Improving and Simplifying Activity Hazard Analysis

P. John Palmer
Acutech Consulting, Inc.
903 Paseo de la Cuma
Santa Fe, NM 87501

ABSTRACT

Activity Hazard Analysis (AHA), sometimes referred to as Job Safety Analysis, is an integral part of Integrated Safety Management principles. AHA offers the potential of identifying job hazards on a step-by-step basis, but suffers from the problem that it often only considers already known issues, and does not act as a predictive mechanism for hazardous conditions. Coupled with this, AHA is often completed on a short time frame with limited knowledge resources for the tasks to be analysed. As a result, AHA does not always offer the degree of problem identification that is desirable. By using certain specific elements of structured hazard analysis techniques such as the What-If Checklist and Hazard and Operability study (HAZOP), it is possible to retain the more informal nature of AHA, while adding significantly to the identification of previously unknown hazards. What-If Checklist and HAZOP are widely used, tested, and proven methodologies in the Process Safety Management field, but are not as widely applied for AHA and JSA activities. With some simple additions to the generally accepted AHA methodology, the use of the methodology can be improved and made more accessible for its users, while not greatly adding to the time and effort required.

INTRODUCTION

Activity Hazard Analysis is similar to a process defined by the Occupational Safety and Health Administration (OSHA) as Job Safety Analysis [1] (JSA). OSHA defines Job Safety Analysis in terms of the benefit of establishing proper job procedures. A JSA consists of "breaking down the job", "identifying hazards", "evaluating hazards", and "recommending safe procedures and protection". The process of identifying hazards by task is somewhat intuitive, although checklists of known hazards can be consulted to ensure a certain degree of consistency and completeness.

Job Hazard Analysis or Activity Hazard Analysis (AHA) are the terms used within the Department of Energy for similar activities. These activities are governed throughout the DOE through standards such as the Integrated Safety Management [2] and certain other standards such as *Hazard Categorization and Accident Analysis Techniques For Compliance With DOE Order 5480.23, Nuclear Safety Analysis Reports* [3]. DOE facilities have also developed facility specific requirements for AHA such as the LIR developed by Los Alamos National Laboratory [4] providing a specific format and inclusive documentation needs.

Most of the DOE documents pertaining to AHA are oriented around safety management systems; that is, the specific management and supervisory functions for the appropriate completion of the AHAs as well as the responsibilities of various levels of the organization for proper field use of the AHAs. Thus, the documentation refers to qualified persons for the completion and various approvals needed to provide a system of checks and balances for workplace safety. These requirements are a necessary part of an integrated safety management system as well as a part of an overall safety commitment for all levels of an organization. However, the safety management systems do not ensure that the AHA considers all hazards.

For example, AHA safety management systems require that "the work provider shall draw upon the knowledge and experience of workers who perform the activity" as well as requiring the AHA to be completed by a "qualified person" [4]. This assumes that the workers and the qualified person are familiar with all hazards that can occur with the work, and is essentially relying on collective memory and experience. It is not a predictive technique.

However, other regulatory requirements have specified predictive methodologies, such as the OSHA Process Safety Management standard [5] and the EPA Risk Management standard [6], which standards are also considered in DOE Standards [7,8]. As well, other DOE standards have referenced predictive techniques in other applications such as Barrier Analysis [9]. In most cases, the predictive techniques are facilitated team based methodologies with specific structural constraints to focus the discussion.

Predictive techniques have several advantages and disadvantages in their use for field based operations. The advantages are :

- Ability to consider low probability or frequency events that have not previously occurred or have been documented;
- Ability to consider larger consequence events than those that have previously occurred; and,
- Synergistic effects of a facilitated team based analysis.

There are very definite disadvantages to predictive techniques, including :

- Planning and conduct of team sessions can be time intensive;
- Choice of team members directly influences the quality of the analysis; and,
- Analyses are typically not "real time" based, slowing rapid turnaround field operations.

