Improvements in the Management of Safety in Research Reactor Operation through Appropriate Application of Selected Power Reactor Good Practices

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Abstract. As good practices are identified they should be incorporated into a facility's safety management system, integrated into all appropriate phases of operation, and improved upon as lessons are learned. A hypothetical research reactor with a basic safety management programme is characterized. The analysis of existing elements and selection of additional elements to enhance the safety management programme are discussed. Six good practices routinely found in the nuclear power industry, scaled appropriately for use by research reactors, are described; Standardized Writers' Guide, Expanded Training, Quality Assurance Oversight, Design Change and Configuration Management, Work Control Process, and Corrective Action Programme. Considerations for the effective implementation of these and similar programme into a research reactor safety management system are discussed.

Introduction

The *Code of Conduct on the Safety of Research Reactors [1]* addresses the management of safety for the entire lifecycle which includes siting, design, commissioning, operation, modification, and decommissioning. This paper considers only the operational portion of that life cycle, operation and modification. Research reactors maintain safety management programmes ranging from the minimum elements to very extensive programmes. A process to enhance a basic programme is described with a discussion of potential elements to be added and prioritizing the additions. Power reactors have developed good practices that can be emulated in research reactor safety management, if they are properly scaled to the operation. Examples of programmes designed to transfer good practices of the power industry into research reactor safety management are presented.

Traditional Elements of Safety Management in Operations

The International Nuclear Safety Advisory Group sets forth the following definitions:

The safety management system comprises those arrangements made by the organization for the management of safety in order to promote a strong safety culture and achieve good safety performance. [2]

Safety Culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance. [3]

Safety in an operation can be viewed in the past, present, and future. Performance records reveal the past. Observing the conduct of operations and the attitudes and behaviours of individuals reveals the present. Safety management for the future is embodied in the documented management policies along with reference information describing the facility, along with the attitudes and behaviours of individuals who implement those policies. The previous sentence is therefore the focus of the paper.

Traditionally each research reactor has a minimum set of elements defining its safety management system. A **policy manual** states what must be accomplished, gives broad guidance in how it is to be done, and defines responsibilities and authorities in executing the task. A **safety analysis report** is maintained describing the facility and its performance during routine and accident conditions, providing a basis for **operational limits and conditions**. **Operating and emergency procedures** give detailed instructions for conducting normal operations in compliance with operational limits and conditions and responding to emergency conditions. A **surveillance and preventative maintenance programme** gives assurance that the facility will respond as designed and provides early indication of failure or improper performance. A **radiation protection programme** is designed to minimize exposure to workers, the public and the environment. Finally, a **training programme** is established to train reactor operators in the appropriate parts of each of the above documents or programmes.

One might consider the previous paragraph to be the minimum elements for an effective safety management system. Many facilities are to be commended for being well beyond this point. The remainder of this paper is written for those facilities seeking to improve their safety management system, identifying the areas where investing resources will have the greatest improvement in overall safety.

Assessing where Enhancements are Needed in Safety Management

If the management of the hypothetical research reactor facility described in the previous section is experiencing difficulties and has committed resources to enhance its safety management, it is important to properly characterize existing strengths and weaknesses so as to direct the resources to the most pressing needs. The following case studies demonstrate the link between observations and weaknesses in safety management, including examples where one must look beyond the apparent problem to identify the root cause requiring attention.

Observation #1: Frequent failure to perform required instrument checks.

Apparent Problem: Operator error.

Actual Problem: Procedures do not include all requirements to perform the checks.

Observation #2: Supervisors often accept hourly log data that is out of specification.

Apparent Problem: Inattention to detail.

Actual Problem: The acceptable range for data is not printed on the log sheet.

Analysis: The initial assessment is poor human performance on the part of the operator in Observation #1 or the supervisor in Observation #2. In reality, they were set up for failure by procedures that do not state the requirements. The root cause, however, may be the lack of consistency in writing procedures; namely, failure to list required instrument checks and acceptance criteria for critical readings in procedures and log sheets.

Observation #3: Routine scrams resulting from ruptured valve diaphragms.

Apparent Problem: Poor diaphragm material on the market.

Actual Problem: Valve was being over-torqued during re-assembly.

Analysis: Observation #3 differs from #1 and #2 in that it involves skill-of-the-trade by a repairman rather than operations. It could have been avoided if the maintenance procedure used by the repairman had stated the recommended torque. The focus for our hypothetical facility, however, appears to be on sufficient training for reactor operator certification with no provisions for training maintenance personnel or providing maintenance procedures. The facility may have rationalized the lack of maintenance training and procedures based on its low risk, considering the scrams to be an inconvenience but not a safety issue.

Observation #4: An “S” hook supporting a personnel carrier from a crane hook failed.

