

## **Method for Evaluating New Safety Controls**

**(LA-UR-00-466)**

Robert F. Miller and Louis Restrepo  
OMICRON Safety and Risk Technologies  
Albuquerque, NM 87199

Carl Schepens  
Sonalysts  
Los Alamos, NM 87544

Davis Christensen  
Los Alamos National Laboratory  
Los Alamos, NM 87544

### **Abstract**

Existing DOE nuclear facilities are often called upon to upgrade safety controls as a result of a safety analysis upgrade, readiness review, safety audit, or other cause. Selection of new controls is sometime based on an ad hoc selection process that lacks a sound technical basis. A systematic method has been developed to identify potential new controls and evaluate them on the basis of risk reduction, cost, and programmatic impact. The method provides a record of the value of new controls that can serve as a sound technical basis for selecting those to adopt. The method uses a five-step approach.

1. Identify accidents to be evaluated and the existing safety controls for those accidents. This step should be based on the facility hazard analysis and should limit the scope of the effort to accidents with significant potential consequences.
2. Conduct brainstorming sessions to identify potential new controls for each accident. The objective of this step is to generate ideas. Widespread participation should be encouraged. This is a good opportunity to tap the hands-on experience of operations personnel.
3. Perform an initial screen of controls identified in the brainstorming session to eliminate those that are not possible to implement or those that would not be effective. This step focuses the analysis to a limited set of controls that have the best prospect for scoring well.
4. Perform the risk reduction/cost/programmatic impact analysis. A scoring scheme has been developed to evaluate each control. A risk reduction scoring matrix considers the magnitude of the consequences of the accident prevented or mitigated as well as how much risk reduction would be realized. A cost matrix considers both the cost of initial implementation and life cycle costs.
5. Review the results of the analysis and develop recommendations for which new safety controls to adopt. A logic scheme is used to develop a recommended action for each control based on the scores for risk reduction, cost, and programmatic impact.

This method has been piloted at a Los Alamos National Laboratory nuclear facility. General observations and lessons learned from the pilot effort are discussed.

## **Method for Evaluating New Safety Controls**

### **Introduction**

Development of this methodology began during a Safety Analysis Report (SAR) upgrade effort for the radioactive solid waste facility at the Los Alamos National Laboratory. The Department of Energy (DOE) office responsible for the Authorization Basis for this facility, the Los Alamos Area Office (LAAO) expressed its expectation for the facility operators to investigate new risk reduction measures as part of the SAR upgrade program. LAAO recommended that a study be initiated to identify potential safety upgrades and evaluate them for cost, risk-reduction benefit, and programmatic impact.

In identifying and evaluating safety upgrades (controls) for a specific operation, trade-offs between cost, risk reduction, and programmatic impact are usually necessary. Decisions are frequently based on an incomplete understanding of these key factors. For existing facilities, there is a natural tendency to propose refinements of existing facility safety features and operating practices rather than look to introduce new, innovative safety measures. Cost is usually an over-riding constraint that must be overcome. A different DOE office is usually responsible for safety than the office responsible for programmatic operations and funding. These cross-currents often result in a less than optimum set of safety features for facility operations. The study that was recommended by LAAO was performed as a structured investigation of potential safety features. The intent was to develop key information that could serve as a sound basis for making the necessary trade-offs and assist in the decision on which safety features to implement.

The Facility and Waste Operations Division of the Laboratory developed the detailed methodology for conducting this study. The methodology has been piloted on the radioactive solid waste facility and development of a final set of controls is in progress. This paper describes the methodology that was developed and some observations from its first application.

### **General Approach**

There are three primary components to this methodology:

- Identify potential safety features (both hardware/equipment and administrative controls)
- Evaluate safety features for cost, risk reduction, and programmatic impact
- Review the evaluations and select a set of safety features for implementation.

The key factor in identifying potential safety features is to encourage innovation—thinking “outside the box.” It should be a discovery process. To achieve the desired results, different ways of performing tasks should be explored. This step can benefit greatly from input from the operating staff. To identify potential safety features, “brainstorming” sessions were conducted to develop lists of potential features that could improve safety. These features include facility hardware modifications, using different equipment, different operating practices, etc.