Notwithstanding the disadvantages, with a carefully planned graded approach to the use of predictive techniques, the methodologies can yield useful results while also simplifying the use of AHA for job tasks. The discussion in this paper is not oriented towards detailed human factors assessments of procedures or tasks, which can be addressed through more appropriate methods such as human factors engineering and design.

DISCUSSION

Process industries have been subject to requirements for predictive hazard analysis methods in the United States for approximately thirteen years since the passage of the Toxic Catastrophe Prevention Act[10] in New Jersey in 1987. The passage of other state regulations such as the Risk Management Prevention Program [11] in 1988 in California and Risk Management Program [12] in 1989 in Delaware, was followed by federal regulations created under amendments to the Clean Air Act in 1990 [5,6].

In the last thirteen years, the process industries have generally settled on several techniques based on ease-of-use, regulatory acceptance, and breadth/depth of hazard identification. These techniques are :

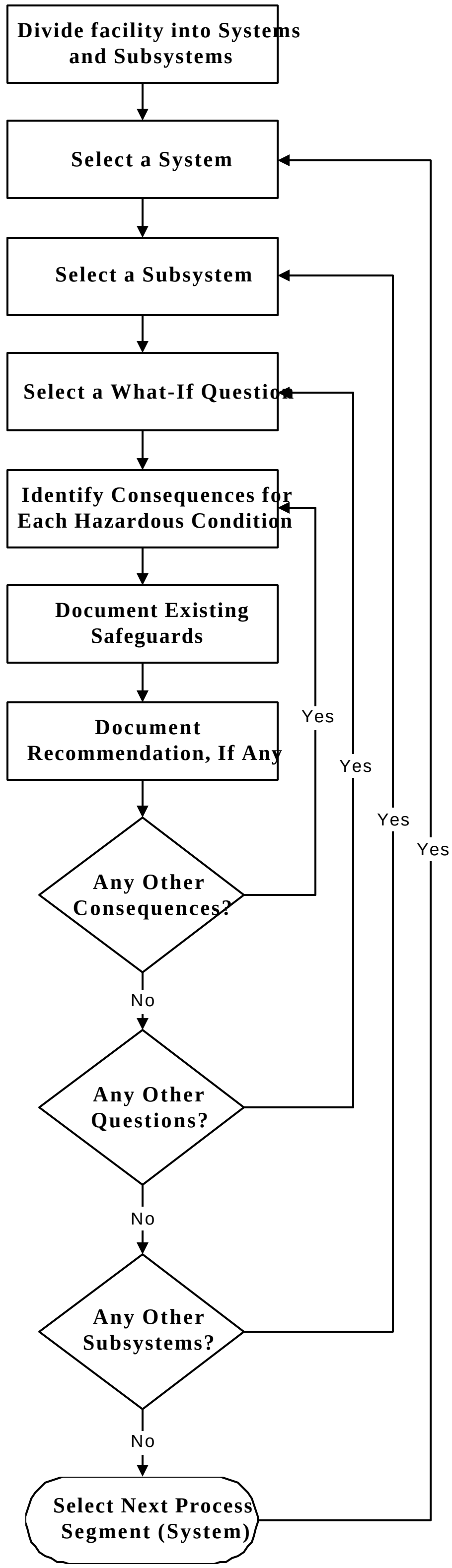
- What-If? Analysis
- What-If-Checklist; and,
- Hazard and Operability Studies.

The What-If? technique consists of a facilitated team asking What-If questions about a process or job. The process or job is divided into systems/subsystems or tasks, and questions are asked about normal and abnormal operations. Each question has consequences and where the consequences are undesirable, safeguards. The technique is intuitive and flexible, but can suffer from a lack of focus or consistency in the level of questions. The technique is highly dependent on the facilitator to maintain focus, consistency, and completeness.

