

## **A SIMPLIFIED RISK-BASED APPROACH FOR ANALYZING HUMAN FACTORS**

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### **INTRODUCTION**

While industry agrees that human factors issues are critically important to process safety performance, the lack of a universally adopted, practical approach to address human factors has hampered progress in the practical application of human factors in process safety. Most process safety management programs do not formally address human factors, other than possibly in a superficial way during traditional PHA studies. As such, human factor risk issues are not addressed in a fully comprehensive approach. For the industry to embrace human factors more than they currently are, more practical guidelines are required and additional information is needed for industry to understand how to expend their efforts on this cause.

This paper presents a format for a task-based analysis approach that can be introduced into an existing PSM structure at a process facility.

### **PRACTICAL METHODS TO ADDRESS HUMAN FACTORS HAZARDS**

PSM is a management systems approach, and does not include details on the methods recommended to identify and address risk. This is particularly true for human factors. For the latter issue, it is imperative to develop a methodology for internal teams to routinely and systematically address risks posed by human factors. There are a variety of techniques available, but we believe that many of them are not practical enough to be commonly used or accepted in industry. PHA teams would benefit from a superior approach for addressing human factors during the PHA, and there are other opportunities for special studies to be conducted then as required.

The basis of the approach is to assimilate human factors into the PHA activities of the organization in a more explicit way than is customarily done.

It is only a matter of time until regulators are more interested in human factors than they have shown to be in the past. OSHA and EPA merely gave mention to the topic when promulgating the PSM and RMP regulations. No doubt human factors are an area ready for significant growth and more attention in the very near future.

### **DEFINITION OF HUMAN FACTORS AND HUMAN ERROR**

In order to properly manage human factors, it has to be clear what is involved. With such a fuzzy definition of human factors in industry presently, there could likely be confusion. Accepted definitions of human factors are:

1. A discipline concerned with designing machines, operations, and work environments so that they match human capabilities, limitations, and needs.<sup>1</sup>

2. [E]nvironmental, organizational, and job factors, and human and individual characteristics which influence behavior at work in a way which can affect health and safety.<sup>ii</sup>
3. Departure from acceptable or desirable practice on the part of an individual that can result in unacceptable or undesirable results.<sup>iii</sup>

Regarding process safety, human factors are a collective issue of prevention and mitigation of catastrophic releases of highly hazardous materials through various human factors considerations.

As it relates to process environments, it is recognized that management decisions and programs, and operational procedures, training, and actions can all contribute to human errors. In addition to these parameters, consideration should be given to incorporating human factors into inherently safer design practices and to improvements in the work environment to reduce the number and likelihood of situations to produce error.

#### **OBJECTIVES AND SCOPE OF THE EFFORT**

To properly address human factors it is necessary to implement a program that takes a management systems viewpoint to the problem. Included with this management system for human factors is the need for a means to identify and analyze human error likely situations. The corporation should develop a strategy for the implementation of a process safety program to address human errors more carefully. This may include the following objectives:

1. To assist the corporation with the development of a human factors approach as a supplement to and to be integrated with the existing process safety management systems;
2. To assist the corporation to develop a specific approach to conduct a Process Hazard Analysis (PHA) with an emphasis on human factors;
3. To develop all supporting training materials and provide the training for the successful implementation of the program.

The scope of the implementation of such a process is as follows:

#### **TASK 1 – ORIENTATION AND PROJECT SCOPING**

The first goal is to meet with the appropriate parties in the corporation to scope out the project and to determine goals, schedule, and other administrative details. Included in Task 1 are the following:

- 1.1. To become familiar with the corporation's Process Safety Management (PSM) program and PSM metrics by reviewing PSM documents, policies, and procedures and through discussions with process safety personnel;
- 1.2. To become familiar with the corporation's perception of human factors and human error issues affecting the corporation through a review of incidents and discussions with process safety personnel;

1	Absolute risk comparison approach	Setting safety goals to a defined risk level, such as no more than X events per year caused by human error
2	Benchmarking approach	Comparison of loss statistics and setting goals based on performance of peer industrial companies, i.e., no worse than the average performer
3	Relative risk reduction approach	Setting goals to reduce risk from where it exists at the time specific to the company, i.e., 20% improvement per year
4	Idealistic approach	Zero incidents or no events attributable to human error

