



ESSENTIAL PRACTICES FOR CREATING, STRENGTHENING, AND SUSTAINING PROCESS SAFETY CULTURE



WILEY

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**PUBLICATIONS AVAILABLE FROM THE
CENTER FOR CHEMICAL PROCESS SAFETY
of the
AMERICAN INSTITUTE OF CHEMICAL
ENGINEERS**

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New York, NY



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This edition first published 2018

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Library of Congress Cataloging-in-Publication Data

Names: American Institute of Chemical Engineers. Center for Chemical Process Safety, author.

Title: Essential practices for creating, strengthening, and sustaining process safety culture / Center for Chemical Process Safety of the American Institute of Chemical Engineers.

Description: New York, NY : American Institute of Chemical Engineers, Inc. :

John Wiley & Sons, Inc., 2018. | Includes bibliographical references. |

Identifiers: LCCN 2018023924 (print) | LCCN 2018024176 (ebook) | ISBN 9781119515142 (Adobe PDF)

| ISBN 9781119515173 (ePub) | ISBN 9781119010159 (hardcover)

Subjects: LCSH: Chemical engineering--Safety measures.

Classification: LCC TP150.S24 (ebook) | LCC TP150.S24 E87 2018 (print) | DDC

660/.2804--dc23

LC record available at <https://lcn.loc.gov/2018023924>

Cover images: ©jimmyjamesbond/iStockphoto; ©crisserbug/iStockphoto

Cover design by Wiley

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

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SUPPLEMENTAL MATERIAL AVAILABLE ON THE WEB

Additional content referenced in this book as well as an electronic form of the culture assessment tool are available at www.aiche.org/ccps/publications/guidelines-culture

ACRONYMS AND ABBREVIATIONS

AI	Asset Integrity
AIChE	American Institute of Chemical Engineers
ALARA	As low as reasonably achievable
ALARP	As low as reasonably practicable
ANSI	American National Standards Institute
API	American Petroleum Institute
BBS	Behavior based safety
CBT	Computer-based training
CCC	Contra Costa County
CCPS	Center for Chemical Process Safety
DCS	Distributed control system
DIERS	Design Institute for Emergency Relief Systems of the American Institute of Chemical Engineers
EHS	Environmental, health, and safety
FMEA	Failure modes and effects analysis
HAZCOM	Hazard Communication (Standard – a U.S. regulation)
HAZOP	Hazard and Operability (Study)
HAZWOPER	Hazardous Waste Operations and Emergency Response (Standard – a U.S. regulation)
HIRA	Hazard Identification and Risk Analysis
HSE	Health and Safety Executive (United Kingdom)
IPL	Independent protection layer
ITPM	Inspection, testing, and preventive maintenance
ISA	International Society of Automation (formerly Instrument Society of America)
ISO	International Standards Organization, Industrial Safety Ordinance
ISD	Inherently safer design
LOPA	Layer of protection analysis
MI	Mechanical Integrity

MKOPSC	Mary Kay O'Connor Process Safety Center (Texas A&M University)
MOC	Management of Change
NEP	National Emphasis Program
NFPA	National Fire Protection Association
OE	Operational excellence
OSHA	Occupational Safety and Health Administration
PDCA	Plan-Do-Check-Act
PHA	Process hazard analysis
P&ID	Piping and instrument diagram
PSI	Process safety information
PSM	The USA OSHA Process Safety Management Regulation
PSMS	Process safety management system
PSSR	Pre-start-up safety review
QRA	Quantitative risk analysis
RAGAGEP	Recognized and generally accepted good engineering practice
RBI	Risk-based inspection
RBPS	Risk-based process safety
RC	Responsible Care®
RCA	Root cause analysis
RMP	Risk management program/risk management plan
RP	Recommended practice
SDS	Safety Data Sheet
SIL	Safety integrity level
SIS	Safety instrumented system
SOP	Standard operating procedure
SWP	Safe work practice
UKHSE	Health and Safety Executive (United Kingdom)
VPP	Voluntary protection program

GLOSSARY

CCPS has developed a standard glossary that defines many common terms in process safety. By reference the current CCPS Process Safety Glossary at the time of publication is incorporated into this book and can be found at <http://www.aiche.org/ccps/resources/glossary>. Additionally, there are some specific terms used in this book that are not currently included in the standard glossary. These terms are defined in the book as necessary when they are introduced.

