BNL-100898-2013-CP

ANALYSES OF INSPECTION REPORTS AT FUEL CYCLE FACILITIES TO DERIVE INSIGHTS FOR A SIGNIFICANCE DETERMINATION PROCESS

Pranab K. Samanta, Vinod Mubayi, and Robert A. Bari

Presented at the ANS PSA 2013 International Topical Meeting on Probabilistic Safety Assessment and Analyses

Columbia, SC
September 22-26, 2013

Nuclear Science and Technology Department

Brookhaven National Laboratory

Notice: This manuscript has been authored by employees of Brookhaven Science Associates, LLC under Contract No. DE-AC02-98CH10886 with the U.S. Department of Energy. The publisher by accepting the manuscript for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this manuscript, or allow others to do so, for United States Government purposes.

This preprint is intended for publication in a journal or proceedings. Since changes may be made before publication, it may not be cited or reproduced without the author's permission.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

ANS PSA 2013 International Topical Meeting on Probabilistic Safety Assessment and Analysis
Columbia, SC, September 22-26, 2013, on CD-ROM, American Nuclear Society, LaGrange Park, IL (2013

ANALYSES OF INSPECTION REPORTS AT FUEL CYCLE FACILITIES TO DERIVE INSIGHTS FOR A SIGNIFICANCE DETERMINATION PROCESS

Pranab K. Samanta, Vinod Mubayi, and Robert A. Bari
Brookhaven National Laboratory
P.O. Box 5000
Upton, New York 11973
samanta@bnl.gov; mubayi@bnl.gov; bari@bnl.gov

ABSTRACT

Inspections carried out at nuclear fuel cycle facilities by USNRC inspectors are used to analyze and improve the safe operation of these facilities. With advances in risk-informed methodologies to analyze facility safety, a significance determination process (SDP) based on categorizing inspection findings according to their risk significance would allow an enhanced focus on findings more significant to risk and hence safety. Defining a SDP that can consistently evaluate the events and inspection findings is expected to foster objectivity, transparency, and predictability which are desirable features of an oversight process for fuel cycle facilities. This paper provides a summary of an attempt to characterize events and inspection reports at fuel cycle facilities to derive insights for such a process. A two- phased SDP was considered where Phase 1 was used to screen out findings of minimal risk significance and Phase 2 was used to characterize the (risk) significance of the inspection finding. This paper discusses evaluations to be conducted as part of the two phases in the SDP for inspection findings related to criticality safety, i.e., those findings that have the potential to increase the likelihood of a criticality accident in a facility. Screening criteria for Phase 1 evaluations for inspection findings affecting criticality safety are presented and event tree analyses for Phase 2 evaluations are performed. Further needs in developing guidance documents for conducting Phase 2 evaluations for SDP are also recommended. This work was carried out in support of NRC's effort to develop an improved fuel cycle oversight process (FCOP).

Key Words: Nuclear fuel cycle, inspection, significance determination of inspection findings, risk analysis

1 INTRODUCTION

Inspections are carried out at nuclear fuel cycle facilities by United States Nuclear Regulatory Commission (USNRC) inspectors to address deficient performance and assure safe operation of the facilities. The inspection findings are analyzed and regulatory actions are taken, as appropriate. With the advances in risk-informed methodologies to analyze facility safety and their applications to operational events and inspection findings in commercial power reactors, there is an increased interest in using similar approaches for nuclear fuel cycle facilities. Such an approach is expected to foster objectivity, transparency, and predictability which are desirable features of an oversight process for the fuel cycle facilities.