The What-If-Checklist technique employs a checklist of questions specific to the operation under study. The use of the checklist is believed to assist the team in consistency and completeness while still allowing the team to postulate new questions. In practice, the quality of the studies is directly affected by the number of already completed studies used to further develop the checklist. A flowsheet to show the process of conducting a What-If? or a What-If-Checklist is shown in Figure 1.

The use of the What-If? and What-If-Checklist techniques is not very different than the current process of conducting an AHA. The team facilitator would ask various questions about identified hazards for each task, consulting a checklist of specific issues and controls. The approach is very close to the Barrier Analysis identified in existing DOE documentation [3], but would be progressively improved on a facility basis. Existing AHAs could be "data-mined" to develop sets of checklists.

Figure 1 – What-If? / What-If-Checklist Technique Flowchart



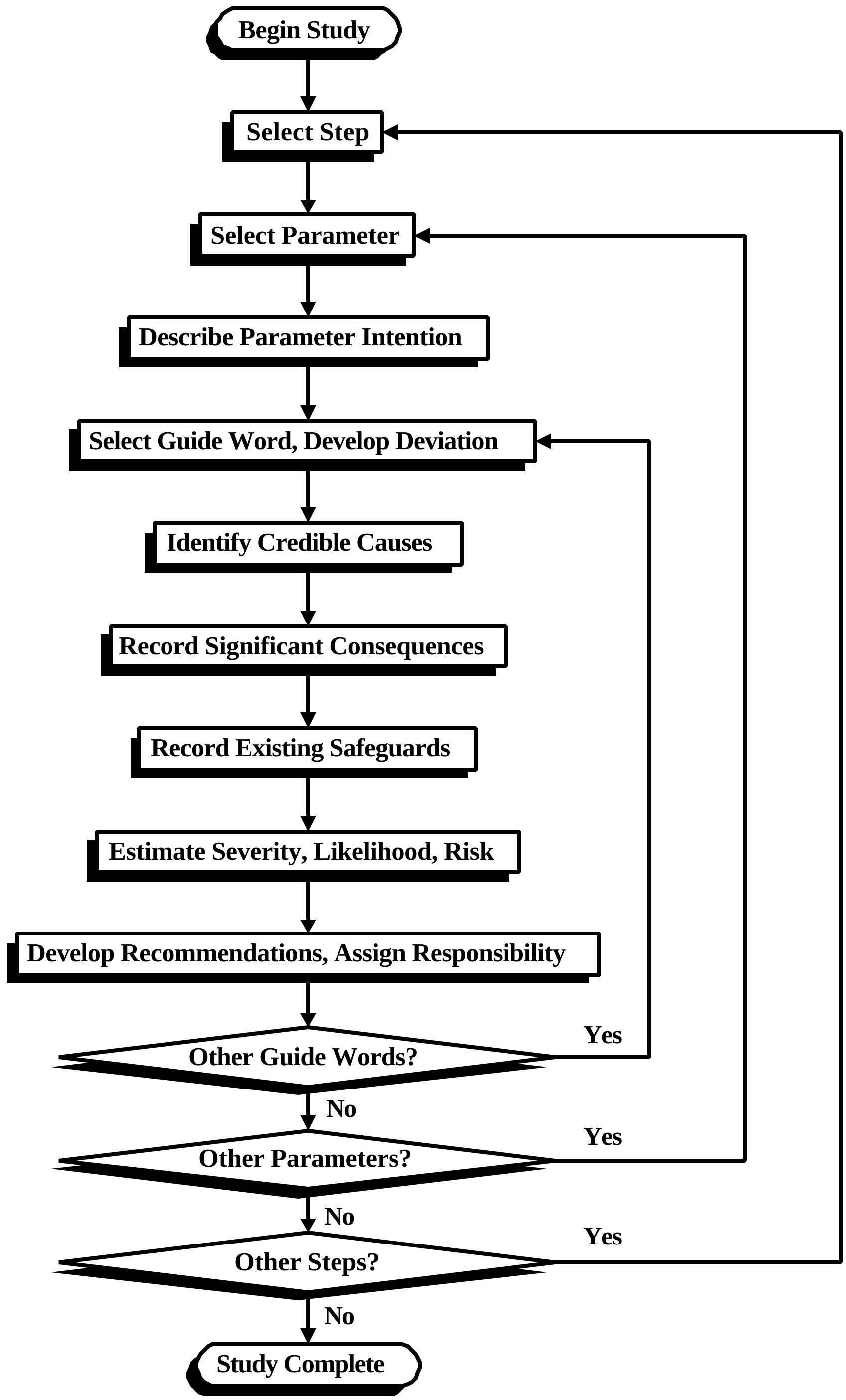
The Hazard and Operability Study, also known as HAZOP, is considered to be one of the more structured and complete analysis methods. In HAZOP, the process or job is divided into pieces called nodes. Operating parameters are determined for each node, and then guidewords are applied to each operating parameter, creating what are called deviations. Examples of the development of task related deviation results are shown in Table 1.

