# Hazard Identification and Risk Assessment for Smaller Changes

## Tips and Tools for Avoiding Misses and Improving Quality

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Okay, we think that we have sufficiently defined “when” Management of Change (MoC) is required. Now for the next question, what level of process hazard review is required for our changes, especially our smaller and smallest changes?

This paper recaps industry guidance and regulatory requirements regarding the intersection of MoC and hazard identification and risk assessment (HIRA) requirements. Hazard identification and risk assessment is also called process hazard analysis (PHA). Some traps associated with language used in regulation and industry guidance are highlighted. A brief overview of the intent of MoC and HIRA/PHA is summarized.

However, the focus of this paper is to provide guidance on how to determine the need for hazard identification and risk assessment within MoCs of any size and to provide guidance on how to help define those process hazard review requirements. Barriers are acknowledged and discussed. However, some solutions and tools are provided. Examples of better practices are offered including a sample screening tool for use in categorizing change type and assigning an appropriate level of process hazard review. The form and format of the hazard review may be scaled for the size of the job. But the hazard analysis methodology should be comparable for all process changes regardless of the size of the project.

Process hazard review is one of the most essential elements of MoC because unintended consequences associated with changes are not initially apparent. Small changes may incorrectly imply to some that less rigor is required. It is important to recognize that like a chain, your plant PHA or HIRA is only as strong as its weakest link. MoC itself is intended to reinforce the notion that the introduction of changes, including small changes, may compromise otherwise robust design and processes. Failure to complete robust and appropriate HIRA within the MoC process has the potential to introduce the same process safety hazards as failure to use the MoC process when making changes. To be effective, the entire process, MoC and the process hazard analysis within MoC, must be thorough and robust.

Keywords: Hazard identification; Risk assessment; HIRA; process hazard analysis; PHA; Management of change; MoC

## 1 Introduction

Just as Management of Change (MoC) is an essential requirement for establishing an effective process safety management program, MoC hazard identification and risk assessment (HIRA), also called process hazard analysis (PHA), is an essential element for an effective MoC process. It could be argued that the HIRA, i.e. PHA, review that occurs within the MoC process is the most important component of MoC and is the primary driver for the requirement to perform MoC. Likewise, just as the size or duration of the change does not affect the requirement to perform MoC, the size or duration of the change does not affect the requirement to perform HIRA. However, some practitioners may misunderstand these requirements. These misperceptions may be due to the same thinking and practices that drove the need for process safety regulation. Ironically, some of the language in regulations, standards, and guidance may also lead to certain misperceptions.

This paper outlines basic steps for assessing changes and for determining the process hazard review requirements. Several tips and tools that may support consistent and effective practice are discussed. Several barriers are acknowledged and discussed along with some potential solutions. And several pitfalls are highlighted that should be recognized and avoided.

HIRA, or PHA, provides methodology for identifying potential hazards associated with changes to the process. It is important to recognize that like a chain, your plant PHA or hazard identification study is only as strong as its weakest link. MoC itself is intended to reinforce the notion that the introduction of changes, including small changes, may introduce unintended consequences and compromise otherwise robust design. Failure to perform robust and appropriate HIRA within the MoC process has the potential to introduce the same process safety hazards as failure to use the MoC process when making changes. To be effective, the entire process, MoC and the HIRA within MoC, must be thorough and robust.

## 2 Terminology and Regulatory Background

The reasons why we require MoC and why we conduct process safety related risk assessments, sometimes referred to as HIRA or PHA, are well understood by process safety practitioners. Numerous historical incident examples are routinely cited including Flixborough, Grangemouth, and many others. This paper addresses process safety risk analysis review requirements which occur under the MoC process with a specific focus on small MoCs, i.e. minor modifications. These changes may involve only a single component, a single flowpath, or a single operating procedure step.

Terminology for the same practices varies from region to region and between regulating authorities. To clarify the terminology that will be used in this paper, refer to Figure 1 and the following discussion. Various technical, environmental, operational, and safety reviews are required under the MoC process. Safety reviews encompass both process safety and personal safety reviews. Process safety reviews, also called process hazard reviews, may be further subdivided into HIRA, or PHA, and other process safety related studies such as mechanical integrity reviews, facility siting studies, and flare/relief system studies. Mechanical integrity may also be referred to as asset integrity, physical integrity, or integrity management of equipment and components. As defined by CCPS Guidelines for Risk Based Process Safety (CCPS, 2011):

> Hazard Identification and Risk Analysis (HIRA) is a collective term that encompasses all activities involved in identifying hazards and evaluating risk at facilities, throughout their life cycle, to make certain that risks to employees, the public, or the environment are consistently controlled within the organization's risk tolerance. . . . A suite of tools is available to accommodate varying analysis needs: (1) tools for simple hazard identification or qualitative risk analysis include hazard and operability analysis (HAZOP), what-if/checklist analysis, and failure modes and effects analysis (FMEA), (2) tools for simple risk analysis [or semi-quantitative analysis] include failure modes and effects, and criticality analysis (FMECA) and layer of protection analysis (LOPA), and (3) tools for detailed quantitative analysis include fault trees and event trees.

HIRA, or other variations on the term, is referenced in the Control of Major Accident Hazards Regulations 2015 (HSE COMAH, 2015) guidance. COMAH is a UK process safety management regulation defined by the Health and Safety Executive (HSE). The EU regulation, now Seveso-III Directive (EU Seveso, 2012) contains similar language as COMAH.

The U.S. OSHA, PSM 29 CFR 1910.119, 1992, as amended (US OSHA, 1992) regulation uses different terminology and regulatory format which may lead to perceptions that PHA is only associated with the U.S. regulation. This perception is incorrect. The methodologies listed as tools to conduct PHA are nearly identical to those defined by CCPS RBPS (CCPS, 2011). The terms PHA and HIRA are used interchangeably in this paper.

The 1992 OSHA PSM regulation (US OSHA, 1992) is frequently cited as one of the earliest performance-based regulations in the U.S. However, in comparison to the UK and European regulations, certain aspects of the U.S. regulation may be interpreted as more prescriptive than those regulations. Because the U.S. regulation separates the two requirements, PHA and MoC, and chooses language that does not explicitly tie the elements together, the language in the U.S. regulation itself may signal to operating companies that formal PHA is not required for small MoCs. Where incidents occur that were not identified in MoC process hazard review, the language in that regulation may contribute as a causal factor to these failures.