ACKNOWLEDGEMENTS

The American Institute of Chemical Engineers (AIChE) and the Center for Chemical Process Safety (CCPS) thank the Process Safety Culture Subcommittee members and their CCPS member companies for their generous efforts and technical contributions to this book. CCPS also thanks the members of the CCPS Technical Steering Committee for their advice and support.

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CCPS offers special thanks to subcommittee members Anne O'Neal, Karen Tancredi, Steve Arendt, Gretel D'Amico, Gilsa Pacheco Monteiro, and Dan Miller, who provided significant input during the production of this book.

CCPS acknowledge AcuTech Group, Inc. for preparing the original manuscript. The AcuTech Team, under the leadership of Project Manager Michael J. Hazzan, also included David M. Heller, Scott Berger, and Martin R. Rose. Lou Musante of Echo Strategies provided additional content under subcontract.

Scott Berger of Scott Berger and Associates LLC provided a structural edit of the manuscript, provided additional content, and typeset the final book.

Peer Reviewers

Before publication, all CCPS books undergo a thorough peer review. This book was no exception; many people offered thoughtful suggestions and comments.

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PREFACE

I have worked in different sectors of the chemicals and oil refining businesses since the 1960s. I began as a lab technician who worked shifts for a major chemical company in Northern Ireland, where I grew up. It was there that I experienced my first and only chemical process fatality during my working years in the chemical industry. I have very vivid memories of that tragedy to this day.

Later I went to work for a chemical company in the United States and I quickly realized it was vitally important to pay careful attention to preventing accidents as the chemicals we worked with included carbon monoxide, phosgene, chlorine, isocyanates and peroxides. In 1982, I served as the environmental manager in a chemical plant that had a catastrophic explosion. The details of that event and its aftermath are embedded deeply in my memory.

In 2002, I was appointed to the U.S. Chemical Safety Board (CSB) as a Board Member and later as Chairman. At the CSB we investigated failures in the chemical, oil refining and other industries – failures that resulted in loss of life, property damage and community outrage. Sadly, I saw many examples – fires, dust explosions, loss of containment, mechanical integrity failures.

In my early years in the chemical industry there was a strong focus on safety, but the emphasis was on the slips, trips and falls type of safety – avoiding injury to workers. Metrics were developed for first aid cases, reportable injuries and lost work day injuries. This was and still is a good practice and for the more progressive companies it made for a safer workplace environment. These companies were said to have a strong safety culture. Of course, process safety was still important, but not in an organized way. We knew the hazards of phosgene or dinitrotoluene and we took steps to mitigate those hazards. In

the more enlightened companies, greater attention was paid to the chemical process hazards, but the culture in many companies was to equate overall safety with personnel safety, including some measures of process safety.

While the personnel safety record in the chemical and oil industry was better than general industry, unfortunately there continued to be major and well publicized fires and explosions in these industries. Tragedies such as the 1989 Phillips 66 explosion in Pasadena, Texas, the 1974 Nypro cyclohexane explosion in Flixborough, England, and the 1988 Shell refinery explosion in Norco, Louisiana. In response to these and other incidents, the U.S. Occupational Safety and Health Administration published its regulations on the process safety management of highly hazardous materials, commonly known as OSHA PSM. The 14 elements of PSM set an obligation for the safe operation of facilities with highly hazardous materials. The process industries have been required to comply with these regulations since 1992.

However, when the fourteen elements of PSM are examined there is an omission. That omission is the development and assessment of the process safety culture. I am very pleased that this absence has now been remedied by the publication of *Essential Practices for Creating, Strengthening and Sustaining Process Safety Culture* by the Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers. This excellent book fills a gap in the literature on process safety and guides companies and manufacturing facilities on the road to a strong process safety culture. It is the latest in a series of more than 100 high quality texts on process safety published by CCPS, many of which can be found on shelves in chemical plants and oil refineries around the world. Writing CCPS books requires the volunteer efforts of many experts from the chemical and oil industries. It is a time consuming but very satisfactory labor of love. I know because I have participated in the writing of a CCPS book.