Table 1 – HAZOP Guideword Examples for Procedures

Guideword	Result	Example
No	Fails to perform the step or task. A step or important part of the procedure is skipped.	The worker does not perform a LOTO on the equipment.
More	Does more than is specified or required in a quantitative sense	The worker opens a valve fully when the procedure calls for "cracking" the valve.
Less	Does less than is specified or required in a quantitative sense	The worker purges a confined space for 10 minutes when the procedure calls for 30 minutes.
As Well As	Does more than is specified in a qualitative sense	The worker locks out several circuits, rather than just the one required
Part Of	Performs part of the step in a qualitative sense	The worker locks out only one breaker when the procedure says to lock out a set of breakers.
Reverse	Does the opposite of what is specified	The worker opens a valve when the procedure says that it is to be closed.
Other Than	Complete substitution	The worker opens valve A when the procedure says to open valve B.
When	The step is not performed when it is supposed to be	The worker does not energise the pipe heat tracing before winter
Where	The step is not performed in the location designated	Waste material is not placed in the appropriate 90 day RCRA waste location
Order	The step is performed out of order	The oxygen content is only checked after the worker enters the confined space
Who	The step is not performed by the appropriate person	Another worker performs the task
Check/Test	The step is not checked or tested as required	The circuit is not checked after a LOTO has been indicated to have been done

The team evaluates each deviation, and specific causes for the deviation are determined, with resulting consequences and safeguards. The process is highly iterative and time-consuming, but the structure of the technique is such that it can allow predictive analysis. A flowsheet that shows the iterative nature of a HAZOP is shown in Figure 2.

Figure 2 – HAZOP Technique Flowchart



Procedurally based HAZOP's require the facilitator to work with the team to determine specific actions or sub-tasks for each step of the work. Typically, the team would pull out verbs and specific locations or materials from the wording of the procedure, and then apply the full sequence of guidewords to each parameter and develop a lengthy list of deviations. For example, the step "Collect waste in plastic bag and place in local beryllium waste drum", could include the verbs "collect", "place", and the location/material "beryllium waste drum", each of which could have a series of deviations. An example of deviations and their implications is shown in Table 2.

Table 2 – Example Deviations

Guideword	Deviation	Implication
No	No collection of waste	As for deviation
More	More collection of waste	Excessive quantities of waste
Less	Less collection of waste	Some material in area not collected
As Well As	As Well as collection of waste	Other waste materials collected with Be waste
Part Of	Part of collection of waste	One area's waste not collected
Reverse	Reverse collection of waste	Waste dropped in cleaned area
Other Than	Other Than collection of waste	Completely different waste materials collected
When	When waste collected	Waste could be collected after area is treated or cleared assuming it to be Be free
Where	Where waste collected	Waste picked up from incorrect location
Order	Order of waste collected	Waste could be designated for low level contaminated drum or high level depending on order of collection
Who	Who collects waste	Non-Be screened personnel working with Be contaminated waste
Check/Test	Check or Test of Waste	Waste is not checked or tested to ensure it is the correct waste to be collected.