**Figure 1.** Human factors program risk reduction goal strategies

- 1.3. To determine program goals per the strategies in Figure 1 and in positioning the program for management commitment and approval. Management commitment is essential for incorporating human factors issues, especially because many of the program suggestions are not explicitly required under the law. A full explanation of the benefits is essential, along with the costs involved. An ongoing management system should be put in place for implementing and supervising the program, ensuring its quality, measuring its success, and providing ongoing training so that expectations under the program are understood. The management system should also include written procedures with designated roles and responsibilities, program requirements, implementation schedule, communications procedures, documentation requirements, and technical procedures;
- 1.4. To develop a draft of the overall project approach based on the findings of Tasks 1.1 and 1.2 and to review it with the corporation and revise it as necessary. The recommended approach is illustrated in Figures 2 and 3.
- 1.5. To define a project schedule with milestones and responsibilities and resources required;
- 1.6. To develop a project budget.

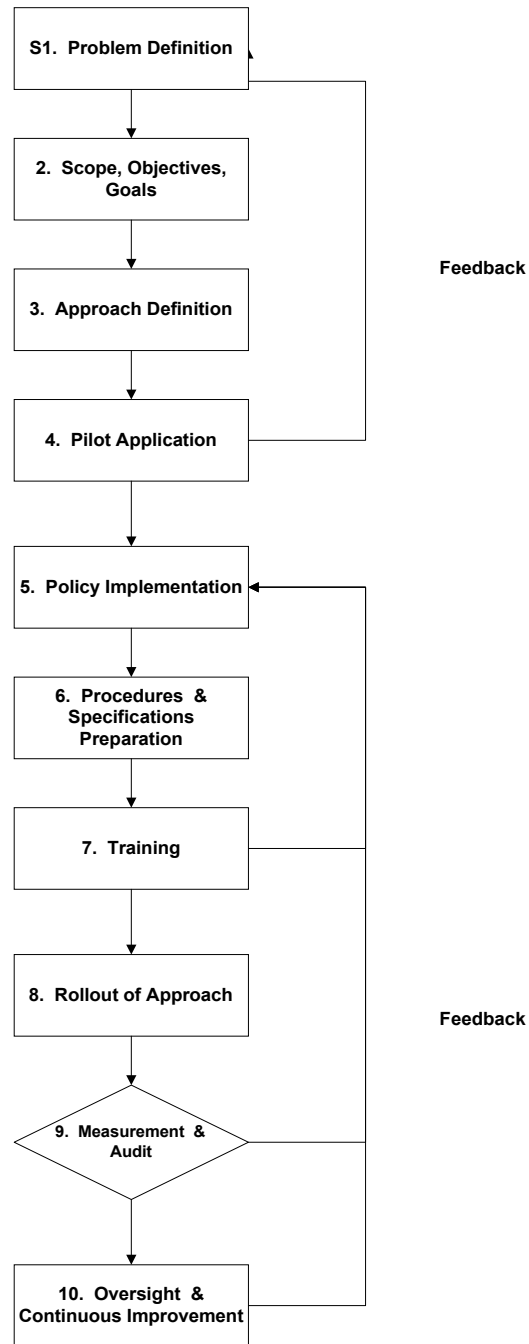
#### TASK 2 – HFPHA APPROACH DEVELOPMENT

Figure 5 illustrates an overall HFPSM (Human Factors for Process Safety Management) approach that includes an Element 6 for human factors consideration in hazards analysis and risk assessment. The team should further refine a generic HFPHA (Human Factors for Process Hazards Analysis) methodology to be specific for the company and discuss how this approach could be implemented within the corporation. The methods developed would be a supplement to and integrated with the existing process safety management systems implemented throughout the corporation.

The philosophy is that risk reduction is justified where the time, expense, and effort required to reduce the risk is commensurate with the level of risk reduction achieved. The underlying basis of the goals of the program to reduce human error risk is a choice of the company management.