The second component is the evaluation of proposed safety features for the three factors. A simple scoring scheme was developed to estimate the relative cost, risk-reduction, and programmatic impact of each control evaluated. The scoring scheme assigned a 1 to 5 score for each proposed feature. The scoring bins were defined sufficiently large such that scoring was performed using estimates rather than detailed quantitative analysis.

To accomplish the third component, a simple logic scheme was developed to identify a path forward for each proposed safety feature based on the scoring. Risk-reduction was the driving factor in this process. Controls with good risk reduction and low cost and programmatic impact would be recommended for implementation. Safety features with inconsequential risk-reduction potential would not be pursued further. Safety features with good risk-reduction potential but high cost or high programmatic impact would be recommended for further discussion with DOE.

## **Methodology**

The method uses a five-step approach, as described in the following paragraphs. It was developed to identify potential safety upgrades to an existing facility.

1. Identify accidents to be evaluated and the existing safety controls for those accidents.

This step was based on the facility hazard analysis and limited the scope of the effort to accidents with notable potential consequences. The focus was on public consequences. It was not intended that worker consequences be ignored, but for the most part, safety features that prevent or mitigate significant releases reduce both public and worker consequences.

For the pilot facility, a preliminary process hazard analysis had been completed and a set of accidents was selected from that analysis. To facilitate the next step, two groups of accident types were identified. The subject facility handles and stores solid radioactive waste, so the significant hazard at the facility is the radioactive waste material inside containers, primarily drums. The accidents of concern are those that could result in a release of the waste material. The types of accidents selected were:

- Spill accidents, including operational spills and natural phenomena events (earthquakes and high winds).
- Fires and explosions, including operational facility fires, external event fires, and onsite transportation fires and explosions.

2. Conduct brainstorming sessions to identify potential new controls for each accident.

The objective of this step was to generate ideas. Widespread participation was encouraged and obtained. This is a good opportunity to tap the hands-on experience of operations personnel.

Two brainstorming sessions were conducted, one for each set of accident types identified in Step 1. Participants included operations personnel, facility personnel, hazard analysts, Laboratory ES&H personnel, and other specialists. A short list of specific accidents was used to structure the sessions. All ideas for safety upgrades to prevent or mitigate the subject accidents were recorded. The sessions together identified 172 items. (This total included some items that were already implemented.)

3. Perform an initial screen of controls identified in the brainstorming session to eliminate those that are not possible to implement or those that would not be effective.

The objective of this step was to focus the analysis on the subset of suggestions that had the greatest potential for being selected for implementation. Ideas suggested in the brainstorming sessions were listed without consideration of their effectiveness or practicality. The initial screening step identified and screened those suggestions that clearly offer little risk reduction

potential or that are impractical. It also screened out those items that were already in place. In addition, the screening process facilitated the subsequent analysis by combining similar items so a general concept would be evaluated once.

For the pilot study, the initial screening process was documented to maintain a record of those controls that were screened from further analysis and the rationale. Approximately 60 of the 172 items passed the initial screen and were identified for further analysis. The screened items included similar numbers of items already implemented, not practical or not effective, and items that were consolidated with others.

4. Perform the risk reduction/cost/programmatic impact analysis.

The safety features that passed through the initial screen were each scored for risk reduction, cost impact, and programmatic impact. Scoring was performed by a small group with representation from the operations staff, facility management, and the hazard analysis team. Each participant developed scores independently and they were averaged to obtain the final score. Records of scoring were kept to capture salient points of the discussion.

Each safety feature was scored 1 to 5 for each of the three factors. The scoring scheme was set up with 1 being the most favorable score and 5 being the most unfavorable score for each factor. The following paragraphs identify the scoring scheme for each of the three factors.