Recognizing the benefits of a risk-informed and performance-based approach to the oversight of fuel cycle facilities, USNRC initiated development of a new oversight process for the fuel cycle facilities, called the Fuel Cycle Oversight Process (FCOP), that is risk-informed and performance-based [NRC, 2009]. NRC Commissioners provided guidance to the staff on the desired revisions [NRC, Feb. 2009; NRC March 2009] and NRC staff issued paper providing possible paths forward for an FCOP [NRC, March 2010]. In addition, a risk-informed, performance-based approach is used for the oversight of nuclear power plants, called the reactor oversight process (ROP), and significant lessons from that program are also available [NRC, 2006]. This work was carried out in support of the USNRC's effort to develop an improved FCOP for its fuel cycle facilities. This work focused on the significance determination process for the fuel cycle facilities, called the Fuel Cycle Significance Determination Process (FCSDP), and conducted analyses of inspection reports to define the details and features of such a process.

2 FUEL CYCLE SIGNIFICANCE DETERMINATION PROCESS (FCSDP)

Future work on the development of a Fuel Cycle Significance Determination Process (FCSDP) is currently in the planning stage. Such work would be designed to provide NRC inspectors and management with a framework to identify those findings/issues that may be potentially risk-significant and define a risk-significance for the finding/issue. In addition, as part of the FCSDP, the inspection findings would also be evaluated for their potential to be cross cutting in nature, and also for potential enforcement.

The inspections findings would be expected to be assessed using the significance determination process (SDP); the finding enters the SDP when there is a performance deficiency associated with the finding. In addition, the finding must be determined to be of greater than minor nature to be assessed in the SDP.

This paper reports on some early studies undertaken to develop the concept of an FCSDP. In this paper, we focus on the findings related to the Criticality Safety Cornerstone. Findings relating to other Safety Cornerstones, e.g., Chemical, Emergency Preparedness, are not discussed here, but are expected to be addressed as part of the overall fuel cycle oversight process (FCOP).

2.1 Phases of Significance Determination

The SDP used to characterize the risk significance of inspection findings is proposed to be conducted in two phases to utilize the resources effectively and to make the process efficient. The two phases are defined as follows:

Phase 1: Initial Screening and Characterization of Findings
Phase 2: Finalization of Risk Characterization.

In the Phase 1 evaluations, an initial screening of the inspection finding is conducted considering the nature of the finding, associated degradation, and the duration of the degradation.

For this initial screening, the inspection findings related to affected conditions, degradation of the control(s), and failure/degradation of the systems, components, and structures are taken into consideration. The Phase 1 evaluation allows screening of inspection findings to very low significance, i.e., Green, without the use of numerical calculations. Items not screened to Green are potentially greater than Green, and are carried to Phase 2 for further evaluations.

In Phase 2, further evaluations are conducted to assign colors (Green, White, Yellow, and Red) to the inspection findings based on an assessment of the inspection finding. A risk analysis is expected to be conducted usually assessing the change in the likelihood of a criticality accident due to deficiency or the degradation identified in the inspection finding. An order of magnitude assessment is expected to be carried out to designate the colors which are expected to signify risk significance of the orders of magnitude. The level of risk analyses to be conducted is expected to be consistent with the level of significance attached with the color scheme. Criteria for defining the colors (Green, White, Yellow, and Red) will be defined as part of the FCSDP.

3 PHASE 1 – INITIAL SCREENING AND CHARACTERIZATION OF FINDINGS FOR CRITICALITY EVENTS

In the Phase 1 evaluation, the state of existing controls at the facility to prevent criticality upset events are judged to determine if they are missing or degraded. These controls can be items relied on for safety (IROFS) as designated by the licensee, or controls such as, active or passive engineered controls, enhanced administrative control, or administrative controls that are present, but not considered to be IROFS. The degraded or missing non-IROFS controls that are normally maintained can be considered to be findings. In these cases, if the underlying IROFS are present, the significance will usually be very low, but if the effectiveness of the IROFS is low, the item may prove to be significant.

The Phase 1 screening for inspection findings related to the criticality cornerstone is designed to screen findings into two categories: findings that can be assessed to be of low risk significance, i.e., can be assessed as Green findings and findings whose assessment of risk significance require further detailed evaluation and should be considered for Phase 2 evaluations where the risk significance can potentially be assessed to be greater than Green, i.e., White, Yellow, or Red finding. It is noted that in many cases, following a detailed Phase 2 evaluation, the risk significance of the finding can be determined to be low, i.e., it may still be assessed as a Green finding.