Step	Task	Purpose
1	Problem Definition	Define the scope, magnitude, and nature of the human factors problem
2	Scope, Objectives, Goals Definition and Commitment	Define the scope, objectives, and goals of a human factors-oriented risk reduction program and obtain management commitment to the program goals
3	Approach Definition	Define the actual methodology of the approach to be followed
4	Pilot Application and Evaluation/Modification	Test the approach on a limited problem, evaluate the success, and modify as required prior to widespread rollout
5	Policy Implementation	Determine the necessary organizational policies required and obtain employee agreement on the merits of the program
7	Procedures and Specifications Preparation	Develop the necessary procedures and engineering design specifications required to ensure human factors are considered in design and operation
6	Training	Train all individuals who must implement or be subjected to the program. Both general orientation and specific procedural training is required.
8	Rollout of Approach	Implement the approach in a priority order
9	Measurement and Audit of Initial Success and Evaluation/Modification	Obtain feedback on the program's effectiveness and acceptance of the program, and respond to concerns; modify as necessary
10	Oversight and Continuous Improvement	Monitor the program on a periodic basis to ensure that it is functioning per plan, and effective in meeting goals

**Figure 2.** Human factors implementation approach



**Figure 3.** Human factors program implementation approach

Element	Description
1	Management knowledge and commitment
2	Written human factors policy
3	Management system for implementing the human factors program
4	Employee knowledge and involvement on human factors
5	Training on human factors issues
6	Incorporating human factors into hazards analysis and risk assessment
7	Human factors in process design and process change
8	Incident investigation and human factors root cause assessment
9	Consideration of human factors in written work procedures
10	Measurement and auditing of the human factors program performance

**Figure 5.** Human factors management system

### TASK 3 – HUMAN FACTORS PILOT STUDY

Next, it is recommended that the team field tests the approach as a pilot test and evaluates its effectiveness before widespread implementation. For Task 3, the team will:

- 3.1 Develop a pilot test protocol and all necessary forms, documents, or reports needed for the evaluation program
- 3.2 Based on the Human Factors Process Safety Management System, the team will review and evaluate the Process Safety Management programs, work processes, and management systems for the pilot process. This may be accomplished through worker surveys, interviews, onsite inspections, job observations, and audits.
- 3.3 Develop all supporting training materials and provide the training for the successful implementation of the program at the pilot site at a particular site.
- 3.4 Conduct certain agreed-upon human error analysis studies to determine the utility of different methods for analyzing risk. Included may be such methods as are listed in Figure 6. To accomplish this, the team will review documents, interview operators, engineering personnel, contract personnel, and management as required, and will conduct a site survey for human factors issues. One of the essential human factors program requirements is that it be incorporated into ongoing hazard analysis and risk assessment efforts. Human factors program development will require that procedures be adopted to conduct the analyses, as well as tools and technical approaches (documentation formats, checklists). In most cases, human factors considerations may be incorporated into existing PHA studies, but for selected studies, specific human factors methods should be adopted. Large facilities or groups of facilities may also consider expediting the typical 5-year PHA cycle in order to review human factors more quickly at areas where human error is likely, or when the consequences of an

event are especially high. In developing a workable program, facilities may consider starting with a pilot study before widespread implementation takes place in order to refine procedures and improve long-term implementation efficiency.

- 3.5 Prepare a written report of findings and recommendations based on the results on the study and recommending forward approaches.