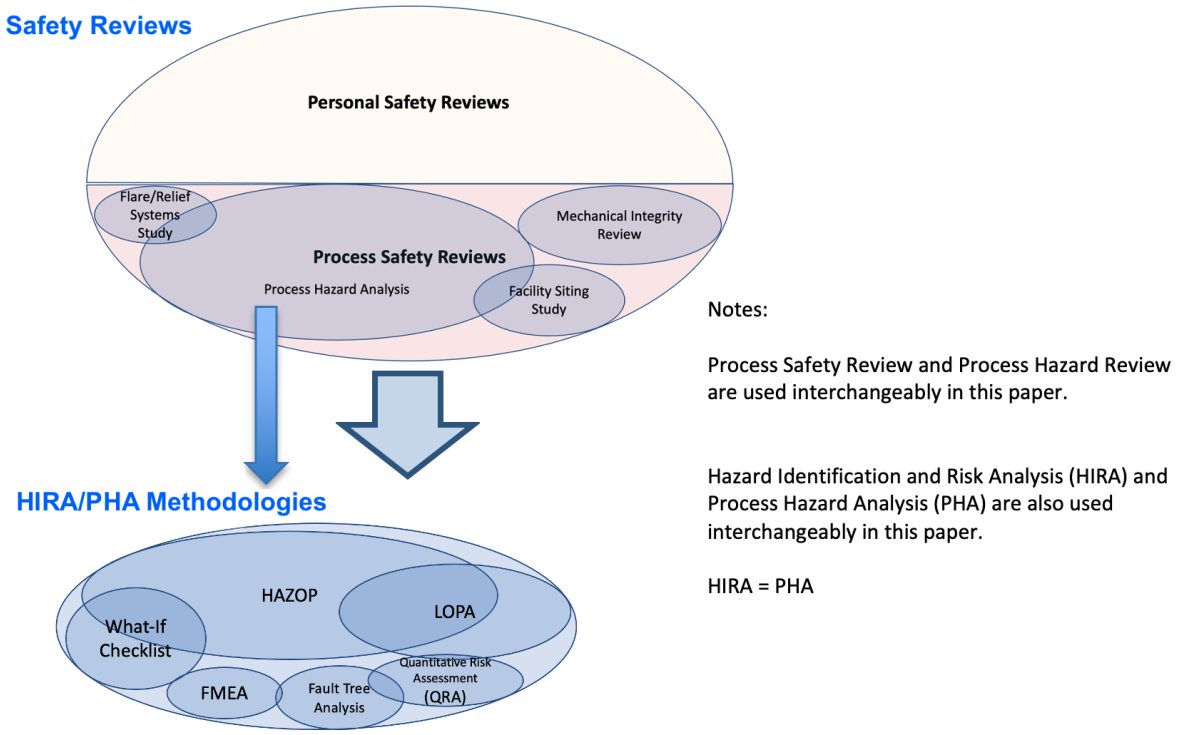



Figure 1: Safety reviews terminology, relationships, and HIRA/PHA methodologies

Likewise, some process safety management industry guidance, such as CCPS RBPS (CCPS, 2011), draws a similar split between hazard identification and risk analysis (HIRA) and MoC program components. The CCPS guidance in the HIRA section does explicitly describe the need for hazard review and risk analysis for projects at various stages of implementation. MoCs are projects involving changes of various size, scope, and complexity. However, the Management of Change section does not provide the same emphasis and does not reference more formal HIRA review technique(s) being applied to MoC project reviews.

In general, the European regulations, namely COMAH (HSE COMAH, 2015) and Seveso Directive (EU Seveso, 2012), provide less specific requirements and language regarding individual program elements while focusing on the need to build wholistic prevention policies, safety management systems, and safety reports. These regulations may offer a preferred approach but practitioners (ie., duty holders) may be subject to some of the same pitfalls that stem partially from U.S. regulatory language and other industry guidance.

Certain regulatory and guidance language may lead to perceptions that HIRA only applies to large scale studies, such as full Plant HIRAs or major project HIRAs. Additionally, the rigorous and time-intensive nature of the HIRA process and methodologies often leads to a perception that these studies are only appropriate for major projects. However, this notion is misplaced. This paper discusses a more appropriate decision basis and tools for defining process hazard review requirements, including HIRA, i.e. PHA, for modifications of various sizes.

## 3 Steps

Outlined below are the basic steps for determining the level of process safety review that should be conducted for every MoC.

### 3.1 Is MoC required?

Determination of whether MoC is required is outside of the scope of this paper. Criteria should be in place to define when MoC is required. A process should exist for auditing to assure that changes are not being implemented without going through MoC. This step is shown as the first decision point in Figure 2.

### 3.2 What reviews are required under MoC?

Within the MoC process, determinations must be made as to what type of reviews must be conducted to completely evaluate the proposed design. These reviews include technical reviews, - such as mechanical, electrical, structural, etc., - environmental reviews, regulatory reviews, operations and maintenance reviews, and safety reviews. See Figure 2. Process safety reviews, including HIRA, or PHA, are a type of safety review. Refer to Figure 1. All reviews relevant to the project design must be completed.

### 3.3 Is process safety review required?

The short answer is “Yes, on every MoC!” While all MoC reviews are essential, the process safety review, it can be argued, is the most critical review. The process safety review is a primary driver for the requirement of MoC under process safety management. All MoCs must, at a minimum, be screened to assess whether changes proposed under this MoC can impact process safety. Some companies may

apply the MoC process broadly. Therefore, not all changes have the potential to impact process safety. In these rare instances, no further process safety review may be required beyond the screening.

Changes that have the potential to impact process safety primarily fall into two buckets. Changes to the process and changes to mechanical equipment that could impact mechanical integrity. A basic screening tool may be used to assess and define the type of change. A sample process safety screening tool is provided in Appendix A, Process Safety Review Screening Form. This form is filled out as the initial stage of the process safety review. This type of form should be completed for every MoC as well as for other work processes involving changes. The answers provided by completing this form will dictate whether further process safety review is required. And the form will define the process safety review method needed, either HIRA or mechanical integrity review.