In the example shown above, each deviation would typically have a set of specific causes developed by the team for the deviation. In turn, each cause would have specific consequences, and safeguards specific to each cause-consequence. In order to review and prioritise the cause-consequence-safeguard combinations, it would be usual to develop a relative risk ranking for each scenario.

Procedurally based HAZOP's tend to be extremely time-consuming and sometimes frustrating for participants. Each specific action is assessed for deviations, and the specific causes determined for each deviation. In practice, the team tends to become quite jaded about issues related to human error and inattention, and as a result, the studies can be tedious. The level of detail for the assessment can be adjusted to compensate for this, but there is quite definitely a case of diminishing returns for less then critical steps in a procedure.

There is also the very perceptible risk that hazard analyses become a rote activity, carried out only to meet "paper compliance" requirements, and not as a tool to assist in improving workplace safety. In a review of the field of Process Safety Management, one of the pre-eminent scholars of the area, Trevor Kletz, noted that "… there is some concern that some companies that claim to carry out Hazops are undertaking little more than a perfunctory examination…" [13].

At this point, the question must be asked - are such detailed hazard analyses necessary? Is there a benefit to adding to the paperwork burden associated with the performance of both ordinary and extraordinary work associated with the DOE complex? Would changes to the existing AHA process add value to the safety management systems currently under use?

The answer to each and every question is "yes".

The DOE Operating Experience Database, available online at http://tis.eh.doe.gov/web/oeaf/oe_weekly/oe_weekly.html, has hundreds of incident cases with identified deficiencies in the management systems associated with AHAs as well as AHAs that did not include specific hazards. For example, OE Weekly Summary 98-13 noted a case where a hazard analysis did not identify the potential for ignition of an aerosol cleaner. The introduction of equipment not addressed in the work planning process for was cited as a proximate issue in the ignition.

How then, should a predictive hazard analysis method be used to improve the AHA process while not making the production of AHAs onerous or time-effective? The answer is to first assess the level of the issues associated with an activity in order to employ a graded approach. That approach has several levels.

Before developing any graded approach, the qualified person could determine if the job effort has previously resulted in near-misses, injuries, or deaths. This can be determined through local information at the facility level, review of ORPS reports for the DOE, review of OSHA or MSHA data, and through generally available industrial databases. This approach is in-line with that suggested by OSHA in their guidelines for Job Safety Analysis [1] where a review of job injury and illness reports as well as near-misses is suggested.

The use of a qualified person to make this determination is essential, as the search effort should be proportionate with the tasks under study. For example, dusting furniture in an office environment is not a task that would require days of analysis and review, where work in a multiply contaminated environment (e.g., chemicals, heavy metals, asbestos, and/or radiological contaminants) could require additional effort.