Method	Description
1. HFPHA - HAZOP or What if for Human Factors	Conduct a typical PHA however include specific deviations and checklist questions related to active and passive human error, latent conditions leading to human error, and an analysis of the response of operators to abnormal situations. Conduct the methods as part of the PHA studies typically done on process systems, however in more detail. Use the procedures as the basis of the analysis, rather than primarily the P&ID. In particular, study startup, shutdown, maintenance, and emergency procedures. Examine control schemes, critical human-dependencies, and areas of high consequence with few reliable and effective safeguards. Focus on the highest risks that are mostly influenced by human actions and at least selectively apply the methods where justified.
2. HFTA - Task Analysis (Facility Survey, Job Observation, Interviews, Detailed Procedure Review, Hazard Analysis, Risk Ranking, Integrity Level determination, Human Performance Improvement Measures)	Conduct field observations of the operation of a process and an onsite observation to ensure human factors specifications and design considerations are met and to identify hazards. Involve operations in the analysis, including a discussion of concerns and risks they perceive. Combine this with a task-wise detailed step analysis that identifies the purpose of the step, the criteria for success, the safe operating limits, the indicators for exceeding those limits, and the possible hazards of exceeding those limits. Identify all means to prevent, detect, and mitigate the hazard, including management systems, procedures, training, facility design changes, operational changes, or additional safeguards. Rank each risk based on a scale or likelihood and severity. Determine the Integrity Level of the human element of the system, and the potential means to improve the reliability of that level.
3. HFPRO - Procedures and Training Reviews using Performance Influencing Factor Analysis	Review operating procedures against the hazards analysis to determine if they coincide and if sufficient guidance is provided to prevent or control the identified hazards. Identify the performance influencing factors for every operating step to ensure they are understood, documented, and managed.

**Figure 6.** Qualitative methods for human factors hazards analysis

### STEPS IN THE HFPHA PROCESS

The HFPHA is a task-based analysis of targeted facilities that are more likely to cause significant consequences should error-likely conditions result in human errors. In this way, resources are focused on the areas of greatest significance based on risk.

The steps in the process are described in Figure 7 and the worksheet for conducting the HFPHA method is shown in Figure 8.

The steps in the process are:

#### DATA GATHERING –

Information/data needed:

1. Process safety information (PSI)
2. Written procedures
3. Field survey results
4. Interviews of the humans (to confirm or not confirm the written procedures)