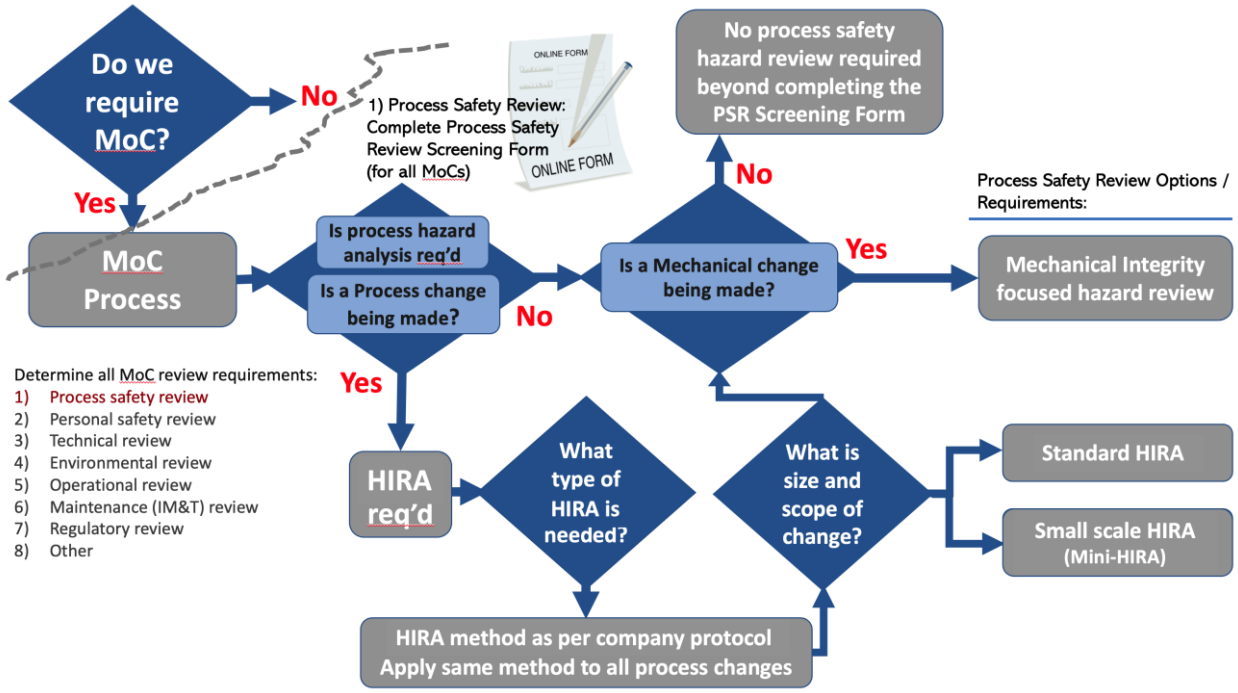



Figure 2: Decision process for determining MoC process safety review requirements

### 3.4 What type of process safety review is required?

a) Is a mechanical integrity review required?

A separate mechanical integrity review is required for changes to mechanical components or in instances where existing mechanical components will be impacted by new process conditions. Every change should be evaluated and addressed with follow-up actions, as needed, to assure that the mechanical integrity of the system will not be degraded upon installation of the new equipment or through continued operation of the equipment. The mechanical integrity review should address mechanical design considerations as well as inspection, maintenance, and testing requirements. As such, the mechanical integrity review may combine existing mechanical design review standards and maintenance standards and checklists that are already in place.

> Note: Instrumentation and control components that are physically connected to the process or control the process must also be assessed for process and/or mechanical integrity impacts. These components must be designed, rated, and maintained to assure that there are no adverse process safety impacts.

b) Is hazard identification and risk analysis (HIRA), ie process hazard analysis (PHA) required?

As shown in Figure 2, the next determination is whether the modification requires HIRA. The basis for this assessment is to determine whether the MoC includes any process change or changes. Any modification that involves a process change, requires a process hazard review, more specifically a HIRA. (No exceptions!) The process safety review screening form guides the user to select HIRA when the modification involves a process change. See Appendix A for screening form example. Any process change, no matter how small, requires a HIRA to be conducted using the standard methodology selected by the company.

At this point, some companies may prescribe alternative methods for performing HIRA or PHA depending on the size or scope of the project or change. The OSHA PSM regulation (US OSHA, 1992) and CCPS RBPS (CCPS, 2011) includes similar language. However, as per Figure 2 and Appendix A, the recommendation made here is to perform the standard company prescribed HIRA or PHA methodology for all changes. The size and scale of the review may differ, but the methodology should be the same.

### 3.5 Standard HIRA Study vs mini-HIRA?

The size, scope, and complexity of the change(s) will dictate the scale of the HIRA but not the methodology. We do not want to weaken the chain by performing inferior HIRA nor by improperly resourcing the effort. Mini-HIRA, or mini-HAZOP, may be used to review the change using the same methodology applied to larger studies. The primary differences between these studies are the software tools that are used, the size of the team, and the duration of the study. Facilitator qualifications should be similar for studies of any size. But qualifications may be broken into two-tiers to allow for a wider pool of trained leaders that are sufficiently qualified to lead small studies. HIRA leaders for studies of any size should be affiliated with a process safety group or department. The term HIRA, PHA, or HAZOP often has the connotation of a major multi-week effort. The HIRA review conducted using HAZOP and/or LOPA for a change of a single component may be an effort requiring less than an hour or two. However, the same method may be applied. Existing scenarios must be reviewed for potential impacts and potential new scenarios must be considered.

## 4 Tips, Pitfalls, and Barriers

The guidance outlined above sounds straightforward. While these are simple ideas, successful application does not always occur. The remaining sections discuss various barriers and pitfalls along with tips and solutions.

### 4.1 Tips

The Process Safety Review Screening Form is an important tool for assure consistency and aid in avoiding misses when assessing process hazard review requirements for all changes occurring to facilities and through projects. Completing this screening form is the initial step in process safety assessment. The form provided here (See Appendix A) may be modified for company specific protocol. However, keep the following in mind when crafting a new form or modifying this form:

1. On screening tools such as this Process Safety Review Screening Form or others, avoid asking questions such as: “Does this change have the potential to introduce process hazards?” The intent of a process hazard review is to uncover hazards that would not otherwise be apparent. The methodology used supports finding these potential hazards. Asking this type of question presupposes the outcome of the hazard review. Screening questions should focus on categorizing changes by physical characteristics that define the change, specifically identifying process changes and changes impacting mechanical integrity. Questions should never relate to the likelihood that hazards will be identified.

   Note: The language in COMAH Part 3, Regulation 10, 195/196 (HSE COMAH, 2015) provides good guidance. Refer to Figure 3. COMAH Section 195 language does not presuppose the outcome of a hazard review regarding likelihood of identifying new and elevated hazards or risks associated with the change. The screening factors focus on classifying the physical characteristics of the change. The guidance provided in COMAH mirrors the approach laid out in this section for using a screening tool to group changes into categories that must be reviewed for potential process safety impacts. The COMAH language and requirements avoid the Pitfall discussed in Section 4.2 and above of presupposing the outcome of a process hazard review.

**Trigger event – a modification – regulation 10(2)(d)**

195 You must review and, if necessary, revise your safety report before certain modifications are made. This is aimed at modifications to establishments, processes, and the nature or quantity of dangerous substances which could have significant repercussions on the major accident hazards. Changes which either increase or decrease hazard or risk are important. It is not intended to deal with trivial changes.

196 Whether a modification has significant consequences will depend on the degree to which it introduces a new major accident hazard, or increases or decreases the risk from an existing hazard. The overall goal is to ensure that major accidents are prevented and the consequences of any that do occur are kept to a minimum. Examples of the sorts of changes which may have significant consequences include:

(a) a change in the quantity of a dangerous substance;
(b) changes of phase of a dangerous substance, eg a change from liquid to gaseous chlorine;
(c) the introduction of new, or removal of existing, dangerous substances;
(d) new processes;
(e) changes to storage facilities;
(f) changes to a safety instrumented system;
(g) changes to the mode of delivery or transport of dangerous substances, eg a change from daily road tanker deliveries to weekly ship deliveries;
(h) changes to the design or location of control rooms and/or the number of people present within them;
(i) changes to the location of occupied buildings and/or the number of people present within them;
(j) changes to the original design parameters such as process operating conditions or practices, changed throughput, design life extensions or removal of safety-critical plant.

