# 1 Introduction

## 1.1 Introduction

This chapter discusses the scope of, the audience for, and the benefits for the readers of this guideline. For readers unfamiliar with the CCPS Risk Based Process Safety (RBPS) approach, this chapter also includes a brief overview of its framework, including how lessons learned from experience (one of the RBPS pillars) are incorporated into each chapter. The last section in this chapter provides the reader with the guideline's framework: how the chapters are organized based on the types of operations at a facility (normal, abnormal, and emergency) and how the risks associated with each transient operating mode—the subject of this book—depends on which mode of operation the process is undergoing at that time.



## 1.2 Scope

The scope of this guideline addresses process safety activities that are essential for effectively managing the risks associated with the different *transient operating modes*, recognizing that not all activities will apply to every mode. Since the risk of incidents can be high during the start-ups and shut-downs for normal operations in most manufacturing facilities, this book presents incidents that occurred during start-ups and shut-downs, providing insights as to why they happened and guidance on how to minimize the risk in the future. The important distinction between "transient operations" and the "transient operating mode" should be understood. This guideline defines the transient operating mode in the context of normal, abnormal, and emergency operations, providing a clear and

understandable terminology of what is a “transient operating mode.” Details on this distinction will be provided in Chapter 2.

The other “transient operations” *do not apply* to the scope of this guideline. These transient operations include, among others, “infrequent or non-routine activities” and “workarounds.” The distinction is critical for understanding of this guideline’s scope, as the term “transient operations” means many different things depending on the context and views of those who are noting such transition times.

For example, “transient operations” include a major grade change in a polymer reactor or summer to winter operating mode change for a refinery. These tend to be routinely practiced, have well documented procedures and are usually done without a shut-down. These types of transient operations are not covered in this guideline either.

It should be noted that the hazards and risks associated with non-routine activities, performed less frequently than normal activities, should be understood by everyone performing the infrequent task. As discussed in this guideline’s Foreword, “many dedicated safety professionals…have borne witness to the human cost, property damage and environmental destruction…” when non-routine, infrequent tasks are not performed safely.

In addition, workarounds can be defined as “creative solutions made to overcome an issue without actually solving it.” Well-intentioned workarounds can be small, quick, and simple “one-minute” changes which create “bad memories” at a facility [2, pp. 209-234]. In other words, incidents have occurred – and will occur - when those performing the infrequent tasks or making simple material or procedural changes have not thoroughly refreshed their understanding of the task’s hazards and have not thoroughly addressed the task’s risks.

Another way to describe the scope of this guideline is to recognize that transient operating modes are planned, anticipated activities, even though some of them, such as an emergency shut-down, are prevented as much as possible. Whether during normal operations or when in transition, all operating modes need to have developed procedures which are documented, reviewed, and practiced through training and on-the-job exercises. By contrast, there are other transient operating modes that are not planned, and therefore should be handled ad hoc by use of rigorous change management and hazards assessment procedures for the specific situation at hand. For example, a batch reactor that has been fed the wrong reactant by mistake and has created a viscous material which cannot be removed by normal cleaning procedures would not have a written procedure applicable to this situation. In this case, a team of experts would be needed to develop specific, non-routine actions to recover from this deviation. This team of experts would understand potential hazards and assess their associated risks, ensuring that the non-routine activity will not place people at risk to a loss of control of a hazardous material or energy.

In short, if the abnormal operation has a procedure associated with it (even if it is only "hit the shut-down button and evacuate"), it is covered by this guideline. If not, then the activity is outside the scope.

Clear definitions help establish a consistent language between practitioners when discussing the transient operating mode-specific risks and how these risks can be effectively managed for each of the transient operating modes. Since the scope of this guideline is limited to the transient operating mode, other references are noted as additional resources [3] [4] [5] [6] [7] [8] [9]. In particular, some of the incident data summarized from the 1990's includes the following:

> *"...emphasizes the need for start-up and shut-down procedures to be in sufficient detail to cover known pitfalls and contingencies. In*

*the case of maintenance, good communication is essential so than everyone knows what others are doing at any time and what responsibilities each has. Split or unclear responsibilities are a recipe for disaster.* [3, pp. 3-4] "

*"To [help] prevent these types of incidents from occurring, facilities should employ effective communications, provide workers with appropriate training, and have in place strong and up-to-date policies and procedures for hazardous operations such as start-ups and shut-downs* [5, p. 1]*."*

