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Criticality Safety Evaluation - An Enduser's Perspective

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CRITICALITY SAFETY EVALUATION – AN ENDUSER'S PERSPECTIVE

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Abstract

This paper presents criticality safety evaluations from an enduser's perspective. Overall issues related to a criticality safety evaluation in an operations support setting are discussed. A work flow process is presented which shows the key steps in conducting an effective criticality evaluation. Finally, a few suggestions are given to assist newcomers to this field.

Introduction

For those performing operations in support of a nuclear facility, the term criticality safety evaluation has a much broader interpretation than just the physics aspect of a criticality safety evaluation. One of the main objectives of an evaluation is to provide a reasonable set of criticality safety controls that will assist the programs in ensuring safe operations with fissionable materials. Since the ultimate goal is to prevent a criticality incident, it is important to recognize the key aspects of a nuclear safety evaluation. The focus of this paper is to investigate the criticality safety evaluation process from an enduser's perspective. An enduser is defined herein as a criticality safety professional that is tasked with the day-to-day support of a nuclear facility. In other words, an enduser is the one governed by the programs schedule and budget allocation to perform evaluations quickly and cheaply, yet at the same time assuring that the double contingency principle is met when deriving a set of simple and easily implementable criticality safety controls.

There are many misconceptions about the process of conducting an effective criticality safety evaluation. For example, there is an extreme view that criticality safety engineers are specialists who spend a major portion of their day hiding behind a computer terminal looking for Monte Carlo solutions. It is believed that they do not have the physics intuition necessary to perform simple hand calculations, or lack of the ability to apply a rule of thumb or utilize reference materials such as handbooks. On the contrary, an experienced enduser will utilize an appropriate analytical tool for the problem at hand, such as ANSI/ANS standards, critical experiment data, handbooks, hand calculations, or computer modeling.

To set the stage for our discussion, we would like to examine the key issues first. Since the line organization operating a facility is responsible for criticality safety in the facility, it is essential that the criticality safety engineer work closely with the operations. It should be recognized that actual implementation of criticality control limits imposed as a result of a criticality safety evaluation is not carried out by a criticality safety specialist but by fissile material operators. Since one of the main objectives of a criticality safety evaluation is to ensure a sound technical basis for safe operation, the criticality safety evaluation process cannot be limited to neutronic considerations alone. It is necessary to take a higher view of the overall work control process and to see how the criticality safety evaluation step fits in such a process to produce an effective criticality safety program to support operations.

Listed below are some of the key issues facing an enduser:

Timely Completion of an Evaluation

- Understanding the scope of a proposed operation
- Defining (limiting) the scope of evaluation

- Proper use of references and analytical methods

Assuring an Adequate Technical/Safety Basis

- Understanding of all operations and interactions (cover all interfaces)
- Application of the double contingency principal
- Understanding of failure scenarios (credible and incredible)
- Understanding of the analytical methods used and their range of application

Providing User-Friendly CS Controls

- CS controls should accommodate the operation's requirements
- CS controls language should be unambiguous (i.e., uniformity and simplicity)
- CS controls should have operator's buy-in
- CS controls should not be an infraction trap

Documentation and QA

- Adequate documentation
- Peer review

Implementation Issues

- "Checks and balances" relationship between operations and CS
- CS controls should be easily implementable
- Accountability should be applied both to operators and CS engineers
- Good communication is essential

From the preceding list, it is easy to see that problems facing a criticality safety engineer are seldom-neutronic issues alone. There is a major gap between what nuclear engineering curriculum offers in many universities and the required skills a CS engineer needs to support day-to-day operations. Table 1 shows a CS evaluation process used at Lawrence Livermore National Laboratory. This process combines many requirements embedded in the issues identified above. Many of the steps shown in Table 1 are self-explanatory. However, we would like to emphasize the following:

Facility-Specific Experience

It is essential for a CS engineer to equip himself with facility-specific knowledge and experience as soon as possible. This learning process takes time. One type of training we have found to be very effective is to assign a new CS engineer to be mentored by a senior CS engineer who also supports the facility. The learning process can also be enhanced if the new CS engineer spends a reasonable amount of time in the facility, visiting the operating workstations and talking with operators. It is noted that the term "new" used herein refers to a CS engineer who does not have facility-specific knowledge.

Clear Documentation of Operation Boundaries

Before starting a CS evaluation, it is necessary for the CS engineer to discuss the proposed operation with the Principal Investigator. The CS engineer needs to visit the workstation to have a clear understanding of the process and the equipment to be used in the operation. It is essential for the CS engineer to discuss credible failure mechanisms and safety features of the proposed process with the Principal Investigator.