Figure 3: Useful guidance from COMAH for formulating a process safety review screening form (HSE COMAH, 2015)

2. The screening form may be filled out by the Project Lead or Project Technical Lead Engineer. However, the Process Safety Review Screening Form may only be technically approved by a representative of the process safety group, typically by an engineer, specialist, and/or lead from that group. That individual should have process safety (or technical safety) in their title. Personnel working in other functional groups may have process safety training. However, if working in another function, they are not representing process safety. The intent is to assure that the change and the responses on the form are being looked at through a process safety lens. The approver must have responsibility and ownership, as well as experience and training, for assuring that process safety reviews are appropriately performed.
   It is recommended that the same form be used for all changes that occur within the facility. The only exceptions would be if process safety hazard reviews are embedded into other change management programs, such as a Temporary Defeated Safety Device program, and those reviews have been previously approved by the process safety department. In some instances, groups may create and implement a separate change review form to meet their group needs but that form or tool may be insufficient in identifying and addressing process safety related concerns. For example, construction groups may have a separate change order process and form. Likewise, operations may develop their own tool for screening procedural changes. These tools may not support distinguishing process changes from other changes. And these groups may feel that further HIRA or PHA review does not apply to their activity. For consistency and to avoid misses, the same process safety review screening tool should be used regardless of the department implementing the work.

Several straightforward practices within both MoC programs and HIRA protocol can improve consistency and outcomes for small MoC HIRAs as well as for larger projects and studies. Consider the following simple practices to support your MoC and MoC HIRA practice and to help avoid missing process safety related concerns:

1. Assure that MoCs carry an accurate, complete, and descriptive title. While the MoC title may sound like a minor concern, instances may occur where an improperly titled MoC may "fly under the radar" for process safety review because of the title communicates an entirely different scope.
2. Insist on complete descriptions of the full MoC project scope.
3. Break MoC project descriptions into each individual change that is occurring. And assess each individual change according to the criteria described in Section 3, Steps. Most importantly, assess each individual change in terms of being a process change or change to mechanical components. HIRA must be performed on each individual process change. Mechanical integrity reviews must be performed on changes to mechanical components.
4. In conjunction with the exercise of breaking down the modification into each individual change, it is a good idea to describe the reason that each individual change is being made. Describing the reason for the change may be advantageous if issues arise during the HIRA review that require resolution. Projects sometimes develop their own inertia and changes are proposed or planned that may not be needed. Understanding the reason that changes are being made may point to solutions or reconsideration of the need for the change.
5. As part of the HAZOP/LOPA, both for full plant HIRAs and small project HIRAs, assure that safeguard and independent protection layer (IPL) descriptions itemize individual components involved in the function. Control or safety functions that are listed as causes should be itemized in a similar manner. The sensing device, the end device, and all components between the sensing and end device should be itemized within the safeguard nomenclature, including the controllers (pneumatic or digital), solenoids, and alarm tags where setpoints may reside. Calling out each component highlights the integral parts of the control or safety loop. Any change to components affecting HIRA causes or safeguards require process hazard review. For example, typical cause or safeguard nomenclature may read as follows:

   - (PT-1234)(PC-1234)(PY-1234) opens (PV-1234) OR
   - (LT-6789)(LIC-6789)(LAL-6789)(LY-6789) closes (LV-6789)

   Note: Tag numbers should align directly with tags used in maintenance systems and/or PLC programming. Communication wiring, fiber, and logic solvers (ie., PLCs) are implied and not practical to call out specifically.

6. As with all design-related reviews, assure that the MoC HIRA is conducted in advance of final commitments on design and in advance of purchasing materials. Hazards identified during the study should be engineered out using inherently safer design wherever possible. All design-related follow-up recommendations must be addressed and resolved before the project design is finalized.

*Anecdote:*
*A change to a burner management system fuel gas train, including valving and controls changes, was nearly missed because the title of the MoC referenced PLC replacement/upgrade (only). Detailed review of the project scope identified 10 specific individual changes. Seven of those changes were process changes. Three were not. The title of the MoC referenced one of the three changes that could be classified as replacement-in-kind (RIK) or RIK with upgraded reliability or functionality. The initial review and assessment of the change using the process safety screening tool identified no process changes. No PHA or further process safety review was deemed necessary beyond filling out and signing the process safety screening form. The MoC was being processed for implementation. The additional scope was identified by another engineer before implementation of the MoC. The process safety approvals were reversed. And a mini-PHA was organized. While conducting the mini-HAZOP, a hazard was identified that was due to a change in closure position of the throttling valve. The new throttle valve had bubble tight closure capability. A programming change was planned to fully close the valve rather than leaving at 6% open upon shutdown. The change resulted in a pocket of trapped gas that did not have a bleed path. The hazard was assessed as a minor hazard, but the condition had not been recognized or intended. Lack of complete venting could also be a potential code compliance concern. There was no process or safety related reason for the change as three other block valves were in series and met code requirements. That change was removed from the project scope. The programming was reversed to*

*original programming. The throttling valve was left at 6% open position rather than full closed upon shutdown. This modification was being implemented at multiple plants throughout the field. Several plants had already completed modifications of identical scope. The condition had not previously been recognized during review, approval, and implementation of the prior MoCs. The technician involved in implementing the modifications field-wide had initially been skeptical of the need for the PHA. But he participated in the mini-HAZOP and aided in identifying the condition. Once identified, he fully supported reversing that change from the scope of the modification and upgrade. He recognized that the change had been implemented in other facilities and followed-up by reversing the change in the other plants.*

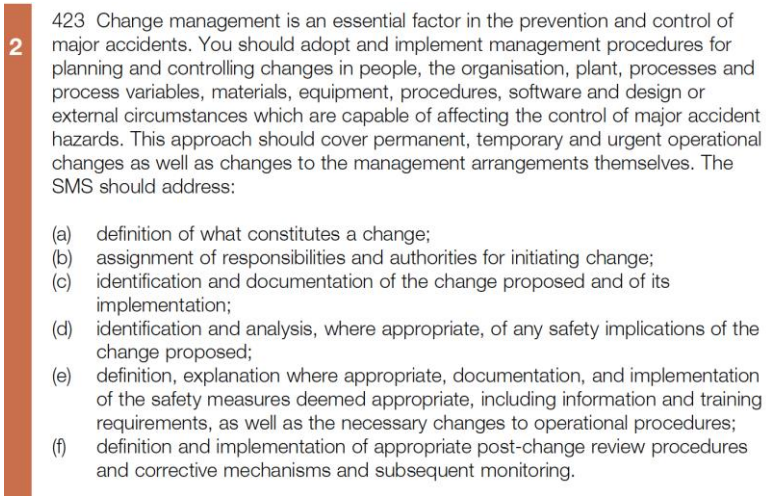
### 4.2 Pitfalls

Beware of several pitfalls or common traps that have been known to snare not only inexperienced personnel, but also seasoned process safety engineers, as well.