The Phase 1 process is expected to be performed by an inspector. If assistance is required, the inspector is expected to consult the risk analyst for additional guidance. For example, the inspector should consult the risk analyst prior to crediting the non-IROFS controls in the Phase 1. The information required for the screening is expected to be gathered during the inspection.

3.1 Intent in Defining the Criteria

The intent in defining the Phase 1 screening criteria is to allow the inspector to make a quick assessment of the significance of a finding so that the focus of the inspection remains on risk significant aspects and minimal attention and resources are expended on findings with low risk significance. To assure that an inspector is able to apply the criteria and make a prompt assessment of the significance of an inspection finding, the criteria are designed to have the following features;

1. The criteria should apply generically to different facilities addressing the criticality safety issues. If detailed plant-specific evaluations are needed, then the criteria should screen for additional evaluations in Phase 2 of the SDP.

2. The criteria should screen to Green, i.e., assess low risk significance for the finding, when such conclusions can be made with large confidence. If there is a potential that the finding may prove to be of larger significance with additional investigation, data, and/or analyses, then the criteria should screen to Phase 2. In simple words, the criteria should be conservative and only assess a Green finding when a compelling reason to make that judgment is apparent.

3. The application of the criteria should not require any detailed analyses by the inspectors and should be compatible with inspections carried out for the facilities.

4. The criteria should preferably be a simple checklist that can be used by the inspectors during the inspection of a facility. The check list should address different issues relevant to criticality safety and the different types of inspection findings expected for these facilities.

5. The criteria should provide clear guidance for screening the inspection findings where the information gathered from the check list is combined to define the screening.

6. The criteria should be understandable to the inspectors and should be easy to use.

3.2 Approach Used to Study Phase 1 Screening

The Phase 1 screening criteria were studied through an assessment of inspection findings at different facilities over a 5-year period. A database was developed for the inspection findings in the fuel cycle facilities from March, 2004 to May, 2009 and was categorized by the safety cornerstones. The database included a summary of each of the inspection findings at the facilities and a link to the detailed inspection report. In addition, the database included the following information about each of the inspection findings: facility name, applicable safety cornerstone

(criticality, chemical, emergency preparedness, etc.,) type (violation vs. non-cited violation), severity of the violation (level of severity I, II, III, IV, etc.), and issue and close date. The data for the criticality cornerstone included both high enriched and low enriched uranium (LEU and HEU) facilities, but details of inspection findings for HEU facilities were removed for the use of the database in the open literature.

The approach used to develop the Phase 1 screening criteria for the criticality cornerstone was defined as follows:

1. Analyses of the inspection findings database to categorize the findings into different groups addressing different types of issues relevant to criticality safety

2. Identification of the relevant characteristics to address in determining the safety significance of the inspection finding, i.e., low risk significance (Green) vs. greater than low risk significance (greater than Green) findings.

3. Development of the Phase 1 screening criteria using the categorization of the issues in criticality safety and the characteristics that can be used to assess the risk significance

4. Assessment and refinement of Phase 1 screening criteria based on application to the inspection findings in the database.

A group of experts was used to conduct the analyses of the inspection findings in developing the Phase 1 screening criteria. The group consisted of individuals with background in aspects related to criticality analyses, evaluation of events and plant conditions that pose risk of criticality accidents in a facility, inspection of facilities with respect to criticality issues, and risk-informed oversight process. The group, individually and collectively, reviewed, evaluated, and screened the inspection findings to define the Phase 1 screening criteria.