This book offers several definitions of process safety culture. Even though there may be some disagreement about a definition of process safety culture, when you visit a facility you very quickly get a sense how important a positive process safety culture is to the facility. You will know it when you see it. From the first moment when you encounter a security guard or a receptionist to a tour of a control room you can quickly gauge the culture. Are process safety metrics displayed around the plant? Are operators communicating with each other in a professional manner? Is the senior manager well versed in the hazards of the operation?

As you read this book you will learn many aspects of how to develop a sound process safety culture. From my experience, a strong process safety culture must start with leadership. By leadership I mean everyone in a leadership position from the chairman of the board to the supervisor on the shop floor. They must set the example. It starts with leadership being aware of the hazards in their processes and putting in place the organization and expertise to control those hazards. Just as important, the senior leadership must communicate his or her concerns about the need for an effective process safety program. These concerns should be an ongoing part of senior leadership's communications with the organization. This is the way to ensure the establishment of a culture of process safety across the organization.

I commend CCPS on the publication of its latest book and I encourage readers to turn its lessons into actions in their day-to-day work of ensuring safety for employees, contractors and the surrounding community. As well as saving lives and preventing injuries it is vital for the financial success and reputation of the chemical process industries.

John S. Bresland
Shepherdstown, West Virginia

NOMENCLATURE

Culture: When used alone in this book, the term culture specifically means process safety culture, and the two terms are used interchangeably. When used to refer to other types of corporate culture, the specific type of culture will be specified, e.g. business culture.

Element Names: Process safety element names have been taken from *CCPS Guidelines for Risk Based Process Safety*. When alternative names are in common use, both the RBPS name and the common name are used, e.g., HIRA/PHA.

Operations: The full spectrum of tasks and activities involved in running a facility, including process operation, maintenance, engineering, construction, and purchasing.

Operator: An individual who runs the process from the control room and/or the field.

Process safety: A disciplined framework for managing the integrity of operating systems and processes handling hazardous substances by applying good design principles, engineering, and operating practices. It deals with the prevention and control of incidents that have the potential to release hazardous materials or energy. Such incidents can cause toxic effects, fire, or explosion and could ultimately result in serious injuries, property damage, lost production, and environmental impact.

Process safety management system (PSMS): A management system for implementing process safety. PSMSs include Risk Based Process Safety (RBPS) as defined by CCPS, the many PSMSs developed by companies to suit their specific requirements, PSMSs specified by regulations, and others.

References to process safety culture core principles:

Throughout the book the names of the core principles of process safety culture are typeset in *italics*. Italics are also used when the context requires use of a different syntax, including the negative forms, such as “They allowed *deviance to be normalized*, leading to...”

Should vs. must and shall: The term *should*, used throughout the book, refers to actions or guidance that are recommended or presented as options, but not mandatory. The pursuit of process safety culture is very personal, and therefore a single approach cannot be mandated. The terms *must* and *shall*, commonly used in voluntary consensus standards and regulations, appear in this book only when quoting other sources. Quotes are offered only to provide perspective, and their use in this book does not mean that the authors consider the quoted text to be mandatory.

EXECUTIVE SUMMARY

Leading process safety practitioners have long recognized that the way leaders shape attitudes and behaviors can make the difference between success and failure in preventing catastrophic incidents. Investigations of incidents in the chemical, oil and gas sectors, as well as experience in the nuclear, and aerospace sectors have shown cultural failures rival management system failures as leading causes. Similarly, when long-term successes have been achieved, strong cultures of process safety excellence have been an integral factor.

This book provides current guidance on developing and improving process safety culture. It discusses how leaders can develop the commitment and imperative for process safety at the top, and then cascade that commitment throughout the organization. It shows how leaders can take the ultimate responsibility for process safety, and foster the core principles of process safety culture.

Of course, process safety culture does not exist in a vacuum relative to overall company culture. Changes to process safety culture may thus require changes in other aspects of the company culture, including, for example, operational excellence, human resources, and quality. This should not be viewed as a zero-sum game. Process safety may borrow key positive cultural attributes from other parts of the culture. Likewise, strengthening process

safety culture may help strengthen other parts of the overall culture.