1. Assure that personnel in your facility are aware that recommendations that stem of hazard reviews (including HIRAs/PHAs), process safety audits, and incident investigations are only recommendations. Some recommendations include or define specific change recommendations. These recommendations are often made after a short discussion or when a hazard is identified, or a finding arises. The recommendation is not a vetted solution. Recommendations for changes originating from HIRAs or PHAs, audits, and investigations must be taken through the standard MoC review process. Any changes associated with those recommendations must be fully reviewed for process safety hazards before implementing the change, no matter how small or simple. These changes may address one process hazard while introducing a new process hazard. It is not uncommon to see process safety review screening forms list the reason that no further hazard review is required as, “This MoC closes recommendation #XYZ from PHA.” Or in some cases, the process safety concern from the HIRA/PHA, audit, or incident is restated in the box justifying “no process hazard review.” These statements are equivalent of restating the scope and reason for the modification. These statements do not constitute a process safety review which has the purpose of looking for new unintended hazards resulting from the change.
2. Modifications or changes to utility or auxiliary systems are occasionally not recognized as changes that affect the process. Because these systems are integral to the control of the process, are connected to the process, and have mechanical integrity concerns as well, process hazards must be considered for changes associated with or affecting these systems.
3. Never set criteria for process hazard review requirements based on an expectation or perception that new hazards, consequences, or elevated risk may be associated with the change. This type of language is unfortunately embedded into certain regulation and industry guidance. Screening tools, which are an initial step in process hazard review, should focus on grouping types of changes by physical properties and parameters, not perception of risk. Presupposing the level of risk in advance of conducting the hazard review embeds a potential point of failure into the process safety management processes. The reason for MoC is that hazards may be introduced that are not recognized or perceived. The reason for conducting the process hazard review is to uncover those potential hazards and risks. Examples of this type of language inserted in industry guidance and regulation are referenced below. Similar language is included in regulation. This language embeds a potential point of failure into the process.

   > From CCPS RBPS (1), Section 9.4.2, p235,
   > *Select analysis methods based on hazards and potential consequences.*
   > . . . To select an appropriate analysis tool, perform an initial screening based on hazards and potential consequences. . . . Conversely, a screening that identifies severe consequences indicates that more rigorous HIRA methods may be appropriate.
   >
   > From CCPS RBPS (1), Section 15.2.3, p 429,
   > At a minimum, an MOC review protocol should . . . evaluate the potential impacts on safety and health. In some cases, *such as complex situations or those with a higher perceived risk*, specific hazard evaluation techniques . . . may be required.

4. Avoid the misplaced thinking that HIRA only applies to large, complex, long duration process hazard review studies. HIRA may be conducted using various methodologies. Those methodologies may be applied to studies of any size and scale. The tools and resources required for the study may vary by size and scope of the review; but the methodology should not differ. Be cautious of regulatory guidance such as COMAH Section 423, (d). The “where appropriate” may embed a potential point of failure in the MoC process by implying that process hazard review is not required for all changes.



2 423 Change management is an essential factor in the prevention and control of major accidents. You should adopt and implement management procedures for planning and controlling changes in people, the organisation, plant, processes and process variables, materials, equipment, procedures, software and design or external circumstances which are capable of affecting the control of major accident hazards. This approach should cover permanent, temporary and urgent operational changes as well as changes to the management arrangements themselves. The SMS should address:

(a) definition of what constitutes a change;
(b) assignment of responsibilities and authorities for initiating change;
(c) identification and documentation of the change proposed and of its implementation;
(d) identification and analysis, where appropriate, of any safety implications of the change proposed;
(e) definition, explanation where appropriate, documentation, and implementation of the safety measures deemed appropriate, including information and training requirements, as well as the necessary changes to operational procedures;
(f) definition and implementation of appropriate post-change review procedures and corrective mechanisms and subsequent monitoring.

Figure 4: COMAH (HSE, 2015) language in Section 423(d) may inappropriately signal process hazard review is always required

### 4.3 Challenges and Barriers

The importance of using the same methodology to conduct not only larger HIRAs but also smaller HIRA studies is highlighted above. This consistency assures that there are no weak links in the wider facility HIRA. And this approach assures that there is no delay, such as until 5-year review or revalidation, until appropriate assessment is conducted. Some challenges and barriers to implementing these solutions do exist. These challenges must be acknowledged and addressed.

1. Access to HIRA or PHA software is routinely cited as an impediment for implementing HIRA methodologies such as HAZOP/LOPA more widely across organizations. However, there are solutions to this problem especially when dealing with very small modifications and changes:
   Solutions:
   a. Modify existing scenarios by using PDF output for HIRA review: HIRA or PHA software is complex and expensive because it is capturing and organizing a large amount of information. The information is presented in a manner to allow for effective PHA studies. But the summary worksheets or tables that are used throughout the study and generated as output following the study are presented and used in a basic table structure. These tables are often provided for end users as PDF documents. The PDFs themselves become part of the process safety information requiring review and update for MoCs. These tables may be used in this PDF format and marked-up through standard redlining work practices.
   b. Review new scenarios using a HIRA/PHA formatted spreadsheet: Format a spreadsheet to match the standard HIRA or PHA table layout that is used by your company. Assure that all standard deviations and supplemental checklists, such as facility siting and human factors, are included in the study as applicable. If LOPA is required by company protocol, configure the spreadsheet to include LOPA specific information such as initiating event frequency, safeguard/IPL probability of failure on demand (PFD), conditional modifiers deemed appropriate per company procedure, and other scenario documentation requirements.
2. Many companies default to different or “simpler” methodology for conducting small scale HIRA or PHA studies because skilled process safety resources are not available to lead these review efforts. This challenge is real and not easy to solve without investment in those resources. In some cases, the problem compounds upon itself. Most companies require strict protocol to approve HIRA or PHA facilitators or leads. This requirement is prudent and well-founded given the complexity of large PHA studies and specific skill set that is needed to effectively facilitate a PHA study. However, by having a single level of HIRA/PHA facilitator approval, companies may have insufficient resources the staff small scale HIRA/PHA reviews.
   Solution:
   a. Having a lower-level HIRA/PHA facilitator designation is recommended for managing small studies. The baseline requirements for HIRA/PHA facilitation remain the same and include: process safety group association; knowledge of process safety management; knowledge, training, and experience in PHA methodology (which includes any methodologies required by company protocol, such as HAZOP and/or LOPA), experience in small PHA facilitation which began with shadowing or co-facilitation, and technical knowledge of the process being reviewed. HIRA/PHA Facilitators for larger studies have the same training requirements but have led larger studies involving more complex and/or interconnected processes and larger data sets. Having internal company PHA facilitation capacity is advisable and most efficient for conducting very small studies. However, if PHA facilitator skill sets are not available within a company for either tier, these roles may be contracted out. Having trained and available personnel, either in-house or on contract, is essential for supporting effective MoC process hazard review.
   b. Process safety group representatives responsible for technical approval of process safety screening assessments may also be assigned based on a tiered qualification process.