3.3 Phase 1 Screening of Criticality Events

Based on the analyses of the inspection findings over a 5-year period and categorization of the findings by the experts, a Phase 1 screening process was defined. The Phase 1 screening for the criticality cornerstone is based on potential changes in the conditions and assumptions, including defense-in-depth and safety margin, contained in the nuclear criticality safety evaluations to ensure that the fundamentals of criticality safety, the double contingency principle and the key parameters affecting criticality as per NRC Bulletin 91-01 [NRC, 1991], are maintained at all times. The screening process involves addressing six broad aspects. In other words, inspection findings are expected in the following six broad functions:

1. Procedures involving criticality safety are affected
2. Degradation or violation of one or more of the key parameters affecting criticality
3. Degradation or violation of the double contingency criterion
4. Degraded operation exceeding operating limits/safety limits
5. Inadequate/incomplete safety analyses and documentation
6. Deficiency/violations identified by the Licensee (non-repetitive with corrective actions defined).

For each of these functions, a list of questions were developed, for use by the inspectors, to determine if the finding should be screened as Green, i.e., low risk significance, or screened for Phase 2, i.e., for further analyses. Below, a list of questions for the first item, Procedures involving criticality safety are affected, is provided as an example. The list of questions for all the functions and an associated flow diagram that can be used by the inspectors can be obtained in [Samanta et al., 2011].

3.4 List of questions for inspection findings relating to "Procedures involving criticality safety are affected"

These questions apply to findings that pertain to possible violations of procedures listed in the nuclear criticality safety evaluation (NCSE) including degradation of controls, degradation of the safety margin for criticality that is built into the design, deficiency in operator actions that may be required to avert a criticality, and inadequate or improper actions by plant personnel and/or inadequate training of plant personnel that may impact criticality safety. These areas may overlap to some degree; for example, deficiency in operator actions or degradation of a control could also involve a reduction of the safety margin that is built in to the process design.

1. Does the finding result in degradation of the controls or systems defined in the criticality safety evaluation (CSE) to avert criticality accidents?

2. Does the finding significantly degrade the large safety margin(s) built into the process design?

3. Can the finding affect operator actions required to avert a criticality accident in the facility?

4. Does the finding involve inadequate or improper actions by and/or inadequate training of the personnel?

If the answer is YES to any one of the above questions, the finding is moved to Phase 2 for detailed analyses. If NO, other functions are addressed, as applicable, or screened as Green, if no other functions apply.

4 PHASE 2 - FINALIZATION OF RISK CHARACTERIZATION

In the Phase 2 evaluation, the analyst is expected to carry out an evaluation of the inspection finding to assess its significance, i.e., to assign a color corresponding to the level of significance. The evaluation to be conducted should be transparent and understandable to the fuel cycle inspectors, fuel cycle facility operators, and other interested stakeholders including the public. The method used should provide consistent results for similar findings across similar facilities. To achieve these objectives, it was considered that event tree analyses carried out in a manner consistent with the engineering analyses conducted for these facilities will be suitable for Phase 2 evaluations. The use of event tree analyses in risk assessment methods also provides the necessary flexibility in determining the risk significance of the inspection findings, i.e., to assign colors using a risk scale. Event tree analyses are also used in the significance determination process of the reactor oversight process (ROP). In that regard, there will be similarity in the approach used in the SDP of FCOP and ROP. However, the use of the event trees to assess the colors of the inspection findings is expected to differ somewhat because of the differences among the facilities, the differences in the types of inspection findings, available data, and the role of operators in operation of these facilities. Event trees are studied to characterize the events and to develop scenarios that could lead to criticality accidents.

The event trees are developed at a level of detail that will be understandable to the fuel cycle facility inspectors, can be related to the inspection findings, and can support significance assessment of the inspection findings. The event trees are developed to address the particular event that occurred and, at the same time, address other related issues such that the event tree model can be applied to other similar findings in the future. These trees can be considered preliminary and are expected to be restructured and consolidated differently as additional experience is gained from analyses of additional inspection reports and events that have occurred at different facilities.

4.1 Example Analyses of an Event in a Fuel Cycle Facility

A spill of uranium solution was studied to exemplify the Phase 2 analyses. Phase 2 analyses consist of engineering analyses and event tree analyses to obtain an order of magnitude assessment of the significance of the event or inspection finding. Phase 2 analyses consisting of the engineering and event tree analyses of additional events can be obtained in [Samanta et al., 2011].