Leaders at any level of the organization will benefit from the guidance provided in this book. Senior executives will likely be drawn most to the first 3 chapters and the beginning of chapter 5, while the remainder of the book contains more detailed guidance useful at the implementation level. However, all readers will find useful information throughout the book.

After defining process safety culture, this book outlines 10 core principles of process safety culture:

- Establish an Imperative for Process Safety
- Provide Strong Leadership
- Foster Mutual Trust
- Ensure Open and Frank Communications
- Maintain a Sense of Vulnerability
- Understand and Act Upon Hazards/Risks
- Empower Individuals to Successfully Fulfill their Process Safety Responsibilities
- Defer to Expertise
- Combat the Normalization of Deviance
- Learn to Assess and Advance the Culture

The book then shows how these core principles strengthen process safety management systems (PSMSs), which implemented together can lead to success. The role of process safety culture in metrics, compensation, and other related activities is addressed. Lastly, the book discusses how to make process safety culture sustainable.

Appendices include more detailed descriptions of several concepts presented in the book, such as organizational culture, human behavior, and high reliability organizations, along with

case histories useful for prompting culture discussions and a process safety culture assessment checklist.

The concepts discussed in this book began to be developed in the wake of the loss of the Space Shuttle Columbia. Members of CCPS toured the Columbia launchpad the day before launch as part of a learning-sharing session with NASA safety experts. This personal exposure to tragedy motivated Jones and Kadri (www.aiche.org/ccps, “Process Safety Culture Toolkit”) to lead an effort to capture key culture lessons-learned from the Columbia investigation and apply them to the process industries.

Since that time, lessons continue to be learned about what makes process safety culture effective. This book attempts to distill the significant amount of published work, as well as the personal experience of CCPS member companies into actionable guidance.

Like other CCPS books, the guidance provided includes numerous options companies can choose from to suit their needs. While the book has been prepared with the similar care of a voluntary consensus standard, it is not a standard or a code, and has no legal or regulatory standing. And that is entirely appropriate to the mission of process safety culture – to create an imperative for process safety with felt leadership that comes from the heart, not forced by requirement.

1

INTRODUCTION

1.1 IMPORTANCE OF PROCESS SAFETY CULTURE

The 2014 FIFA World Cup semifinal between Germany and Brazil featured two of the most technically proficient teams to contest a match. Within a half-hour, however, the difference between the two emerged, as Germany scored five goals on a shell-shocked Brazil on the way to a 7-1 rout.

The difference? Neymar da Silva Santos, the captain, leader, and culture-setter of the Brazilian side, had suffered a fractured vertebra in the previous match, and could not even cheer his teammates on from the sidelines. With their culture-leader absent, Brazil failed to execute their usually formidable game plan and suffered a catastrophic loss.

Similarly, process safety cannot succeed without culture leadership. Investigation of numerous incidents in major hazard operations has clearly revealed culture deficiencies. The data show that without a healthy process safety culture, even the most well-intentioned, well-designed process safety management system (PSMS) will be ineffective. For example, Union Carbide was known as a process safety technology leader in the early 1980s. However, weak culture at its Bhopal facility allowed many “Normalization of Deviance” failures leading to the December 3, 1984 tragedy. Simply stated, a strong, positive process safety culture enables the

PSMS = Process Safety Management System

facility's PSMS to perform at its best. This gives the facility its best chance to prevent catastrophic fires, explosions, toxic releases, and major environmental damage.

Like all cultures, process safety culture starts with strong, committed, and consistent leadership. Just as commanding officers set the cultures of their troops, senior leaders of facilities and companies set the process safety culture of their organizations. Senior leaders set the underlying tone for how an organization functions and motivates the individuals within the organization to maximize the impact of their collective talent (Ref 1.1).

Without leadership's direct, continuing, and strong participation in setting process safety culture, the culture will suffer gaps in one or more of the ten cultural principals (see chapter 2). This leadership should cascade through the organization, with each leader helping their subordinates, peers, and managers maintain focus on achieving the desired culture.