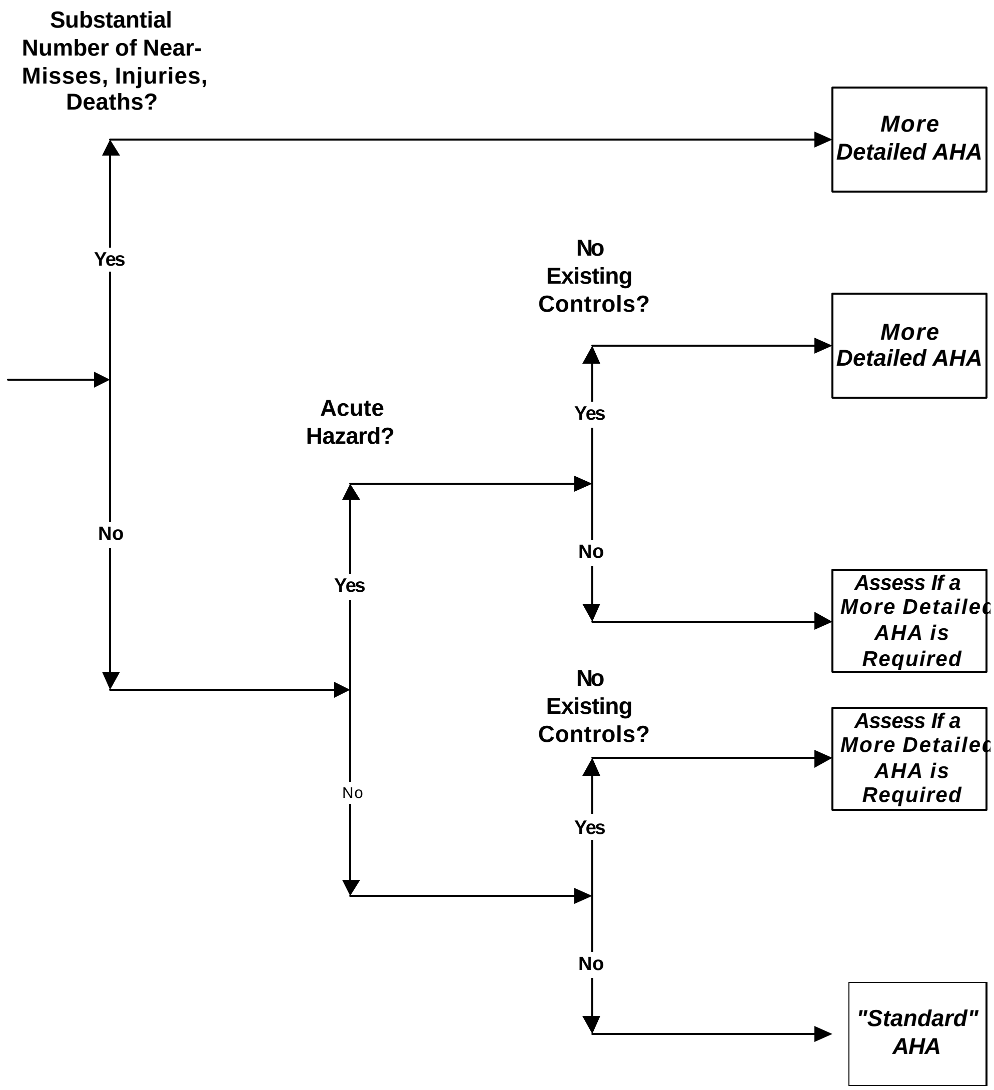
Cases where there are no specifically known acute hazards, but where procedural failures have resulted in substantial numbers of near misses, or in injuries or fatalities would merit a higher level of AHA effort.

Differentiating activities where workers are exposed to known acute or chronic hazards is the first part of the graded approach. Acute hazards typically offer little if any response time to allow the worker to avoid injury, where chronic exposure hazards can be prevented or mitigated more easily. In addition, industrial hygiene or health physics testing and monitoring can allow diagnosis of low-level chronic exposures, where acute hazards may not be detected in a timely fashion due to certain test results delays (e.g., air monitoring for asbestos would not determine a release of flammable vapour). Acute hazards could require additional effort.

The next part of the graded approach would be to determine if the known acute hazard is addressed by existing administrative or engineering controls. For example, confined space entry is a defined process with certain administrative and engineered controls available. Non-permitted or undefined controls situations could require additional effort.

The process of deciding on the level of effort is shown as a decision tree in Figure 3.

Figure 3 - Decision Tree for AHA Level of Effort



The amount of additional effort to be followed for the various cases can be kept quite simple. Instead of applying a substantial barrier to the already existing process of conducting an AHA, a cross of structured methodologies can be applied. For more complex issue cases, a cross of the What-If-Checklist and the HAZOP methodology could be applied.

Instead of attempting to break down every task into many subtasks, deriving deviations from each task, the use of deviations for the task could be applied. There is an established set of guideword-derived deviations available that could be posed to the team as What-If questions. This would allow the team to quickly note which cases are applicable and focus on those without needing to pursue lengthy discussions on ultimately non-relevant issues. At the same time, it could provoke predictive analysis on otherwise undiscussed issues.