<u>Engineering analyses</u>

The Phase 2 analyses starts with gathering detailed information for the finding or the event which culminates in a detailed description of the event/finding. The detailed description should support the engineering analyses, and subsequently for the development of the event tree, if and as required.

The engineering analyses involve clearly defining the following aspects:

1. What Controls Existed?
2. What Controls Failed?
3. Were Controls Identified as IROFS?
4. Was the scenario addressed in the facility integrated safety analyses?
5. Overall engineering assessment of the event or inspection finding.

Event Tree: High Concentration Spill

This event tree addresses different scenarios that may arise following a spill of high concentration fissile material. The event tree focuses on the cleaning of the spill and develops scenarios that may result in a criticality condition in the process of cleaning up the spill. The scenario development focuses on the use of vacuum cleaner and associated failures that may result in criticality conditions. It also addresses other procedures to clean up the spill. The procedure to sponge liquid into proper container is addressed broadly without addressing details of the procedure that may involve failures. Also, alternate procedures may be used or other failures may happen or criticality occurrence due to use of non-procedural methods may also be included as part of this tree.

High concentration spill requiring cleanup occurs infrequently (generally < 1 per year) in a facility during operation. These types of spills need to be defined. For example, one facility defined such spills as those that are greater than 14 ¾ liters in volume with a U-235 concentration in excess of 45 g/l. It is estimated that these events occur once every 5 or 6 years. Data from facility operations can be used to estimate this frequency. Vacuum cleaners (VC) are normally used to clean the spill. The likelihood that a VC is used will depend on the facility procedures, availability of VC, and past practices or experience data relating to clean up of spills at the facility. Failure of VC operation implies that the spill remains on the floor and successful operation implies that the spill of high concentration fissile material is collected within the VC. The VC may be transported outside of a particular area for cleanup and the collected fissile material within the VC can be disposed using appropriate procedure. The transportation of the VC will depend on plant procedures and practices, the location where the spill occurred, and the nature of the spill. The spill also may be cleaned using proper containers to sponge liquid into them for disposal following procedures. Different failures may occur in this process to collect the spill. The removal of the fissile solution collected in the VC involves error in the process that may result in accumulation of the fissile solution in another unfavorable geometry. The failure to remove the fissile solution from the VC may imply criticality accident in the VC. Proper disposal of the fissile solution that is collected from the spill requires following a procedure that includes specific steps. In general, there is a high likelihood that disposal is carried out appropriately. Some situations may involve transportation of the VC containing the high concentration spill. Housing may need to be developed for the vacuum cleaner. Vacuum cleaners are often transported in a facility. Housing structure that is used to transport vacuum cleaner can be

analyzed for failures. Spillage may occur in the housing created for the transportation. Failure in the transportation process may result in spillage in other areas. Adequate preparation and configuration control are needed for housing for transportation and for transporting the VC. The accumulation of fissile solution in the VC in some unfavorable geometry may lead to criticality accidents. Criticality safety analyses could be used to define the likelihood of occurrence of criticality, conditional on the absence of control of the key factors, mass, moderation, and geometry, and given the extent of safety margin on k_{eff} applicable in the identified condition. Guidance can be developed for defining the likelihood for different scenarios.