Leadership of culture should survive economic downturns and keep pace with upturns and technology changes. Culture leadership should persist through acquisitions and divestitures. Perhaps hardest of all, it should survive changes of personnel. Altogether, leadership should be committed to establishing and maintaining a sound process safety culture and should establish the proper philosophical tone for the culture. This tone should emphasize the true importance of process safety and the faithful execution of the PSMS. The importance of strong leadership will be further discussed in section 1.4 and in Chapter 3.

1.2 DEFINITION OF PROCESS SAFETY CULTURE

Many experts have defined culture as what people do when their boss is not around. A group of people with a common purpose (e.g., co-workers, teammates, and families) develops a set of beliefs, customs, and behaviors that become embedded in how

the group thinks and works. With continued practice, these beliefs and behaviors become reinforced and integrated into the group's value system (Refs. 1.2, 1.3). As time goes on, the group's actions reflect common and deeply held values. The group expects newcomers to adopt or "buy into" these values to become accepted into the group.

Unfortunately, negative cultures can also exist, where common values result in attitudes and actions with negative consequences. In such cultures, peer pressure can reinforce negative behaviors. This may happen for example, if a new co-worker berated for following the approved procedure instead of the common but unsafe shortcut.

The International Nuclear Safety Advisory Group (INSAG) of the International Atomic Energy Agency (IAEA) made one of the first definitions of safety culture in the investigation of the aftermath of the Chernobyl accident in 1986 (Ref 1.4).

"Safety Culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance."

The preceding definition describes the result of the culture, but not the culture itself (Ref 1.5). In the wake of the *Challenger* and *Columbia* disasters, NASA (Ref 1.6, 1.7) began to recognize that key personnel defined organizational culture, and that change in personnel can lead to negative culture change:

"Organizational culture refers to the basic values, norms, beliefs, and practices that characterize the functioning of a particular institution. At the most basic level, organizational culture defines the assumptions that employees make as they carry out their work; it defines "the way we do things here." An organization's culture is a powerful force that persists through reorganizations and the departure of key personnel."

Describing groundbreaking CCPS work in 2005, Jones and Kadri (Ref 1.8) adapted these published definitions to process safety and recognized the link of culture to management:

*“For process safety management purposes, we propose the following definition for process safety culture: The combination of group values and behaviors that determine **the way process safety is managed.**” (emphasis added)*

In the wake of its investigation of a refinery explosion in Texas City, TX, USA, the US Chemical Safety Board (CSB) leveraged the CCPS work Jones and Kadri described (Ref 1.9). CSB recommended that the company conduct an independent assessment of process safety culture at their five U.S. Refineries and at the Corporate level. The resulting Baker Panel report (Ref 1.10) identified numerous culture gaps and improvement opportunities. They then went on to say, “We are under no illusion that deficiencies in process safety culture, management, or corporate oversight are limited to the company.” This statement proved to motivate many process safety culture improvements in refining and chemical companies globally.

Additional study led CCPS to define process safety culture based on the critical role of leadership and management. CCPS’s Vision 20/20 (Ref 1.11) CCPS stated that a committed culture consists of:

1. Felt leadership from senior executives. Felt leadership means more than a periodic mention of process safety in speeches and town hall meetings. It means that executives feel a deep personal commitment and remain personally involved in process safety activities.
2. Maintaining a sense of vulnerability.
3. Operational discipline, the performance of all tasks correctly every time.

This sums up several definitions of culture from other sources as it applies to environmental, health, or safety programs and issues:

- **(Ref 1.12):** “Safety and health are (or have become) part of the company culture—and frequently part of the management system. ‘Culture’ is traditionally defined as ‘a shared set of beliefs, norms, and practices, documented and communicated through a common language.’ The key word here is ‘shared.’ Companies have found that if safety and health values are not consistently (and constantly) shared at all levels of management and among all employees, any gains that result from declaring safety and health excellence a ‘priority’ are likely to be short-lived.”
- **(Ref 1.13):** “The attitudes, beliefs and perceptions shared by natural groups as defining norms and values, which determine how they act and react in relation to risks and risk control systems.”
- **Canadian National Energy Board (Ref 1.14):** “Safety culture means ‘the attitudes, values, norms and beliefs, which a particular group of people shares with respect to risk and safety’.”
- **UK Health and Safety Executive (Ref 1.15):** “The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organization’s health and safety management.”