## 5 Summary

Apply the following tools and practices to improve process hazard review quality and completeness on small projects and modifications.

1. Screen all changes for process safety review requirements. Consistently use a standard process safety review screening tool to assess the change and to place it into one of the following buckets:
    a. Change involves a process change => must conduct HIRA/PHA
    b. Change affects mechanical components => must conduct mechanical review and integrity assessments
    c. Change is not a process change nor affects mechanical components => no further process safety review is required beyond initial screening. (Changes in this bucket are the exception, not the rule.)
2. Never set criteria for process hazard review requirements based on perception of new hazards or elevated risk that may be associated with the change. The reason for MoC is that hazards that may be introduced are not recognized or perceived. The reason for process hazard review is to uncover those potential hazards and risks.
3. Improve assessment and avoid misses by improving MoC descriptions.
    a. Assure the MoC project titles accurately reflect the project scope.
    b. Assure that MoC scope descriptions are complete.
    c. Break down MoC project scope into each individual change.
4. Assure consistency and avoid misses by using the same screening tool for various types of changes, including MoCs, construction change orders, operating procedure changes, and other change processes.
5. Assure quality and consistency in the usage of the process safety review screening tool by requiring process safety department review and technical approval for every completed form.
6. Assure that the process safety department is adequately resourced to support review and approval of process safety review screening forms and facilitation of HIRA studies including mini-HIRAs.
7. Apply HIRA methodology consistently to projects and changes of all sizes. Avoid the misplaced thinking that HIRA or PHA only applies to large, complex, long duration process hazard review studies. HIRA/PHA may be conducted using various methodologies. Those methodologies may be applied to studies of any size and scale.
8. Craft and provide mini-HIRA tools that allow for the application of company prescribed HIRA methodology to small studies facilitated by process safety group representatives having access to standard computer technology tools.
9. Use redlining technique for updating HIRA or PHA tables following mini-HIRA/PHA reviews.
10. Completion of follow-up recommendations and actions that stem from the HIRA, when identified, is equally as important as conducting the HIRA by any methodology. Follow-up actions must be completed for HIRA studies of any size.

## 6 Conclusions

Every change that is introduced into a facility handling hazardous materials and processes requires process safety review. That process safety review may be initiated by screening the change with an assessment tool to define the type of change and the process hazard review method required. Every process change made to the facility will require HIRA and mechanical changes must be assessed for potential impacts to mechanical integrity. Risk-based management of hazards is not effective if the assessment of risk comes before, rather than after, the HIRA or PHA. The purpose of the hazard analysis is to identify and assess the risk.

HIRA methodology should be applied consistently to changes of all sizes. Differences between large-scale and small-scale studies include duration of the study, size of team, and tools used to conduct and document the study, but not the methodology of the study. Simple changes may be assessed by the same methodology used for complex processes. Process hazard review requirements should be reviewed and approved by qualified process safety representatives. Process hazard reviews of any size must be led by a process safety representative trained for the size, scope, technology, and complexity of the study.

Hazards being introduced into processes by modifications and changes are not always readily apparent. Process hazard review methodology is used to uncover hazards, assess risks, and recommend changes to reduce risk, as needed. That methodology should be applied consistently to all process changes to assure that the full plant HIRA is not degraded and that unrecognized hazards are not introduced into the operation. A chain is only as strong as its weakest link. Failure to perform robust and appropriate HIRA within the MoC process has the potential to introduce the same process safety hazards as failure to use the MoC process when making changes. To be effective, the entire process, MoC and the HIRA within MoC, must be thorough and robust.

## 7 Acknowledgements

The author wishes to thank iChemE and Hazards 31 for their interest in this paper. And the author wishes to thank the Hazards 31 reviewers who provided comments on the content.

## 8 References

(1) CCPS, *Guidelines for Risk Based Process Safety,* Center for Chemical Process Safety. American Institute of Chemical Engineers, New York, NY, 2011.
(2) EU, The Seveso Directive – Prevention, Preparedness, and Response. European Commission (Seveso-III), 2012, Available at http://ec.europa.eu/environment/seveso/.
(3) HSE, Control of Major Accident Hazards Regulation (COMAH). Health and Safety Executive, 2015, Available at https://www.hse.gov.uk/comah/guidance.htm; https://www.hse.gov.uk/pubns/books/l111.htm, Accessed Sep 5, 2021.
(4) U.S. Department of Labor Occupational Safety and Health Administration (OSHA), Process safety management of highly hazardous chemicals, 29 CFR 1910.119(e) and (l), Jun 1, 1992, as amended Feb 8, 2013.

# Appendix A: Process Safety Review Screening Form Example Template

(See next pages, 3 page document)

## Process Safety Review Screening Form

If change is covered under Temporary Defeated Safety Device (TDSD) Procedure, refer to that procedure for requirements and protocol. Completion of this form is not required.
All changes (MoCs) not covered by TDSD, including temporary facility modifications, construction project change orders, or changes to operating procedures, require completion of this form.
If Answer Yes or Unsure for Items in Section 1 thru 5 (and change is not covered by Temporary Defeated Safety Device Procedures), refer to direction provided under Participants; Method; Outcome; & Approval.