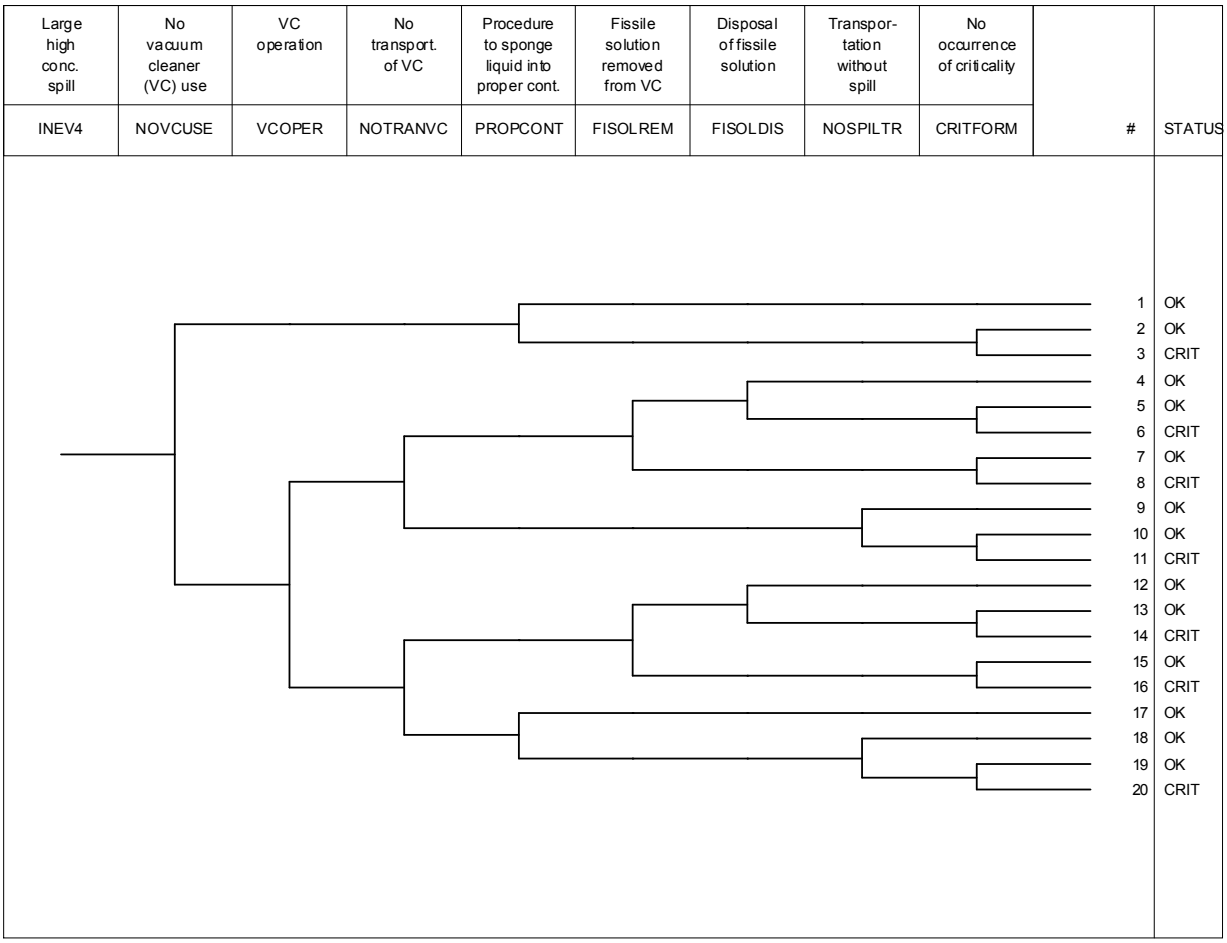

Figure 1. Event tree for assessment of inspection finding related to large spill in fuel cycle facility

5 LESSONS AND INSIGHTS FROM ANALYSES OF INSPECTION REPORTS FOR AN FCSDP

In this paper, we studied a significance determination process for fuel cycle facilities focusing on findings and events related to criticality safety, i.e., those findings that have the potential to increase the likelihood of a criticality accident in a facility. We studied a two-phased

SDP and derived insights on the details and features of such a process based on analyses of inspection reports and events at fuel cycle facilities.