When the equipment is being shut down (the transition time), the word *shut-down* is used in this guideline. This spelling, with the hyphen between the words, distinguishes the activities taken on operating equipment *during a transition* (when the equipment is being *shut-down*) and the activities conducted when the equipment *is not operating* (during a *shutdown* – no hyphen). In particular, the hyphen is essential when discussing incidents, as many incident reports designate "shutdown" without distinguishing between the shut-down mode and a project-related shutdown. Thus, the incidents in this guideline will focus on those that occurred when the equipment *was being shut-down*. For consistency within this guideline as well, when the process equipment or process is starting up, *start-up* with a hyphen will be used (recognizing that another common spelling is "startup").

This guideline will discuss two general transient operating modes (the time when a process is in transition between its idle and its operating states.) Specifically, the normal start-up and normal shut-down times are defined as:

1. Start-up time—from an idle, safe, and at-rest state to normal operations, and
2. Shut-down time—returning from normal operations to its normal idle, safe, and at-rest state.

If there is an emergency shut-down, the controlled end state of the process equipment should be idle, safe, and at-rest. If the emergency

shut-down is unanticipated, the non-operating end state may not be safe. Any hazards and their associated risks should be addressed before resuming operations.

Every effort has been made to be consistent throughout this guideline when distinguishing between the start-up and shut-down modes and the startup and shutdown stages in a project (see discussion in Chapter 4).

### 1.3 Audience

The intended audience for this guideline are those at all levels in an organization who should ensure process safety, especially during the transient operating mode. This includes decision-makers at all levels, including: senior executives, corporate managers, facility and group managers, supervisors, engineers, operators, mechanics, electricians, and associated support personnel, as well as contractors and those managing contractors. *This audience is not too broad* [10] [11] [12] [13]. Severe incidents have occurred when decision-makers, no matter what their level in an organization, were not aware of how their decision could—and did—increase their process safety risks during the transient operating mode.

Everyone should understand how their decisions can adversely affect the risks associated with a process undergoing one of its two transition times: its start-up or its shut-down. When everything is going well, when the normal start-ups, operations, and shut-downs proceed as expected, the risks can be managed effectively based on operating experience, well-established operating procedures, and thorough skills-based training. These efforts across the entire organization represent part of a comprehensive process safety and risk management program. Thus, everyone has the operational discipline to follow the established procedures and understand how to safely

manage unexpected situations which may arise during transition times. The following pages show that without understanding of the complexity inherent in managing the process safety risks, some quick decisions have led to serious process safety incidents. These incidents occurred, in part, due to both short term and long term decisions in different groups, such as those resourcing the manufacturing efforts, those scheduling the product, and those designing, constructing, operating, maintaining, and changing the equipment handling hazardous materials and energies.

## 1.4 Benefits

It is hoped that the information presented here, gleaned from decades of process safety hazard and risk reduction experiences around the world, and experiences both good and abysmal, has been adequately compiled and conveyed on these pages. In particular, when this information is understood and applied to address the risks associated with the start-up and shut-down times, the overall risk to an organization will be reduced. The significant consequences and incident's impact will be reduced; there will be fewer incidents with fatalities, serious injuries, environmental harm, property damage, and business interruption losses. Those are the benefits.

## 1.5 Applying CCPS Risk Based Process Safety (RBPS)

The CCPS Risk Based Process Safety (RBPS) approach is a proven methodology to help organizations understand their process safety hazards and effectively manage their process safety risks [14]. The RBPS approach consists of a process safety management program with four "pillars" and twenty "elements" that integrate a company's overall process safety risk management efforts. This approach was

compiled from successful experience in many industrial organizations across a broad range of industries in different jurisdictions around the world. The approach continues to evolve today. For readers unfamiliar with these pillars and elements, refer to Chapter 10 for an overview, as the discussions and lessons learned from start-up and shut-down incidents will be based on the CCPS RBPS foundation. In addition, note that there is no hyphen—*by design*—when the "CCPS Risk Based Process Safety (RBPS)" approach is being discussed. However, a Risk-Based Inspection (RBI) program, for example, used in maintenance-related efforts applies a hyphen between risk and based.

## 1.6 Incident discussions and guidance

This guideline uses incidents, from both published investigation reports and internal company incident information, that provide details on what went well and what went wrong during the start-up or shut-down. The anonymous company incidents submitted to this book or located in generic incident databases are presented for sharing.

