SECTION B - CHAPTER 4: PROCESS HAZARD ANALYSIS

Section 450-8.016(b)(1)(A) of County Ordinance Code Chapter 450-8 as amended by County Ordinance 2006-22[1] requires Stationary Sources to include human factors in the Process Hazard Analysis (PHA) process. The intent of this chapter is to identify requirements of the PHA process that Stationary Sources must or should meet and to identify methods that Stationary Sources may adopt to meet the requirements. This chapter applies to traditional PHAs and to all accepted methodologies (i.e., those methodologies listed in Section 450-8.016(d)(1) of County Ordinance 2006-22). It also applies to procedural PHAs when the Stationary Source determines that a procedural PHA is more beneficial than a traditional PHA and may be conducted on select procedures to supplement the traditional PHA for the unit process. Examples of when a procedural PHA may be more beneficial are activities such as unloading/loading procedures, complex valve configurations, high hazard activities with high active failure potential, and bypassing independent protection functions. Although this chapter uses the term "PHA" throughout, it applies to PHAs performed on existing systems, PHA revalidations, and PHAs performed during the design of a new process. This chapter also applies to project PHAs, where the project may involve significant modifications to a covered process or processes. Each Stationary Source must document the criteria applied when determining whether changes are simply modifications of the existing process or whether they constitute the design of new processes. Stationary Sources electing to develop and implement programs other than those described in this chapter must consult with Contra Costa Hazardous Materials Programs (CCHMP) representatives.

4.1 REQUIREMENTS OF THE PROGRAM

PHAs conducted by the Stationary Source must meet the requirements listed in Section 450-8.016(d) of Chapter 450-8 and:

- Identify active failures or unsafe acts that employees may execute
- Identify latent conditions that may exist at the Stationary Source, if not already done through another procedure
- Consider the effects of existing latent conditions on the frequency of and consequences associated with the active failure or unsafe act
- Assess the adequacy of safeguards (i.e., physical and administrative) toward reducing the risk associated with the active failure or unsafe act
- Manage the active failures and latent conditions by formulating and implementing action items in accordance with Section 450-8.016(d)(4)
- Evaluate action items or recommendations formulated during the explicit latent conditions review (Chapter 3) to ensure that they address the potential deficiency without creating additional deficiencies

4.2 TRADITIONAL PROCESS HAZARD ANALYSIS

Stationary Sources should adopt an approach to ensure that human factors (i.e., active failures and latent conditions) are included in the PHA process. This guidance document

conceptually describes two approaches. Regardless of approach, the PHA must meet the requirements outlined in Section 4.1.

4.2.1 FIRST APPROACH

The PHA is performed in accordance with accepted practices.[2] Additionally, Stationary Sources should complete the applicable sections of a latent conditions checklist, as described in Section 3.1 of this document. Not all of the answers to the questions or indicators included in the checklist are applicable to the PHA (e.g., some of the questions are overall management philosophy which may be more appropriately addressed elsewhere) if the checklist list is not customized. The PHA team members should be provided with copies of the completed latent conditions checklist (or documentation of an alternative approach) prior to the study. This documentation should include all the action items or recommendations formulated to resolve the latent conditions and the status of each. The PHA team leader or facilitator should use the results of the latent conditions checklist to focus and direct the PHA discussions in a manner similar to management of change (MOC) documentation and incident investigation reports (i.e., the results of the checklist should be used to focus and identify scenarios and failure modes for the analysis) to consider the effects of existing latent conditions on the frequency of and consequences associated with any active failure or unsafe act. The PHA team should evaluate the consequences of implementing action items or recommendations from the latent conditions review, where appropriate.

4.2.2 SECOND APPROACH

The PHA is performed in accordance with accepted practices.[1] PHAs performed must include a review of each active failure or unsafe act resulting in a potentially hazardous scenario. The PHA team should analyze the failure and document "*why*" employees would execute each active failure or unsafe act resulting in a potentially hazardous scenario. The PHA team should consider the effects of existing latent conditions on the frequency of and consequences associated with any active failure or unsafe act. The checklist described in Chapter 3 should be applied to guide PHA team members in identifying all possible latent conditions that could contribute to the active failures or exacerbate the consequences. The PHA team should identify the latent conditions for each individual active failure, or elect to group active failures with the potential for similar latent conditions (e.g., the latent conditions contributing to "Operator inadvertently opens wrong valve", may be similar regardless of the valve type; however, the likelihood may be increased in a congested and unlabeled location).

4.3 PROCEDURAL PROCESS HAZARD ANALYSIS

Stationary Sources should consider conducting procedural PHAs when it is beneficial; however, CCHMP identified two distinct situations that the use of procedural PHA should be

considered. First, there are certain processes or activities for which a procedural PHA can provide a more thorough and efficient review than a traditional PHA (e.g., unloading/loading, manual manipulation of complex valve configurations, bypass of an independent protective function, etc.). For these processes or activities, the Stationary Source should conduct a procedural PHA rather than relying on the traditional PHA. Second, there are certain activities or procedures within a process that the Stationary Source can identify as having "*high active failure likelihood and high hazard potential*". For these activities, the Stationary Source should conduct a traditional PHA on the process as described in Section 4.2, but may also elect to conduct procedural PHAs on specific procedures used within the process (e.g., furnace lighting, manually gathering samples of acid, hot catalyst samples, sampling that requires additional PPE, etc.). These two approaches are discussed in more detail in subsections 4.3.1 and 4.3.2. Regardless of approach, the PHA must meet the requirements described in Section 4.1.