The Phase 1 screening criteria were structured using the grouping of the criticality functions/ inspection issues and the characteristics of the issues. The criteria addressed potential violations of conditions and assumptions, including defense-in-depth and safety margin, contained in a facility's nuclear criticality safety evaluation (NCSE) to ensure that the fundamentals of criticality safety, the double contingency principle and the key parameters affecting criticality as per NRC Bulletin 91-01 [NRC, 1991] are maintained at all times. It can be noted that the grouping of the criticality functions/inspection issues are not totally distinct; there are some overlaps among them. For example, inspection finding with procedure violation may relate to degradation/violation of key parameters or degradation/violation of the double contingency criteria. A degradation/violation of the key parameter may also be a violation of the double contingency criteria. An inadequate or incomplete safety analysis may also lead to operation in an unanalyzed condition. This overlap among the functions/categories defined results due to the focus on the ways inspection findings are documented. This relationship among the functions/categories defined has that advantage that the chance of missing any finding of significance is significantly reduced. This is consistent with the intent of Phase 1 screening criteria that the assessment of Green findings is made with large confidence. In addition, this grouping/categorization makes the criteria consistent with the manner in which inspection findings are documented.

The approach used to develop the Phase 1 screening criteria is based on analyses of inspection findings at the fuel cycle facilities for which the oversight process is being developed. However, the Phase 1 screening criteria presented here are generic, i.e., they can be used for the range of facilities currently operating and is under the oversight process. The criteria developed focus on different types of functions involved in assuring criticality safety and not on features of the facility that can be considered facility-specific.

The development of criteria based on observed inspection findings at the facilities is focused on the inspection findings that have been made under the current system and as such, this implies an assumption that the current inspection practices adequately address the inspection findings expected for the fuel cycle facilities in the future. The use of an expert group in developing the criteria partly addresses this assumption since the expert group used judgments drawn outside of the inspection findings to define the criteria covering also the issues anticipated beyond those identified in the data compiled from inspection findings.

The event tree analyses presented here provides the essential building blocks for defining the risk significance, i.e., the color for an inspection finding. The event tree analyses can be used to define the combination of events that can lead to a criticality accident and considering the failures that have occurred, it can define the remaining barriers which can be transformed into a

significance of the event/inspection finding. If detailed data and information are available, a quantitative evaluation can also be conducted. Alternatively, a qualitative evaluation can also be defined. However, formalizing the method into a predictable, consistent approach for defining the risk significance of inspection findings for use in the FCOP will require addressing and defining a structured process for consistent use in the SDP for FCOP. Some of the aspects are recommended for further development and can be summarized as follows:

1. Assessment of criticality risk considering deviations in key criticality safety parameters
2. Event tree models addressing expected accident scenarios for processes applicable to fuel cycle facilities
3. An approach for assessing human error probability for different types of human errors
4. A database addressing input data needs for significance assessment

Each of the items is briefly explained below.

The nuclear criticality safety evaluation (NCSE) that is required to be performed by the licensee for each process in the facility as part of the licensing procedure establishes the values and allowed deviations of each of the key criticality safety parameters in each process. Inspection findings are associated with deviations in criticality safety parameters implying likelihood of a criticality accident. Approaches will need to be developed for assessing the likelihood of a criticality accident considering the specific set of values of the parameters, as assessed in the inspection finding. The detailed facility and process NCSEs could be useful in establishing the values of criticality likelihood for a particular scenario in assessing the significance of a finding. .

For an analyst to assess different types of inspection findings in the fuel cycle facilities, a catalog of event tree models can be developed for addressing the expected accident scenarios. This will provide guidance to the analyst, reduce burden for conducting assessments, and above all, will assure consistency in evaluations across the facilities. This will require defining a set of initiating events applicable to these facilities, event tree models for each of the initiating events for considering different processes in these facilities, and consideration of model modifications to include differences in facilities and in an inspection finding. System models for different types of systems used in these facilities may also need to be addressed.