Everyone learns from experience.

The goal of sharing incidents is to prevent others from learning from the bad experience the hard way. The collective global goal is to reduce the process safety risks and prevent incidents that cause harm to people, the environment, and the business. As the cases presented are reviewed, it should be noted that:

1. The guidance—these learnings—are framed within the CCPS Risk Based Process Safety (RBPS) approach described in Chapter 10,

And most importantly:

2. The year of these cases is noted since those that occurred *before* the publication of the initial CCPS RBPS guidance in 2007

were typically used, in part, to help *provide the learnings from the industrial experience reflected in this approach to risk*.

Thus, these incidents provide learnings by identifying the elements that were not implemented or were ineffectively implemented at the time of the incident. Unfortunately, the incidents which have occurred after 2007 only reinforce the simple fact that there is still much to learn. Even with later publications of other risk-based approaches, the significant incidents might not have happened had the company understood and applied a risk-based process safety approach.

## 1.7 Framework

The overall chapter order in this guideline follows the operations team activities using the framework based on the three general operating modes—normal, abnormal, and emergency—depicted in Figure 1.1:

- Introduction and definitions (Chapters 1 and 2)
- Part I – Normal Operations Chapters 3, 4, and 5)
- Part II – Abnormal and Emergency Operations (Chapters 6, 7, and 8)
- Part III – Other Considerations (Chapters 9 and 10)
- Appendix (Incident Reviews and Additional Information)

These three operating modes set the stage for different types of transition times. It is essential to note that normal operations are the day-to-day, expected mode of operation. During this mode, everything goes as expected. There are standard start-up and shut-down procedures for transitioning between idled and operating equipment—everything goes according to design and plan. However, not everything goes according to plan every day. Thus, the operations team may have abnormal operations, or if matters cannot be resolved, may have emergency operations.

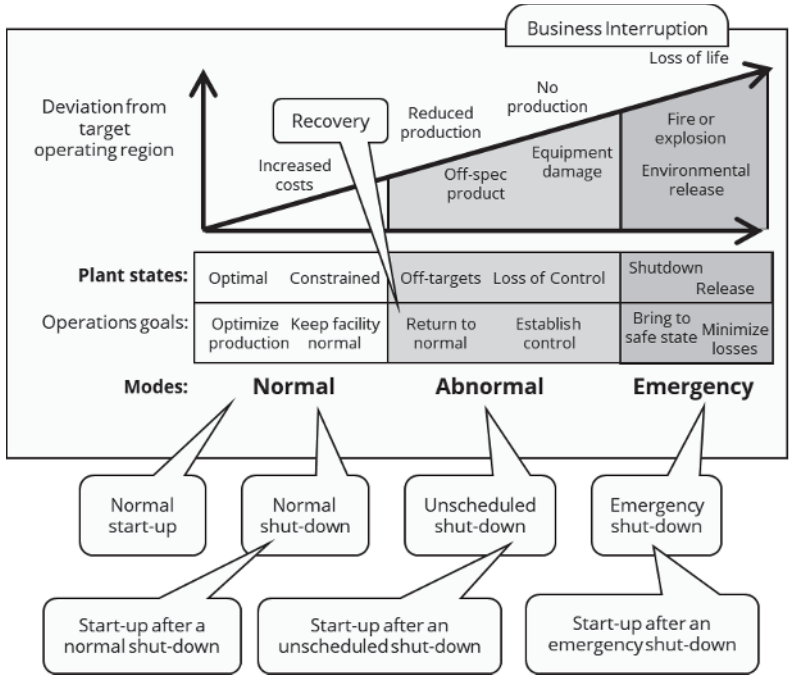


*Figure 1.1 Three types of facility operations and their corresponding transient operating modes.*
*(Adapted from* [15, p. 22]*)*

The ten transient operating modes discussed in this guideline are introduced in Table 1.1. The Appendix provides the summary of a detailed incident review focusing on published incidents that occurred during the transient operating modes listed in Table 1.1, and includes additional guidance on how to more effectively manage unexpected situations, especially those than may cause or may happen during transient operating modes.