4.3.1 PROCEDURAL PHA RATHER THAN TRADITIONAL PHA

There are certain activities or procedures for which a procedural PHA may be best suited. Stationary Sources must first identify these activities or procedures (e.g., loading/unloading, manually moving hazardous materials). Stationary Sources should then apply a systematic approach to conducting a procedural PHA. Two such approaches are briefly discussed below[3].

- Guidewords (i.e., missing, skip, out of sequence, as well as, more, less, and other than) are combined with the parameter "step" to establish deviations (e.g., skipped step, other than the step) for a Hazard and Operability Study (HAZOP) or questions (e.g., What if step number 3 is skipped) for a What-If Analysis. The remainder of the study is conducted according to accepted practice.[1]
- Guidewords (i.e., omit or incorrect) are combined with the parameter "step" to establish deviations (e.g., omitted step number 3 or performed XYZ instead of step number 3) for a HAZOP or questions (e.g., what if XYZ is performed instead of step number 3) for a What-If Analysis. The remainder of the study is conducted according to accepted practice.[1]

4.3.2 PROCEDURAL PHA IN ADDITION TO TRADITIONAL PHA

Stationary Sources electing to conduct a procedural PHA in addition to a traditional PHA should first identify "*high likelihood active failure and high hazard potential*" tasks. Other ways to state this include: there is a potential for a Major Chemical Accident or Release (MCAR) from the activity; a similar activity has resulted in a MCAR; or there is a high consequence if the procedure is not adequate. The Stationary Source should screen all activities performed in their processes using established criteria, some criteria to consider include, but not limited to the following:

- Frequency: infrequent/non-routine or so frequent to result in complacency
- Criticality
- Emergency or temporary procedures such as emergency shutdown
- Large equipment or process unit startup/shutdown procedures
- Hazards (e.g., flammability, toxicity, asphyxiation) in the process
- Consequences of failure
- Human interactions with the process that could result in a hazard
- Familiarity of employees with the process

Stationary Sources should then apply a systematic approach to conducting a procedural PHA (Section 4.3.1).

Procedural PHAs can provide a more detailed review of potential active failures or unsafe acts and the effects of latent conditions than traditional PHAs. However, procedural PHAs can be resource intensive and possibly not the most efficient or effective means of ensuring that procedures are efficient (i.e., safe, accurate) and that the hazards of deviating from the procedure are well understood. Consideration of human factors in procedures will be addressed in detail in Chapter 6.

4.3.3 CONSIDERATION OF TIME SEQUENCING

During a procedural PHA, questions should be raised regarding the availability of personnel to perform a task as specified. Many times the types of procedures evaluated have critical time constraints and the "*PHA team*" or "*HAZOP team*" may have difficulty in effectively assessing the availability of appropriate personnel and whether the tasks can be completed as listed. Without this understanding, the procedural PHA is likely to fall short on verifying the accuracy and efficacy of the procedure. For example, the "*PHA team*" or "*HAZOP team*" may identify that a particular operating procedure necessitates a heavier personnel demand during response to emergency situations. In particular, manual operation or field verifications may be required to bring the process to a safe state in an emergency situation. To assist in assessing the impacts of these demands on existing personnel, "*PHA teams*" or "*HAZOP teams*" are encouraged to perform time sequencing analyses to outline all of the tasks and their sequence that must be performed during critical and emergency situations.[4] The intent of such an analysis should be to identify if there are situations where, for example, an operator is required to perform multiple tasks in unreasonable timeframes based on the situation (e.g., an operator must run up to the fifth deck to turn a switch, run down to the first deck for another switch, and back to the fifth deck all within a short timeframe). Such an analysis is more than just adding up the number of instrument loop counts on the process.[5] Another example is when evaluating unique or complex equipment that requires additional resources to bring to a safe state during process upsets. The "*PHA team*" or "*HAZOP team*" should then identify the consequences of failure to perform all the task in the given time and

identify action items to mitigate the situation as appropriate (e.g. installation of motor operated valves (MOVs) to reduce time to operate the valve, or the configuration of alarms that allows for earlier detection and more response time, etc.)

In conclusion, Stationary Sources must evaluate the execution of unsafe acts and improve upon existing safeguards that reduce risk. The Stationary Source must conduct a PHA which incorporates the results of the latent conditions review (Chapter 3) or that poses and analyzes the question "why" when an active failure or unsafe act resulting in a hazard is identified. Stationary Sources should perform procedural PHAs on those activities for which it would be more appropriate than performing a traditional PHA. Stationary Sources may elect to conduct a procedural PHA, in addition to traditional PHAs, on those tasks that have a "high active failure likelihood and high hazard potential".

[1] Modifications were made to the Contra Costa County's Industrial Safety Ordinance (ISO) in 2006. The definition of an MCAR was modified to include the potential of a combustible vapor cloud as well as a flammable vapor cloud. Since the corresponding City of Richmond's Industrial Safety Ordinance has not been amended, Stationary Sources subject to the City of Richmond's ISO are encouraged to comply with the County ISO amendments.
[2] CCPS *Guidelines for Hazard Evaluation Procedures*, 1992

[3] Bridges, Kirkman, and Lorenzo, "Include Human Errors in Process Hazard Analysis", *Plant Safety,* 1996
[4] I. Nimmo, Its Time to Consider Human Factors in Alarm Management, Chemical Engineering Progress, November 2002
[5] I. Nimmo, Determining Operator Workload and Console Loading is more than a simple loop count, Chemical Engineering Progress, November 2002