Both the engineering analyses and event tree modeling of events show that human errors play a significant role in different scenarios leading to accident conditions. Fuel cycle facilities rely heavily on manual control during normal operation, as well as manual actuation to respond to faults and potential accident conditions. Human errors of omission and commission represented by a failure to follow procedures or by wrongly implementing a procedure play a large role in the events that have occurred. The type and nature of the human errors experienced in these facilities may be different than that observed in nuclear power plants. Understanding these human errors and assessing the error probability or the credit for these actions will have an

important role in the determination of the significance of an inspection finding. This would involve the development of Human Reliability Analyses (HRA) and HRA worksheets for assessing and estimating human errors and performance shaping factors in fuel cycle facility processes. Some of the human errors for which inspection violations have been cited may appear trivial, such as incorrect posting of notices, but may reflect a safety culture that can lead to more serious errors such as transporting fissile liquids in non-standard and non-approved containers that violate geometry control. A systematic approach needs to be developed that takes into consideration the human role in fuel cycle facilities and provides an assessment of the actions based on the performance shaping factors applicable to a situation.

A systematic compilation of input data needs is required to support both qualitative and quantitative evaluation of inspection findings. Input data relate to equipment failure, human errors related to operation, initiating event frequency, equipment unavailability and common cause failure of similar equipment. Some of this data, such as equipment failure, has been collected to perform the integrated safety analyses (ISA) for these facilities. To conduct significance assessments of inspections in a consistent manner across different facilities, a database can be developed providing generic data for different types of failures that can be used when facility-specific data are not available. This database will also need to address different types of human failures that are expected in these facilities by considering different circumstances that lead to these failures. The database will be a valuable support for the analyst to assign significance to an inspection finding in a consistent manner.

6 CONCLUSIONS

In this paper, we considered a significance determination process for assessing the significance of inspection findings in fuel cycle facilities. The significance of inspection findings is expected to be used to make regulatory actions consistent with the significance of the findings. A two- phased SDP was considered where Phase 1 was used to screen out findings of minimal risk significance and Phase 2 was used to characterize the (risk) significance of the inspection finding. This paper studied the two-phase significance determination process and presented evaluations for the two phases in the SDP for inspection findings that are mainly related to the criticality safety, i.e., those findings that have the potential to increase the likelihood of a criticality accident in a facility. The Phase 1 process is generic, i.e., it does not depend on the facility design and can be used for the facilities under consideration. The Phase 2 process requires more detailed information and can be used to incorporate facility-specific features to obtain fairly accurate estimate of the significance of a finding or event. The use of event tree analyses was considered an appropriate way to conduct the analyses and to present to the inspectors. Event tree analyses can support both qualitative and quantitative evaluations for determining the significance of the findings. Useful lessons and insights were derived and recommendations for further developments were made. The development of FCSDP is in an early stage and this paper explores ideas that can help its advance.

7 ACKNOWLEDGMENTS

The authors would like to acknowledge NRC Project Manager, Felix Gonzalez, for his support and Mr. Dennis Damon, NRC for many useful discussions. We also acknowledge Mr. Rudolph Bernhard, NRC, for his effort in conducting the Expert Group discussions and in development of the Phase 1 Screening Criteria. NRC inspectors' participation in the Expert group discussions, their valuable input in providing details of the inspection findings, and review of the work conducted significantly helped progress in this work and are gratefully acknowledged.

8 REFERENCES

1. P. K. Samanta, V. Mubayi, and R. A. Bari, "Preliminary Analysis of Events and Inspection Reports of Fuel Cycle Facilities to Support Significance Determination Process", Internal Report, Brookhaven National Laboratory, June 2011.
2. NRC, Reporting Loss of Criticality Safety Control, Bulletin 91-01, October 18, 1991.
3. NRC, Reactor Oversight Process, Revision 4, NUREG-1649, December 2006.
4. NRC, Notice of Availability of Revised Fuel Cycle Oversight Process, Request for Public Comment on Revision of the NRC's Fuel Cycle Oversight Program, NRC-2009-0386, Federal Register, Vol. 74, No. 170, September 3, 2009.
5. NRC, Revising the Fuel Cycle Oversight Process, SECY-10-0031, March 19, 2010.
6. NRC, Staff Requirements – Briefing on the Fuel Cycle Oversight Process Revisions, M10049, May 12, 2010.

.