*Table 1.1 List of the different types of transient operating modes.*

| Different Types of Transient Operating Modes | |
|---|---|
| 1 | Shut-down (normal) |
| 2 | Start-up (normal) |
| 3 | Shut-down designed for a planned shutdown |
| 4 | Start-up after a planned shutdown |
| 5 | Shut-down designed for an extended shutdown |
| 6 | Start-up after an extended shutdown |
| 7 | Shut-down activated for an unscheduled shutdown |
| 8 | Start-up after an unscheduled shutdown |
| 9 | Shut-down activated for an emergency shutdown |
| 10 | Start-up after an emergency shutdown |

The corresponding chapters—the guideline's framework—are listed in Table 1.2:

1. The scope of this guideline, the ten start-up and shut-down transient operating modes, are covered in Chapter 4 through Chapter 8, and
2. Other transition times specifically associated with the equipment or process life cycle, the *initial* start-ups and the *final* shut-downs, are covered in Chapter 9.

There are times when the equipment is scheduled for special projects or routine maintenance [16] [17]. Although these project- or maintenance-related activities are performed safely on idled equipment, sometimes these activities are performed at or near operating equipment. The normal operations flow chart (Figure 1.2), including the transition times—the transient operation modes—and

associated process and facility shutdowns, covers the normal operations mode; Chapter 3 discusses the normal operations; Chapter 4, process shutdowns; and Chapter 5, facility shutdowns. The transient operating modes—the shut-downs and start-ups—associated with normal operations, process shutdowns, and facility shutdowns are covered in each of these chapters, as well. These modes of operation will be defined in more detail in Chapter 2.

*Table 1.2 Chapter framework for this guideline.*

| Chapter | | Type of Transient Operating Mode | |
|---|---|---|---|
| 1 | Introduction | | |
| 2 | Defining the Transient Operating Mode | | |
| ***Part I - Normal Operations*** | | | |
| 3 | Normal Operations | 1 | Shut-down (normal) |
| | | 2 | Start-up (normal) |
| 4 | Planned Shutdowns | 3 | Shut-down designed for a planned shutdown |
| | | 4 | Start-up after a planned shutdown |
| 5 | Extended Shutdowns | 5 | Shut-down designed for an extended shutdown |
| | | 6 | Start-up after an extended shutdown |
| ***Part II - Abnormal and Emergency Operations*** | | | |
| 6 | Recovery Operations | | |
| 7 | Unscheduled Shutdowns | 7 | Shut-down activated for an unscheduled shutdown |
| | | 8 | Start-up after an unscheduled shutdown |
| 8 | Emergency Shutdowns | 9 | Shut-down activated for an emergency shutdown |
| | | 10 | Start-up after an emergency shutdown |
| ***Part III - Other Considerations*** | | | |
| 9 | Other Transition Time Considerations | | |
| 10 | Risk Based Process Safety (RBPS) Considerations | | |
| Appendix | | | |
| A | Incident Review | | |