Some of the deviations and associated questions listed below are based on a review of the DOE Operating Experience Database and incidents associated with deficiencies in the conduct of AHAs or the safety management systems associated with ISM and AHAs.

Table 3 – AHA Specific What-If Deviation Questions

Guideword	Deviation	Question
No	No Task	What if the task is not done?
Order	Order of Task	What if the task is done out of order (before, immediately after, other sequence)?
Reverse	Reverse Task	What if the task is done in reverse?
Part Of/Less	Part of or Less of the Task	What if the task is only partially done?
Location	Location of the Task	What if the task is done in the wrong place?
Person	Person doing the Task	What if the wrong person does the task?
Safeguard/Control	Safeguard or Control for the Task	What if the task is done without the/any identified control?
Permit	Required Permit for the Task	What if the task is done without the identified permit?
Training	Required Training for the Task	What if the task is done without the required training?
Approval	Required Approvals for the Task/Permit/Training associated with the Task	What if the task is done without the appropriate approval?
Equipment	Equipment required for the Task	What if the task requires other non-listed equipment?
Testing	Testing Required for the Task	What if the task is done without the appropriate facility walkdown?
Documentation	Documentation Associated with the Task	What if the documentation is not completed for the task?
Notification	Notification of Workers or Other People in the Area of the Task	What if workers or people in the area of work are not notified that the work is taking place?

Other guidewords specific to facility AHAs could be added to the list with related What-If-Checklist questions. The list of What-If-Checklist questions is not restricted to one question per deviation. For example, the qualified person and workers making the assessment could split the "Part Of/Less" Guideword up if this would develop a better hazard analysis. The use of deviations to assist in a more structured set of What-If? questions for an AHA is intended to make the studies more effective, not more onerous and time-consuming. The qualified person facilitating the AHA should always endeavour to use the technique flexibly and not relentlessly.

In conducting an AHA, the qualified person might not have to ask the involved workers every question. Some would be inapplicable to certain tasks, or would be redundant with other questions. The intent of a deviation based What-If-Checklist is not to create a straitjacket for the qualified person, but to offer a basis for predictive hazard analysis. In addition, the use of a more detailed process would have to subject to a graded approach so that the effectiveness of the process would not be wasted in lengthy reviews, ultimately resulting in poorer Activity Hazard Analysis at all levels.

For less complex issues, a simple What-If-Checklist could be developed by data-mining the existing AHAs used at a facility. In many cases, this is already being accomplished by "customizing" existing AHAs for specific project or task efforts. The development of a more comprehensive What-If-Checklist from those existing AHAs could offer greater consistency and completeness for qualified persons who might not have conducted an AHA for a specific job or task.

CONCLUSIONS

Not all AHAs require a detailed assessment using a structured analysis technique. Only certain higher risk jobs or tasks may require the use of more advanced techniques. Careful review of jobs and tasks is needed before the decision to use structured approaches. ***Implementing detailed AHA techniques for all work activities would be wasteful of resources and could bring the use of AHAs in disrepute with the workers who are supposed to be benefit from the AHAs.*** The intention of proposing additional tools for AHA performance is that incidents with higher frequencies or consequences can be successfully addressed, and worker injuries prevented.

As well, one should consider that as AHAs are developed and implemented, the focus of what tasks and jobs require detailed AHA techniques will change based on the results of workplace near-misses and injuries. Determining what jobs or tasks require more or less detailed AHA techniques will be a dynamic and ongoing process.

By addressing the most important highest risk jobs with increased attention through enhanced AHA techniques, the remaining AHAs can be more properly handled through simple checklist reviews or through Skill of Craft type approaches. The better use of safety resources and more reasoned analysis of proven risks will ultimately simplify the use of AHAs. One size doesn't fit all in clothes, and one overreaching approach doesn't adequately address all of the hazards of work.

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