These definitions share common themes and terms. For something to become embedded in the culture of an organization or group, it is believed by its members. The belief becomes a common or shared belief, a value, or a norm. These norms result in certain repeated actions or behaviors.

The shared beliefs and values may create a culture that is either positive or negative, either strong or weak. A strong positive process safety culture would generally exhibit norms such as:

- Always doing the right thing even when nobody is watching or listening,
- Not tolerating deviance from approved policies, procedures, or practices,
- Maintaining a healthy respect for the risks inherent to the processes, even when the likelihood of serious consequences is very low; and
- Performing actions safely, or not performing them at all.

Conversely, a negative or weak culture would generally exhibit norms such as:

- Tolerating deviance from approved policies, procedures, or practices,
- Allowing such deviance to become regular occurrences,
- Exhibiting complacency regarding the operation's process risks; or
- Allowing short-cuts to occur to get something done more quickly or more cheaply.

The CCPS Culture Subcommittee distilled the published definitions listed above, along with their personal ongoing experience in building and strengthening process safety culture. For purposes of this book, a sound or strong positive process safety culture is:

The pattern of shared written and unwritten attitudes and behavioral norms that positively influence how a facility or company collectively supports the successful execution and improvement of its Process Safety Management System (PSMS), resulting in preventing process safety incidents.

From this starting point, Chapter 2 will describe core principles of process safety culture. Chapter 3 will discuss the leadership

dimensions of culture. Chapter 4 will address culture from the standpoint of organizational dynamics, human behavior, compensation, ethics, external influences (e.g. contractors, vendors, public sector), and metrics. Chapter 5 will discuss the ways in which culture can directly impact each element of CCPS's Risk Based Process Safety (RBPS) PSMS. Chapter 6 will provide a guide for getting started establishing a strong culture or improving culture. Chapter 7 will address how to achieve a sustainable culture. The appendices provide additional background on culture, case histories that may be useful in discussing culture issues, and a culture assessment protocol. Taken together, the concepts discussed in these chapters provide the concepts and guidance to make these concepts a reality in an organization.

This book does not discuss regulations, but instead comes from the point of view that a strong positive culture adequately addresses process hazards, whether regulated or not. This represents the first concept of a strong, positive process safety culture: the organization's leadership and all personnel believe in the necessity of process safety and commit to it, even in the absence of regulatory requirements.

Some people have expressed the belief that safety culture cannot change. They consider core principles, company values and principles, and how the company behaves. They then conclude that good cultures will stay good, while poor cultures cannot improve. Mathis disagrees, suggesting that those who claim culture is static may be resisting the culture change (Ref 1.5).

From a sociology point of view, cultures of all kinds develop via social conditioning. With the right conditioning, applied patiently over time, leaders can build strong positive cultures. Typically, this requires patience and persistence. It can take some time to build workers' trust and to convince them that the intended culture change is not a temporary fad.

Conversely, negative conditioning can occur. Since trust can be lost much faster than it can be gained, even momentary lapses in process safety leadership can lead to rapid degradation in the culture.

Clearly then, process safety has an inherent capability to improve – and to degrade, and no single culture resides in the DNA of the organization. This makes it essential to have the patience to improve of process safety culture over time, and then maintain focus on culture over time to maintain consistent good performance.

While this book addresses process safety culture, the concepts of process safety culture are not unique to process safety. Good concepts may be leveraged from the overall company culture or various subcultures (e.g. the company's innovation, sales, financial, EHS, and other cultures). At the same time, if any of these company cultures contain values contrary to a good process safety culture, leaders need to recognize this and find a way to keep those values out of the process safety culture effort.

The company and facility's country and regional cultures should also be considered. These can make a culture effort either easier or more difficult. Diversity of the organization's personnel can inject a wider range of external cultures that could impact a culture effort. Essentially, everyone within a diverse group of employees will have to make unique kinds of culture changes to arrive at the desired common process safety culture. Diversity may also inject different languages or different ways that things are expressed into a given facility, and should be accommodated in the communications between personnel. Leaders of culture change need to consider these factors.

Diversity plays an even more significant role when a company strives to establish a global process safety culture. Each facility has a distinct culture. Any facility may have positive cultural aspects that will help the process safety culture transformation effort, just