#### **Risk Reduction Scoring**

A separate scheme was developed for accident preventers and accident mitigators. The scheme was biased to award a higher score for safety features that are effective for the higher risk accidents. The scheme for preventers takes into account the frequency and potential consequence of the subject accident. The scheme for mitigators takes into account the potential consequences of the subject accident. The concept is that a safety feature that offers moderate risk reduction for a high-risk accident is more valuable than a safety feature that offers significant risk reduction for low-risk accident.

Baseline frequency and consequences estimates were based on the hazard analysis. Reductions in frequency and consequence estimates were developed in a similar manner to estimating mitigated accident frequencies and consequences in the hazard analysis process.

If a safety feature prevents or mitigates multiple accidents, it was scored for the accident scenario that results in the lowest numeric grade for the control, or in other words, the greatest risk reduction. If a safety feature is both a preventer and mitigator, it was scored for both, and the lowest numeric value obtained from the two categories was the final score for risk reduction.

#### Accident Prevention

The control being evaluated was scored for how effective it is in preventing an accident. A score of 1 to 5 is given with 1 being more effective than 5. The scoring was based on the following:

- The ability of the control to prevent the accident from occurring.

- The level of the unmitigated consequences of the accident in question (e.g. a control that prevents an accident with unmitigated consequence of 25 rem is more valuable than one that prevents an accident with consequences of only 2.5 rem).
- The accident frequency of occurrence (i.e., a control that prevents an accident that is likely receives a better score than one that could prevent an accident that will likely never happen).

Table 1 identifies the control scoring scheme.

**Table 1. Risk Reduction Scoring Scheme - Accident Preventers**

Effectiveness of accident preventer	Unmitigated Accident Frequency								
	$10^0$ to $10^{-2}$ per year			$10^{-2}$ to $10^{-4}$ per year			$10^{-4}$ to $10^{-6}$ per year		
<i>Unmitigated Accident Consequences (rem)</i>	>25	<25, >2.5	<2.5	>25	<25, >2.5	<2.5	>25	<25, >2.5	<2.5
Reduces <i>f</i> by more than 2 OOM	1	1	1	1	2	3	3	3	5
Reduces <i>f</i> by 1 to 2 OOM	1	1	3	1	2	4	3	4	4
Reduces <i>f</i> by approx. 1 OOM	1	2	4	2	3	4	4	4	5
Reduces <i>f</i> by approx. ½ OOM	2	3	4	3	4	5	4	5	5
Slightly reduces <i>f</i>	3	3	5	4	5	5	5	5	5
No/negligible reduction in <i>f</i>	5	5	5	5	5	5	5	5	5

Notes

*f* = accident frequency

OOM = order(s) of magnitude

Doses are TEDE to the maximally-exposed offsite individual

Accident Mitigation

The control being evaluated was scored for how effective it is in mitigating associated accidents. A grading of 1 to 5 is given with 1 being more effective than 5. The scoring was based on the following:

- The ability of the control to reduce the consequences of the accident as measured by dose in rem.
- The level of the unmitigated consequences of the accident in question (e.g. a control that mitigates an accident with unmitigated consequence of 25 rem is more valuable than one that provides the same level of mitigation to an accident whose consequences result only in 2.5 rem.).

The scoring scheme for risk reduction for accident mitigators is provided in Table 2.

**Table 2. Risk Reduction Scoring Scheme - Accident Mitigators**

<b>Effectiveness of Accident Mitigator</b>			
<i>Unmitigated Accident Consequences (rem)</i>	>25	<25, >2.5	<2.5
Reduces consequences by more than 2 OOM	1	2	3
Reduces consequences by 1 to 2 OOM	1	2	3
Reduces consequences by approx. 1 OOM	2	3	4
Reduces consequences by approx. ½ OOM	3	4	4
Slightly reduces consequences	3	4	5
No/negligible reduction in consequences	5	5	5

**Cost Impact Scoring**

The control being evaluated was scored based on the cost to implement the control. A score of 1 to 5 was given with 1 having the least adverse effect on cost and 5 having the most severe impact on cost. The scoring was based on the following:

- The initial cost of implementing the control including costs for new equipment, modifications, installation labor, and personnel costs (design, procedures, training, etc.).
- The life cycle costs associated with maintaining the control element for 15 years.