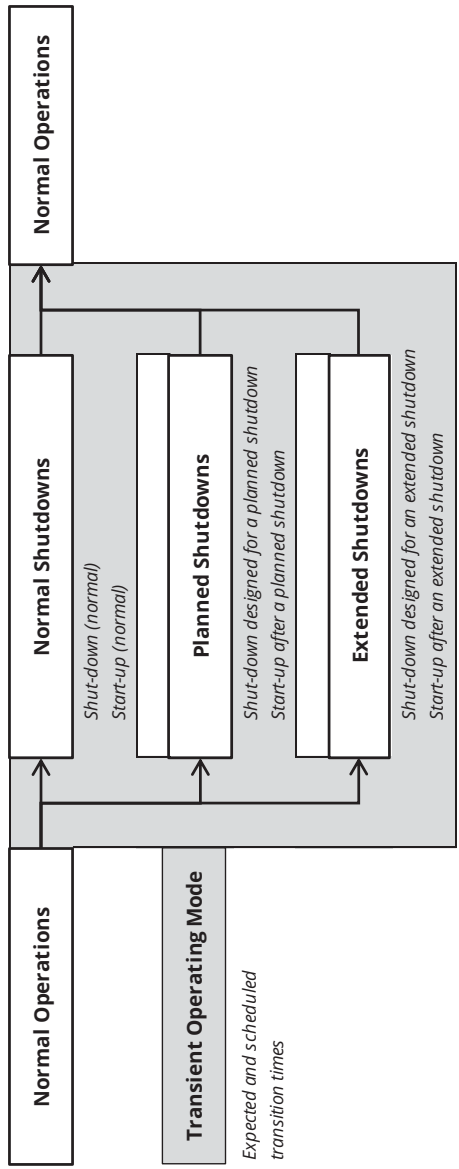


*Figure 1.2 Example normal operations flow chart.*

However, process upsets are anticipated and accounted for with engineering and administrative controls designed and implemented to monitor and respond to these upsets. These abnormal operations can have successful or unsuccessful outcomes, either recovering the process back to its normal operating conditions and resuming normal operations or resulting in an unscheduled process shut-down. As is depicted in Figure 1.3, the equipment and process may need to shut-down when the recovery efforts are unsuccessful, transitioning the process from its normal operating state to the shutdown mode. It is important to note at this point that there is a temporary operating time, often designated as a standby mode, which provides time for process upsets to be diagnosed before either completely recovering the process conditions or shutting the process down.

As is depicted in Figure 1.3, there are two general types of shut-downs during abnormal operations: normal shut-down procedures and emergency shut-down procedures. Note that normal shut-down procedures can be used for both planned and unplanned shut-downs. Emergency shut-down procedures are, by definition, unplanned events and emergency situations. If a significant loss event occurs, the emergency shut-down procedures are activated, potentially resulting in impact to people, the environment, and assets.

Part II of this guideline covers the abnormal and emergency operations modes: Chapter 6 discusses the successful response to abnormal operations—the recovery; Chapter 7, the shut-downs and start-ups afterward associated with unscheduled shutdowns; and Chapter 8, the shut-downs and start-ups afterward associated with emergency shutdowns.

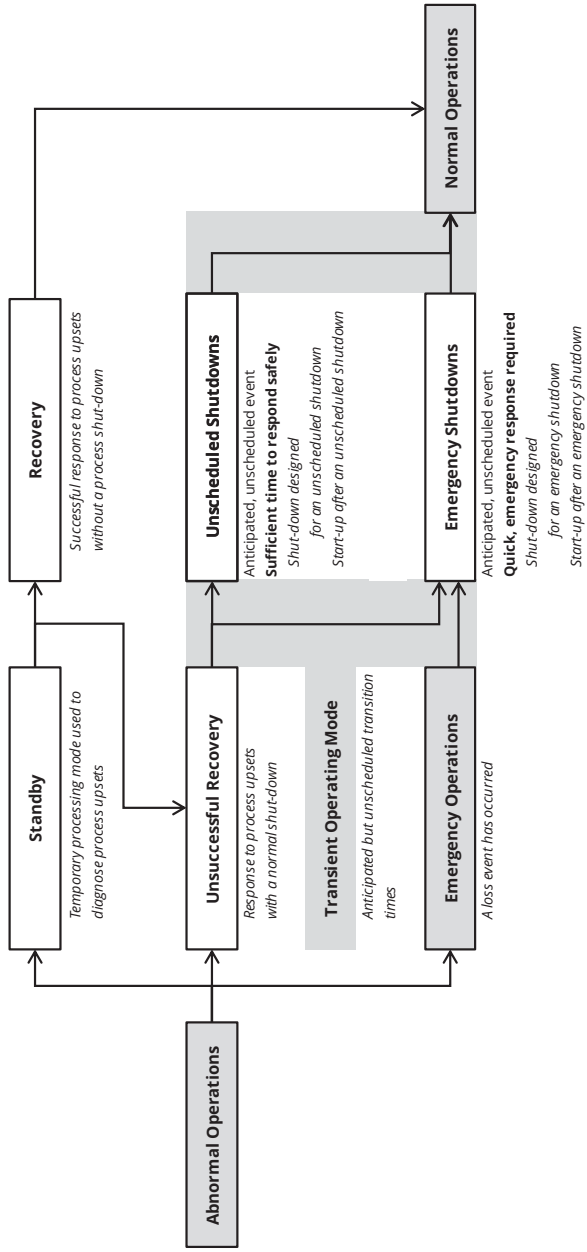


*Figure 1.3 Example abnormal and emergency operations flow chart.*

Part III of this guideline covers other items that should be considered when effectively managing the risks associated with transition times. Chapter 9 covers the transition times related to the facility life cycle, such initial start-ups and decommissioning—the steps essential for a final shut-down. The last chapter, Chapter 10, provides a brief overview of the CCPS Risk Based Process Safety (RBPS) approach, providing guidance on how the RBPS elements apply during transition times.