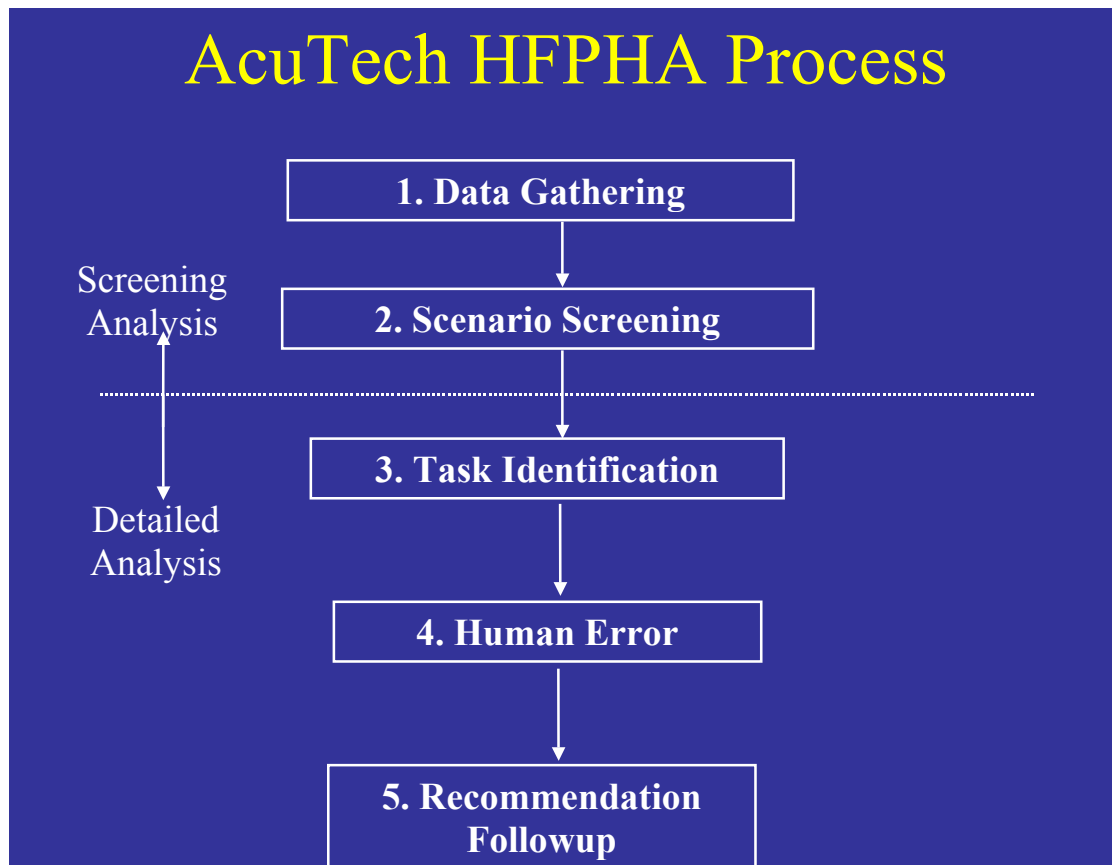


Figure 7.



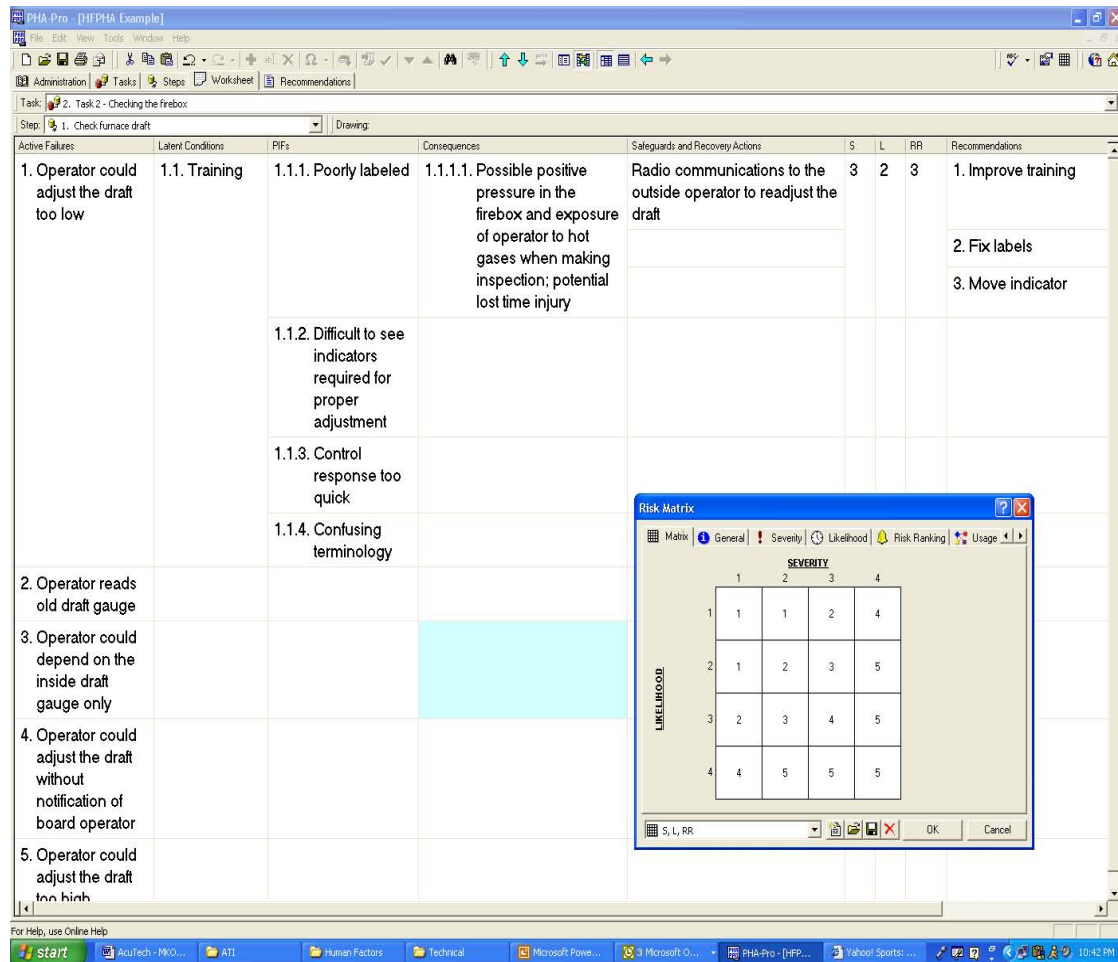


Figure 8. HFPHA worksheet

5. Identify possible Performance Influencing Factors (PIFs) (from checklist)
6. Identify possible latent conditions for the tasks/subtasks to be analyzed (checklist)