The cost impact scoring scheme is provided in Table 3.

**Table 3. Cost Impact Scoring Scheme**

<b>Initial Cost</b>	<b>Annual Cost</b>				
	<\$1K	\$1K to \$25K	\$25K to \$50K	\$50K to \$250K	>\$250K
< \$1K	1	1	2	4	5
\$1K to \$25K	2	2	2	4	5
\$25K to \$50K	3	3	3	4	5
\$50K to \$250K	4	4	4	5	5
\$>250K	5	5	5	5	5

**Programmatic Impact Scoring**

The control being evaluated was scored for how it will affect programmatic or mission impact. A score of 1 to 5 was given with 1 having the least adverse impact and 5 having the greatest impact. The scoring scheme for programmatic impact is shown in Table 4.

**Table 4. Programmatic Impact Scoring Scheme**

Degree of Adverse Programmatic Impact	Score
No adverse impact on mission	1
Negligible adverse impact on mission	2
Small adverse impact on mission	3
Significant impact on mission, but it can still be accomplished	4
Will make mission nearly impossible to accomplish	5

5. Review the results of the analysis and develop recommendations for which new safety controls to adopt.

The three scores for each safety feature represents a set of comparative data that can be combined and evaluated in a number of ways to assist in the final decision-making process for specific controls to implement. For the pilot study, the following logic scheme was developed and used to develop a recommended action for each control based on the scores for risk reduction, cost, and programmatic impact.

Any control evaluated that provides good risk reduction (accident prevention or mitigation) will be considered for incorporation. A control will not be eliminated based on mission impact or cost considerations if it offer significant risk reduction. The analysis results will be evaluated against four outcomes.

- a. Good Risk Reduction (score  $\leq 3$ ) with low impact (score  $\leq 3$ ) and low cost (score  $\leq 3$ ).

Controls in this category should be considered for implementation.

- b. Good Risk Reduction (score of  $\leq 3$ ) with high impact (score  $> 3$ ) and any cost.

Controls in this category provide good risk reduction (accident prevention or mitigation), however they have a significant adverse impact on mission accomplishment. A recommendation to implement any of these controls must be reviewed with DOE prior to further action.

- c. Good Risk Reduction (score of  $\leq 3$ ) with high cost (score  $> 3$ ) and any impact.

Controls in this category provide good risk reduction (accident prevention or mitigation), however implementation may be too costly. A recommendation to implement any of these controls must be reviewed with DOE prior to further action.

- d. Inconsequential Risk Reduction (score of >3) with any impact or cost scores

Controls in this category provide inconsequential risk reduction (accident prevention or mitigation) and should be eliminated from further consideration.

Additional, more detailed studies of cost and risk reduction potential might be necessary to provide the necessary information for the final decision-making process.

## **OBSERVATIONS**

The following observations were noted during the piloting of this methodology for the radioactive solid waste facility at the Los Alamos National Laboratory.

1. The brainstorming sessions turned out to be an excellent opportunity for the hazard analysts to gain insight from the operating staff. During the preliminary hazard analysis, some members of the operating staff were consulted and they did provide requested input. However, the brainstorming sessions gave the operating staff an open forum in which many of the operational risks were discussed and many good suggestions were raised.
2. Cost constraints limit what can practically be done. A number of new safety features were identified that have the potential to reduce the risk of facility operations, but their cost is prohibitive. (Cost impacts were judged relative to the facility's operating budget and perceived from availability of funds for capital improvements based on routine discussions with the DOE program office.)
3. Good records of this study can be used in the future to defend the set of safety measures that was selected for implementation. Such records will document the decision-making process and the rationale for not implementing certain safety features.
4. This methodology can be expanded to evaluate existing controls that continue to be implemented based on historical practice. The controls can be evaluated to determine if they are providing risk reduction commensurate with their actual cost and programmatic impact.