Apparent Problem: Load was too heavy for the “S” hook.

Actual Problem: No one with rigging expertise had evaluated equipment and practices.

Analysis: While our hypothetical facility was considered a low risk facility from a nuclear safety standpoint, significant personnel injury could result in the non-nuclear incident described.

Observation #5: Labs cleaned by Custodian X are frequently found contaminated.

Apparent Problem: Custodian X cleans up after messy, careless lab workers.

Actual Problem: Custodian X has not developed a strong safety culture.

Analysis: Upon investigation the full picture came to light. Custodians Y and Z do the same work as X except that the labs they clean are rarely found contaminated. When observing work habits and attitudes, significant differences were identified. Custodian X considered his job to be putting in time, emptying waste containers and mopping up floors behind experimenters. Meanwhile, Custodians Y and Z take pride in the low survey results in labs they clean. They ask experimenters about likely sources of contamination and have learned when and how to double bag trash. They routinely ask health physics technicians where readings are highest and correlate that information with their work practices to further reduce contamination levels. Custodians Y and Z exhibit the behavioural traits of a strong safety culture whereas X demonstrates the other extreme; note the sense of ownership of Y and Z, their effective communication with those around them, their positive questioning attitude, and their effective use of feedback.

In assessing where enhancements to safety management are most needed, evaluating actual situations in a facility is an obvious place to start. However, it is best to anticipate the need for improved safety management before a problem exits. This can be done by evaluating problems experienced by others and asking the questions, “Could this happen at my facility? Do I have an accident waiting to happen?” Another technique is to postulate scenarios like those above and again asking how your facility would respond. As suggested in the analysis of the above scenarios, careful analysis and sound insight are required to address the root cause and not focus attention on symptoms.

The nature of the nuclear power industry has forced it to address safety management issues more aggressively than research reactors, resulting in a wealth of readily available information and experience. The reasons include power reactors being significantly larger and more complex; they pose a greater hazard if miss-managed; there is an economic driving force for good operating practices; and they require integration of a much larger staff. However, power reactor programmes must be adapted judiciously and appropriately scaled for use in research reactors as discussed in a subsequent section of this paper. Research reactors tend to be staffed and managed by technical people who may over-emphasize the technical aspects and under-emphasize the behavioural aspects of safety management. Power reactors addressed this same issue years ago, resulting in an emphasis on behavioural aspects of safety management.

Programmes to Consider for Improved Safety Management in Operations

A previous section of this paper described a hypothetical research reactor facility with what was termed traditional elements of safety management in operations. They included:

- Policy Manual
- Safety Analysis Report
- Operational Limits and Conditions
- Operating and Emergency Procedures
- Surveillance and Preventative Maintenance Programme
- Radiation Protection Programme
- Training Programme

Assuming that the above elements already exist, additional elements will be discussed below that are common to facilities where more complex safety management systems are in place. Before assuming that status quo is sufficient for the above elements, however, they should be reviewed in the context of the entire safety management system and upgraded where appropriate. A likely finding will be that human performance is not addressed appropriately. While human behaviours demonstrating a strong safety culture may be discussed on their own, they are most effectively discussed in the context of how they are integrated into each task being performed.

Standardized Writers' Guide - Just as an operating procedure is written after careful study and analysis, and then followed precisely rather than re-developing a new procedure with each subsequent operation, so every best practice should be captured for re-use whenever it proves beneficial. A writers' guide may address major policies (e.g., how sensitive information should be documented), consistent formatting (e.g., requirement for a table of contents), or seemingly trivial details (e.g., page number system). The writers' guide is the result of thoroughly considering such aspects as the desired result, what information to convey, how information is best communicated, how documents interface to provide complete coverage without any gaps, the ability of the reader to comprehend the subject matter, ease of updating a document, and the most effective format. It may include a checklist for procedure preparation calling for the author to assure that each required instrument check is a procedural step, that each instrument reading to be logged is accompanied with the acceptable range, etc. The writers' guide can also be helpful in informing authors when and where to address human behaviours. For example, it may address the need for a document to discuss communication, feedback of information, ownership of a process, or a questioning attitude. The result will be not only that any two individuals will develop consistent and compatible documents but that any single individual will develop consistent and compatible documents year after year. The objective is that good practices are reinforced; poor practices are eliminated.