Double-Contingency Principle and Contingency Analysis

It is a good practice for the CS engineer to perform a contingency analysis early in the evaluation process, because it will identify potential problem areas and failure scenarios. The contingency analysis, if properly done, also provides an excellent planning tool to scope out the required bounding analyses.

Communication is a Fine Art

To be able to communicate effectively will contribute greatly to building a good working relationship with operations personnel. Better CS controls can be developed if both the CS engineer and operations personnel work together to make sure that the CS controls are clear and implementable; and without infraction traps. Communication is a two-way street and it takes great skill to arrive at reasonable compromises without hostilities.

Neutronic Physics

Although the physics side of a criticality safety evaluation may only be a small portion of the assessment, it is nevertheless an important aspect of the evaluation. The double contingency principle requires that two independent, unlikely, and concurrent changes in process conditions need to occur before a criticality event is possible. A clear documentation of operation boundaries from the operation personnel is a good starting point because it sets the basis of the assessment. It is essential for a criticality safety engineer to understand the bounding scenarios in terms of neutronics such as fissile overmass, upset conditions with moderator/reflector materials, and credible system configurations, etc. The basic assumptions used and the basis for defining the bounding scenarios need to be explained to allow effective peer review. A peer review by other criticality safety professionals independent of but familiar with the facility operations is a necessary step to ensure the technical soundness of the assessment.

Understanding the analytical methods and their range of applications, be it a handbook or a particular cross-section library in a computer modeling, is never an easy task. A sound knowledge of a facility-specific technical basis is not easy to come by either. At LLNL, we use a mentor to guide a new CS engineer in this important area.

Criticality Safety and Conduct of Operations

From an enduser's perspective, it is easy to demonstrate that an effective criticality safety evaluation will not arise from a defective criticality safety program. Similarly, a defective conduct of operations infrastructure will certainly result in defective criticality safety evaluations and in defective implementation of the criticality safety controls. Many of these ills can be attributed to lack of adequate planning, management commitment, and funding mechanism, although the symptoms generally show up years later in the conduct of operations areas. This is particularly relevant when the whole industry is changing from an expert-based criticality safety support framework to a rule-based infrastructure. It should also be pointed out that a holistic approach to resolve any criticality safety issues is urgently needed. For example, any approach of fixing technical issues should include addressing the underlining management issues, such as criticality safety organization reporting level; independence of the criticality safety group; adequate funding mechanism to support core competency areas; and conduct of operations.

A Few Suggestions to CS Engineers

To be an effective CS engineer is not an easy task. It takes more than an excellent neutronic expert to be a great CS engineer. For a newcomer to this field, the following suggestions may be helpful:

- Take time to familiarize yourself with the CS technical bases pertaining to the facility you support. A good knowledge of the facility is a must. Thus, do spend time to visit operations and get to know operators.

- Spend time to familiarize yourself with pertinent regulations. Also, do know technical data in key handbooks and the National Consensus Standards.

- Practice communication and personal skills when inter-relating with people. Be a team player whenever you can, but stand firm on your concerns regarding nuclear criticality safety.

- Try to find a mentor if you can for the above areas. If not, do it yourself. Just maintain an open mind and cherish the learning opportunity to grow professionally.

Conclusion

In today's regulatory and management environment, it is not easy to perform effective criticality safety support -- there are many obstacles. With the retirement of many experienced criticality safety professionals, it is essential that an effective mentoring program be in place to transfer the experience-based knowledge to the next generation of criticality safety engineers. This is easier said than done, because it will take funding rather than regulatory oversight rhetoric or excuses to push it through.

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Figure 1. Evaluation process steps.

Step	What	*Implementation Mechanism*
1	Program gives the Criticality Safety Group (CSG) a "heads up" about what is needed for the next 6 months	1 CSG Technical Seminar 2. Program Plan
2	Assign priority by program	Discussed at Priority meeting held every Thursday
3	For each assignment, Responsible Individual (RI) provides CSE with Section 2 of the Operational Safety Plan (OSP)	Use "Guidelines for Process Description Writing"
4	CSE visits the workstation and discusses possible failure scenarios with RI	
5	CSE performs CS evaluation	
6	CSE discusses the proposed CS control conditions with RI	
7	Documentation through formal memo	
8	CS Independent Review (RIR) per DOE requirement	
9	Issue CS Input for OSP	
10	Attend OSP Review meeting	
11	CSE works with RI and fissile material handlers to support the operations	Frequently drop by RMA to answer questions and receive feedback
12	CSE does walkthrough to ensure criticality control implementation	Quarterly walkthrough