Performance Influencing Factors may include:

1. Task, Equipment, and Procedural Characteristics
  - a. Feedback mechanisms available?
  - b. Hardware interface factors:
    - i. Job aids
    - ii. Labeling
    - iii. Color coding
2. Physiological/Psychological Stressors:
  - a. Fatigue
  - b. Climate extremes
  - c. Movement repetition

- d. Distractions
  - e. Sleep deprivation
  - f. High task overload
  - g. Threats
  - h. Negative reinforcement
  - i. Lack of rewards, recognition, or benefits
3. Review written documentation and interview someone knowledgeable of the procedures for the following modes of operation:
    - a. Normal startup
    - b. Startup following temporary shutdown
    - c. Startup following emergency shutdown
    - d. Normal operations
    - e. Emergency operations
    - f. Alternative operations
    - g. Temporary operations
    - h. Normal shutdown
    - i. Emergency shutdown
  4. Have operations walk through the steps for each process above. Pay particular attention to:
    - a. the relevancy and accuracy of the operating procedures and training;
    - b. the actual practice vs. documented procedures;
    - c. any undocumented steps to avoid hazards;
    - d. communications issues during the above steps between field and control room staff;
    - e. perceptions of authority for shutdown vs. rules;
    - f. depth of rules vs. general training and knowledge required for operations.
    - g. discussion of system human factors issues.
  5. Use a checklist to review issues by:
    - a. visual walkaround to observe physical layout and design and to identify any human factors (design-related) issues;
    - b. interview operations to obtain feedback of design and policy/procedure/management/staffing issues that may affect human error;
    - c. discuss near misses and human errors that have occurred;
    - d. discuss training and supervision received on operations, hazards recognition, near miss or actual events;
    - e. discuss feedback mechanisms for any staff concerns with human factors issues.

#### SCENARIO SCREENING -

Review the following sources to determine which processes deserve consideration:

1. Existing process PHAs (assuming high quality)
2. Management of change PHAs or safety reviews or hazard reviews
3. Risk assessments
4. Incident investigations (particularly near misses)
5. PSM audit results
6. Any other safety-related analytical activity

**TASK IDENTIFICATION**

1. What humans and their activities interact with the process? Review:
  - a. SOPs (normal, startup, shutdown, etc.)
  - b. Emergency operating procedures
  - c. Inspection/Testing/Preventive Maintenance (ITPM) tasks
  - d. Sampling/lab activities
  - e. Unloading/loading activities
  - f. Others
2. Select those tasks for further analysis from above that have contributed to the screened scenarios

**HUMAN ERROR ANALYSIS**

Analyze the tasks using the worksheet format provided in Figure 8.

**RECOMMENDATIONS & FOLLOW-UP**

Use the normal method(s) of collecting, managing, and documenting the resolution of PSM-related recommendations

**CONCLUSION**

The HFPHA method is a practical approach to focus resources on human factors issues and human error-likely situations on a risk-basis. It has the following advantages:

1. Relatively simple
2. Includes a screening step to reduce overall workload and focus resources on a risk-basis
3. Uses an analytical framework and documentation methods (i.e., PHA, recommendations resolution) that are already familiar to plant personnel
4. Uses ranking tool that is already familiar to plant personnel
5. Includes consideration of latent conditions, PIFs, and recovery actions
6. Can be applied to any level of human activity (task or subtask)

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**ENDNOTES**

<sup>i</sup>Lorenzo, D.K. (1990). *A Manager's Guide to Reducing Human Errors*. Washington, DC: Chemical Manufacturers Association, Inc.

<sup>ii</sup>Reducing Error and Influencing Behavior, HSG48, HSE (1999).

<sup>iii</sup>Bea, Holdsworth, and Smith, "Human and Organization Factors in the Safety of Offshore Platforms", a paper presented at the 1996 International Workshop on Human Factors in Offshore Operations.