Enter X below

| | Yes | Un-sure | No | | Minimum Participants | Method | Outcomes/ Potential Outcomes | Approvals Required |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | **Potential for Broader Outside Impact** | | | | |
| 1.1 | | | | Does the change involve modifications to occupied spaces including adding new occupied building, removing occupied building, or modification of an existing occupied building? Are occupied spaces in the vicinity of the process involved in the change? | PHA Facilitator; (for large scale reviews, Facility Siting Specialist); Operations Rep (Operator) Project Tech Lead Engr | PHA Study via Facility Siting Checklist | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 1.2 | | | | Are there roadways (public or non-controlled) within (____) of process equipment or a process flowpath involved in this change. | PHA Facilitator; (for large scale reviews, Facility Siting Specialist); Operations Rep (Operator) | PHA Study via Facility Siting Checklist | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 1.3 | | | | Does the change involve process streams that feed or are fed by adjacent downstream/upstream facilities (internal or external)? Consider potential process changes as defined in Section 4 that feed downstream facilities or reverse flow paths to those facilities (consider shared infratructure, custody transfer, etc.) | PHA Facilitator; Operator Rep; Project Tech Lead Engr Operator Rep (3rd party) Project Tech Lead Engr (3rd p) | PHA Study | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 2 | | | | **Impacts to PHA Scenario Causes / Consequences (Unmitigated)** | | | | |
| 2.1 | | | | Does the change add, impact/modify, or remove a cause for an existing scenario or add, impact/modify, or remove equipment/components that are a cause for an existing scenario? | PHA Facilitator; Operations Rep (Operator); Project Tech Lead Engr | PHA Study or Mini-PHA Study (new/modified scenarios only) | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 2.2 | | | | Does the change impact an existing scenario by increasing the maximum potential pressure that may be introduced into a node? Or does the modification change the source of that pressure? | PHA Facilitator; Operations Rep (Operator); Project Tech Lead Engr | PHA Study or Mini-PHA Study (new/modified scenarios only) | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 2.3 | | | | Does the change impact an existing scenario by altering (lowering) the node design pressure (ie. pressure rating of new or modified components or equipment is less than the pressure rating of the weakest equipment or component for the existing node). Does the change involve equipment that limits the node pressure rating? | PHA Facilitator; Operations Rep (Operator); Project Tech Lead Engr | PHA Study or Mini-PHA Study (new/modified scenarios only) | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 2.4 | | | | Does the change impact PHA scenario documentation by lowering the maximum potential pressure source that may be introduced into a node? Or by raising the node design pressure (ie. any/all equipment or components which limit the node pressure rating are being is being replaced, modified, and/or re-rated to a higher pressure rating. (Risk is lowered due to these changes or other similar changes.) | PHA Facilitator; Operations Rep (Operator); Project Tech Lead Engr | PHA Documentation updates required (only) | Updated Documentation; Update PHA Tables; Communication of change and lower risk to Operations | |
| 3 | | | | **Impacts to PHA Scenario Safeguards/Protective Layers (Mitigated Consequences)** | | | | |
| 3.1 | | | | Does the change add, modify, or remove any mechanical safety device (such as pressure safety valves (PSVs), rupture discs, check valves, etc) or have any potential to affect probability of failure on demand of the device (including changes to components, changes to test frequency, changes to process media, setpoints, etc)? | PHA Facilitator; Operations Rep (Operator); Project Tech Lead Engr; Possible participants: Process Engineer; Mechanical Engineer | PHA Study or Mini-PHA Study (new/modified scenarios only) Relief Device Calculations Review | Design changes; Additional safeguards (preventative and/or mitigating); Update Relief Device Calculations; Update PHA Tables | |
| 3.2 | | | | Does the change add, modify, or remove any Safety Instrumented Function (SIF) (or Interlock or Instrumented Protective Function (IPF)) or have any potential to affect probability of failure on demand of a component of an SIF including changes to burner management systems (BMS), changes to sensing devices, final elements, logic solvers, control logic/programming, communications equipment (wiring, fiber), components, test frequency, setpoints, etc) | PHA Facilitator; Operations Rep (Operator); Project Lead Tech Engr; SIS/Instrumentation Engineer | PHA Study or Mini-PHA Study (new/modified scenarios only); SIS Documentation/Calculations Review; Process Safety Time Calculations Review (as needed) | Design changes; Additional safeguards (preventative and/or mitigating); Update PST Calcs; Update SIF Documentation / Database; Update PHA Tables | |
| 3.3 | | | | Does the change add, modify, or remove any credited independent protection layer (IPL) or credited safeguard. | PHA Facilitator; Operations Rep (Operator); Project Tech Lead Engr | PHA Study or Mini-PHA Study (new/modified scenarios only) | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 3.4 | | | | Does the change have potential to impact the design or sizing basis for the flare system? | PHA Facilitator; Operations Rep (Operator); Project Tech Lead Engr; Process Engineer | PHA Study or Mini-PHA Study (new/modified scenarios only) Relief Device Calculations Review; Flare System Review | Design changes; Additional safeguards (preventative and/or mitigating); Update Relief Device Calculations; Update Flare System Report; Update PHA Tables | |
| 3.5 | | | | Does the change add, modify, or remove any safeguard (including mitigating safeguards and/or safeguards not credited as independent protective layers such as gas detection systems, fire suppression, HVAC, operator responses to alarms, etc.)? | PHA Facilitator; Operations Rep (Operator); Project Engr Tech Lead; Possible participants: Engr rep from HVAC, Fire & Gas, etc | PHA Study or Mini-PHA Study (new/modified scenarios only); Technical Review (discipline specialist) | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 4 | | | | **Process Changes (Potential New or Modified Scenarios)** | | | | |
| 4.1 | | | | Does this change add a new node to the existing facility PHA study? | PHA Facilitator; Operations Rep (Operator); Project Tech Lead Engr | PHA Study or Mini-PHA Study (new/modified scenarios only) | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 4.2 | | | | Does the change add, modify, or remove process equipment, (ie. vessels, tanks, pumps, compressors, exchangers, piping, etc.)? | PHA Facilitator; Operations Rep (Operator); Project Tech Lead Engr | PHA Study or Mini-PHA Study (new/modified scenarios only) | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4.3 | | | | Does the change add, modify, or remove a process flow path for any process stream, auxiliary stream, or utility stream (ie., new tie-in, change tie-in location relative to other flow paths, new potential blocked flow or trapped pressure location; size change (pipe, valve, or flow orifice), control valve or shut-down valve action changes, changes to valve stops, locking, or resets, etc.) | PHA Facilitator; Operations Rep (Operator); Project Tech Lead Engr | PHA Study or Mini-PHA Study (new/modified scenarios only) | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 4.4 | | | | Does the change modify process variables such as pressure; temperature; flowrate; velocity; fluid composition; heat/material balance; etc.) Includes primary process streams and auxiliary or utility process streams. | PHA Facilitator; Operations Rep (Operator); Project Tech Lead Engr | PHA Study or Mini-PHA Study (new/modified scenarios only) possible PHA Documentation updates (only) if all changes are as in 2.4 above. | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 4.5 | | | | Does the change add, modify, or remove a Basic Process Control System (BPCS) (including changes to sensing devices, final elements, control logic/programming, communications equipment, components, test frequency, setpoints, etc)? | PHA Facilitator; Operations rep (Operator); Project Tech Lead Engr | PHA Study or Mini-PHA Study (new/modified scenarios only) | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 4.6 | | | | Does this change involve reactive chemicals? Does this change involve chemicals or materials that may auto-ignite? | PHA Facilitator; Operations Rep (Operator); Process Engineer; Project Tech Lead Engr | PHA Study or Mini-PHA Study (new/modified scenarios only) | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 4.7 | | | | Does this change involve materials and/or process fluids that are considred highly hazardous or toxic, such as H2S, or potential asphyxiants, such as nitrogen. | PHA Facilitator; Operations Rep (Operator); Process Engineer; Project Tech Lead Engr | PHA Study or Mini-PHA Study (new/modified scenarios only) | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 4.8 | | | | Does the does the change involve processes where dust may be accumulated or processed? | PHA Facilitator (specialist in Dust Hazards, DHA); Operations Rep (Operator); Project Tech Lead Engr | PHA/DHA Study or Mini-DHA Study (new/modified scenarios only) | Design changes; Additional safeguards (preventative and/or mitigating); Update PHA Tables | |
| 5 | | | | **Other Equipment/Device Mechanical Changes** | | | | |
| 5.1 | | | | Does the change introduce a new deadleg or change an existing deadleg? | Discipline Engineering Group (Mechanical/Corrosion) Consult with Process Engineering Group | No PHA; Technical Review (Mechanical) Technical Review (Corrosion) IM&T Review | Design changes. Inspection, Maintenance, and Testing (IM&T) Program updates. Update Deadleg Register. | |
| 5.2 | | | | Does the change affect mechanical components, rating/mechanical integrity of components (ie., replacement of valve(s); replacement of valve components including elastomers; materials changes; corrosion resistance changes; change of pipe specification; etc). | Discipline Engineering Group (Mechanical/Corrosion) | No PHA; Technical Review (Mechanical) Technical Review (Corrosion) IM&T Review | Design changes. IM&T program updates. Update PHA Tables. | |
| 5.3 | | | | Does the change affect instrumentation components including rating/mechanical integrity of instruments (ie., replacement of sensing device, transmitter, gauges; including elastomers; materials, connections; sensing range or span; etc) | Discipline Engineering Group (Instrumentation) | No PHA; Technical Review (Mechanical) Tech Review (Instrumentation) IM&T Review | Design changes. IM&T program updates. Update PHA Tables. | |
| 6 | | | | **No Process Changes Identified** | | | | |
| 6.1 | | | | No Process changes or Mechanical Integrity related changes identified | Project Tech Lead Engr; Process Safety Engineer | No formal or semi-formal process hazard review required | Statement below completed, reviewed, and approved | |

