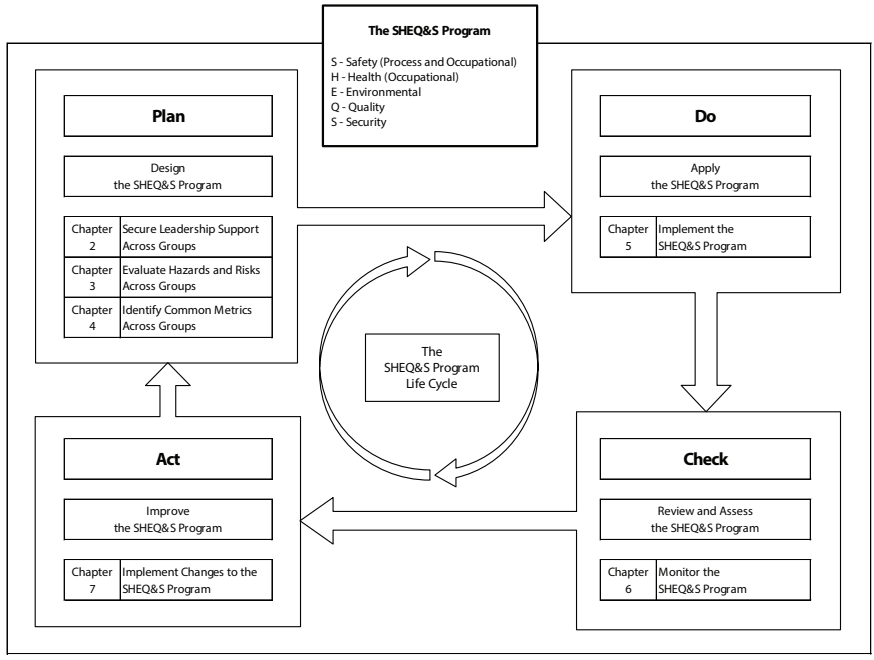

Figure 1-3. The Phases in the Plan, Do, Check, Act (PDCA) Approach

Phase 3) The "Check" intent for the SHEQ&S program

The "check" phase includes monitoring the SHEQ&S program metrics and auditing for trends. Every program needs to be reviewed on a regular frequency to ensure that organizational complacency does not occur.

The "Check" phase chapter:

Chapter 6. Monitor the SHEQ&S Program Performance

Phase 4) The "Act" intent for the SHEQ&S program

The "act" phase addresses the main driver of change for the SHEQ&S program: trending and gap analyses. New people, staffing reorganizations and findings from investigations or gap analyses may affect the selection of the SHEQ&S program metrics.

The "Act" phase chapter:

Chapter 7. Implement Changes to the SHEQ&S Program

For effective management of process safety risks within each SHEQ&S system, a company's culture and management style require strong operational discipline by everyone in the organization, whether they are contributing at the planning, doing, checking or acting phase, to help ensure and sustain safe and reliable operations.

1.5 HOW ESTABLISHED MODELS CAN BE USED IN INTEGRATED SYSTEMS

Different industries may manage Process Safety under various titles including Safety Management System (SMS), Operational Excellence (OE), Integrity Management Systems (IMS), Process Safety Management (PSM), Health, Safety & Environment Management System (HSEMS) or Security Management Systems (SeMS). Although there are different approaches and models that are tailored to meet a company's culture and management style, this guideline uses a structure that combines the CCPS's Risk Based Process Safety approach and international models (including the ISO 9000, ISO 14000 and the Certification Europe OSHAS 18000 series of standards) for illustrative purposes, recognizing that other management systems have similar structures. Additional management system frameworks are noted in the references at the end of this chapter. Whether a company is working with SMS, OE, IMS, PSM, HSEMS and/or SeMS systems, this guideline provides a methodology to help identify and select common metrics used to monitor and help improve process safety performance.

Some jurisdictions may require a "Safety Case" from which regulators expect the company operating a process with hazardous materials and energies to make

the case for safety – the company has taken all measures necessary to prevent major incidents and have reduced their risk as low as reasonably practicable (ALARP). The Safety Case identifies the hazards and risks, describes how the risks are controlled, and describes the safety management system in place to ensure the controls are effectively and consistently applied. The basic principle is that those who create the risk must manage it. Because the company has the greatest in-depth knowledge of the hazards at its facility, the company must assess its processes, procedures and systems to identify its hazards, evaluate its risks and implement appropriate controls. This includes a demonstration that the company is employing recognized and generally accepted good engineering practices (RAGAGEP) in its engineering design, including human factors considerations, by using robust management systems. Although the Safety Case is not a management system, it demonstrates that a company complies with the regulation by having a safety management system included in its integrated SHEQ&S program.

1.6 EXCLUSIONS TO THE SCOPE

The scope of this guideline does not include advice on the development or implementation of specific business, process safety, occupational safety and health, environmental, quality and security systems and their respective programs. The guideline focuses on combining existing systems into an "integrated" SHEQ&S program based on common metrics which affect process safety performance. It is intended to provide a format, or a framework, for easy adaptation anywhere in the world. The references provided in this book provide multiple resources for detailing the design and implementation of the specific systems and their programs.

1.7 KEY AUDIENCE FOR THIS GUIDELINE

This guideline is intended primarily for people who help implement and monitor their group-specific risk reduction management systems, whether they are at the corporate, the facility or the process unit level of an organization. This includes the leaders and Subject Matter Experts (SMEs) within these groups: process safety, occupational safety and health, environmental, quality and security. This guideline will be a useful training tool and reference for corporate and/or site managers and leaders across all of the groups, helping them better understand the complexities inherent in reducing their overall operating risk (see discussion on developing leadership capabilities in Section 2.6). In addition, this guideline will help process safety auditors establish process safety-specific metrics that can be evaluated, both for program compliance and for system implementation at a facility.

This guideline applies to the people at small, medium and large facilities handling hazardous materials and energies, especially those required to have a

formal regulatory or corporate-driven process safety management (PSM) program. The design of this guideline will benefit smaller facilities with limited resources, as well as larger facilities which struggle with inefficiencies across business units within the facility. Large corporations will benefit from integrated metrics when managing global corporate process safety risks, as well.

1.8 SOME RECENT ADVANCES IN PROCESS SAFETY METRICS

It is hoped that this guideline captures the essence of some recent advances in process safety metrics. Note that there are process unit-specific, facility-specific and company-specific metrics which apply to each group at each level. These metrics may not apply to the other groups or levels in the organization. In addition, it is beyond the scope of this guideline to describe in detail the different types of metrics which have been identified, such as “leading” and “lagging” indicators. Please refer to Appendix B for a brief overview and specific references for more details on recent advances in identifying and selecting process safety metrics.