Expanded Training - Knowledgeable and skilful workers are critical to a strong safety culture; training should therefore have a prominent priority. Top performing organizations practice succession planning wherein new workers are identified, trained, and attain relevant experience before being promoted. At the same time, the entire workforce is given continuing training and cross training to be more effective employees. Skills-of-the-trade are emphasized in on-the-job-training and classroom training and are systematically refreshed in pre-job briefings which provide feedback, assessment, and opportunity for questions. Human factors and human behaviours are considered in training. Managers and supervisors are continuously mindful of activities where training is needed, as in the above case study of the rigging failure. A Systematic Approach to Training (SAT) has been adapted for research reactors for the preparation, implementation, and evaluation of training programmes. [4, 5] Reactor operations and radiation protection are common subjects for training. Increased knowledge of radiation protection has resulted in substantial reductions in personnel exposure, minimization of radioactive waste, and a reduced number of radiation areas and contaminated areas in nuclear facilities.

Quality Assurance Oversight - While most nuclear facilities embrace some level of quality assurance, the level differs significantly. Where staff size allows, a person may be designated as the quality assurance representative responsible as a minimum to approve safety related replacement parts and design changes. Safety-related work may have hold points requiring quality assurance approval before work proceeds. In larger organizations a quality assurance team may function as internal auditors, performing reviews in the same manner as regulatory inspectors. A significant volume of information on this topic is readily available.

Design Change and Configuration Management - As facilities age and replacement parts are no longer available, and new technologies emerge that allow improved replacements, reactor facilities are changing. With each change one must review the safety analysis and design basis to assure that facility changes do not adversely affect them. With each change identified in the safety analysis report, that document is either updated or the change is recorded in some cumulative file of deviations. Where the safety analysis is changed it must be re-done and in some States the regulatory body must review the change. Meanwhile, at the reactor all changes must be integrated into the appropriate facility documents; procedures, surveillance instructions, maintenance procedures and records, training materials, facility drawings, etc.

Work Control Process - Just as written procedures are important for consistent high quality performance of repetitive tasks, a systematic form of work control is necessary for the same results when performing one-of-a-kind work activities. While a design change process focuses on the engineering, analysis, and documentation of a change, a work control process goes into effect when actually implementing the change. The process must be flexible enough to control everything from a minor change to a major facility change. For a major task, the work control package identifies the major sub-tasks and responsible individuals or groups. All activities are identified before work commences, allowing an overall review of the project and information to all facility workers of work in progress. The project manager identifies supervisors involved and communicates expectations, schedules, and interfacing activities. The management team prepares work requests, radiation work permits, special procedures, equipment tag-out lists, and post-maintenance testing. The work control process identifies items to consider during the evolution such as plan-of-the-day meetings, pre-job briefings, hold points, foreign material exclusion, chemical hazards, and security.

Corrective Action Programme - One of the common untapped resources in any operation is the worker's input. If workers feel their input is important they are vigilant in identifying deficiencies, resourceful in suggesting improvements, and empowered by contributing to the safety culture. If workers feel their input is unimportant and they only respond to management directives, their resourcefulness is wasted and their sense of ownership is lost. A corrective action programme is a form of continuous improvement designed to identify issues promptly, correct deficiencies, assign priorities based on the safety significance of an issue, determine root causes, and track issues to completion. Major components of an effective corrective action programme are worker input, trend analysis, and feedback to the worker.

Considerations in Importing Lessons Learned

This paper has attributed the innovative programmes discussed in the previous section to the nuclear power industry. That is certainly where they have generated the greatest attention and seen the broadest implementation. The intent of this paper is to identify readily accessible examples of effective implementation that may be used as a resource in replicating a specific programme. Power reactor management is generally willing to share such intellectual property with research reactors. Another resource is the IAEA Safety Standard Series, particularly those publications dealing with power reactors.

Caution must be exercised when importing power reactor resources into research reactor operations. Since the size of the operating organizations generally differ by at least an order of magnitude, the programme must be scaled down appropriately to make it manageable, efficient and effective.

Many of the programmes discussed have been implemented at research reactors where one may in fact, find their roots. If a research reactor facility should find the programme they desire already implemented at another research reactor, that would be a better place to begin since it will already have been scaled.

One final word of advice is to only take on what can be handled effectively. If an assessment of one's safety management identifies three programmes that are desired, rank them as to which should be started first, second, and third; make sure resources are sufficient for the first one before starting the others.

Summary

Good practices generally associated with the nuclear power industry have been reduced to procedures in elements of safety management entitled:

- Standardized Writers' Guide
- Expanded Training
- Quality Assurance Oversight
- Design Change and Configuration Management
- Work Control Process
- Corrective Action Programme

This list is only a sample, not intended to be a comprehensive compilation. An organization that is committed to enhancing its safety management programme should first assess its needs and then determine which of these elements (or others not listed) will provide the greatest enhancement of existing programmes. Since scaling a programme from a power reactor organization to a research reactor organization is difficult, a simpler approach is to utilize a programme already scaled to a research reactor if one exists.

REFERENCES

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[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Power Plant Personnel Training and its Evaluation – A Guidebook, Technical Report series No. 380, Vienna (1996).