7 **Process Safety Review Method:**

Method of Process Safety Review Chosen (if Required): * Indicate Not Applicable (N/A) if none rqd and complete Section 8 Statement below.

Process Safety Review Lead Requirements:

Required Participants: ( Yes / No / Optional )

| Apprvd PHA Facilitator (large studies) / Apprvd PHA Facilitator (small studies) / Other / NR | | | Select/Circle One |
|---|---|---|---|
| Operator (Unit or Facility) | Yes / No / Optional | Select/Circle One | Required |
| Operations Lead Rep | Yes / No / Optional | Select/Circle One | |
| Project Technical Lead Engr | Yes / No / Optional | Select/Circle One | |
| Plant Engr / Facility Engr | Yes / No / Optional | Select/Circle One | |
| Process Engineer | Yes / No / Optional | Select/Circle One | |
| SIS/Instrumentation Engineer | Yes / No / Optional | Select/Circle One | |
| Mechanical Engineer | Yes / No / Optional | Select/Circle One | |
| Third Party Rep | Yes / No / Optional | Select/Circle One | |
| Maintenance Rep (Technician) | Yes / No / Optional | Select/Circle One | |
| Operator (Control Room/Board) | Yes / No / Optional | Select/Circle One | |
| Other: | Yes / No / Optional | Select/Circle One | |

8 **Statement / Completion Sign-Off**

* If No Process Safety Review is required beyond completing this form, include Statement below explaining rationale and considerations.

| | Name (Printed): | Signature | Position / Title | Date |
|---|---|---|---|---|
| **Statement:** | | | | |
| | | | | |

| | Name (Printed): | Signature | Position / Title | Date |
|---|---|---|---|---|
| Form Completed By: (typically Project Technical Lead Engineer) | | | | |

9 **Approvals** (as required/defined by company based on company procedures)

**Process Safety Approval:** *(Process Safety representative sign off on all Process Hazard Review Decision Forms. Specific position, as rqd by company procedure based on size of project.)*

| | Name (Printed): | Signature | Position / Title | Date |
|---|---|---|---|---|
| Process Safety Engineer or Specialist: | | | | |
| Process Safety Lead or Supervisor: | | | | |

**Additional Management Approvals:** *(As required, based on assessment above and company defined approval requirements.)*

| | Name (Printed): | Signature | Position / Title | Date |
|---|---|---|---|---|
| Project/Change Lead or Supervisor: | | | | |
| Plant Operations Supervisor: | | | | |
| Area Operations Manager: | | | | |
| Manager (Other): | | | | |

10 **Approval Requirements** (defined by company)

| | |
|---|---|
| Highest: | Position A; Position(s) B; Position(s) C; Position(s) D |
| Higher: | Position A; Position(s) B; Position(s) C |
| Moderate: | Position A; Position(s) B |
| Lower: | Position A |
| Baseline: | Initial approval (process safety approval) only by Process Safety group representative |

11 **Process Safety Hazard Review Requirements** (defined by company)

| | |
|---|---|
| PHA Study: | PHA using HAZOP; HAZOP/LOPA; or other approved technique |
| Mini-PHA: | PHA using company approved simplified method, such a mini-HAZOP, mini-LOPA, with PHA Tables updates. |

Other Supporting Calculations: Relief Device (including PSV, PRV, rupture disc, etc) Calculations; Process Safety Time (PST) Calculation; Instrumented Protective Functions (IPF) Calculations

Other Supporting Reviews/Studies: MoC Technical Review (discipline specific); Safety Instrumented Systems (SIS) Reviews; Flare System Studies; Major Accident Risk (MAR) Studies (supporting facility siting dat

12 **Process Safety Hazard Review Particpants**

| | |
|---|---|
| PHA Study: | PHA Facilitator is Process Safety group representative that meets company PHA Facilitator Training requirements (large study). Participants as rqd by company PHA procedure and this form. |
| Mini-PHA: | PHA Facilitator is Process Safety group representative that meets company PHA Facilitator Training requirements (small scale). Participants as rqd by company PHA procedure and this form. |

13 **Process Safety Hazard Review Tools**

| | |
|---|---|
| PHA Study: | PHA software (Brand X) |
| Mini-PHA: | PDF of PHA Tables (existing equipment/scenarios); Mini-HAZOP Spreadsheet (new equipment or scenarios) |

14 **Acronyms**

| | |
|---|---|
| BMS | Burner Management System |
| BPCS | Basic Process Control System |
| HAZOP | HAZard and OPerabiity Study |
| IMT | Inspection, Maintenance, and Testing |
| IPF | Instrumented Protective Function |
| IPL | Independent Protective Layer |
| ISD | Inherently Safer Design |
| LOPA | Layers of Protection Analysis |
| MAR | Major Accident Risk |
| MoC | Management of Change |
| PFFM | Process Flow Failure Modes |
| PHA | Process Hazard Analysis |
| PRV | Pressure Relief Valve |
| PST | Process Safety Time |
| PSV | Pressure Safety Valve |
| SIF | Safety Instrumented Function |
| SIS | Safety Instrumented System |
| TDSD | Temporary Defeated Safety Device [Procedure] |