PROCEDURE OVERHAUL AT THE NIST CENTER FOR NEUTRON RESEARCH

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The National Institute of Standards and Technology (NIST) Center for Neutron Research operates a 20 MW research reactor whose primary purpose is to produce cold neutrons for material sciences experiments. On February 3rd, 2021, a fuel element was unlatched, causing an accident that resulted in a multi-year cease in operations of the reactor. One of the root causes of the fuel element latching issue was inadequacies in procedure clarity and compliance, exacerbated by the loss of experienced personnel who shored up deficiencies in the procedure with their internal knowledge of the system. In this particular accident, the refueling procedures were rife with subjective instructions that could not ensure proper performance for newly trained individuals. The NCNR needed an overhaul to bring all procedures, not just those relating to refueling, to an acceptable level. To address this issue, the organization undertook a comprehensive review of its procedures and document management system. Gaps and redundancies were identified, and all Reactor Operations and Engineering (ROE) staff were consulted for feedback and suggestions for procedures. Existing standards both from within and outside of the nuclear industry were used to create a standard at the organization for procedure writing, review, adherence, and auditing. Further, the implementation of a document management system was used to keep records and ensure up-to-date instructions were in use for all NCNR staff. This presentation will describe the actions taken by the corrective action team to overhaul the procedures at the organization, to improve procedural and regulatory compliance, operational efficiency, and continuous improvement. Moreover, this effort demonstrated the organization's commitment to quality, safety, and reliability.

1. Introduction

The National Institute of Standards and Technology (NIST) Center for Neutron Research (NCNR) is a national resource for industry, universities, and government agencies. NCNR operates a 20 MW research reactor, namely the National Bureau of Standards Reactor (NBSR) that provides neutrons for material sciences experiments. On February 3rd, 2021, a fuel element was not properly latched during a routine refueling evolution. Since the fuel element was not properly latched, it did not receive adequate cooling, which caused the fuel element to fail, exceeding the safety limit for the fuel cladding temperature during the initial startup of 20 MW. This resulted in a lengthy shutdown during which the NCNR investigated the root causes of the incident and took and planned corrective steps to prohibit such events to happen again.

One of the root causes was inadequacies in procedure clarity and compliance, exacerbated by the loss of experienced personnel who shored up deficiencies in the procedure with their internal knowledge of the system. In this particular incident, the refueling procedures lacked detail during critical steps in the procedure and contained incomplete or sometimes even misleading information. In the weeks following the February 3rd incident, similar problems were noted in various other NCNR procedures. This made clear to the organization that all procedures in use at the facility needed an overhaul where gaps and errors were identified and addressed to fix these deficiencies.

2. Methodology

The first step in finding a solution is to clearly describe the problem. After the immediate steps of ensuring that the personnel, site, and surrounding area were safe, the organization visually investigated the core and determined that one of the fuel elements had become unlatched. The organization investigated the cause by conducting interviews with staff members, reviewing video surveillance, and reviewing documentation, most notably the procedures which the operators follow to perform plant evolutions. Interviews were held with 17 individuals over 8 weeks, with key operators interviewed by the Chief of Reactor Operations (CRO) and Reactor Operations Training Coordinator. From these interviews, it was determined that there were misunderstandings stemming from inadequate procedures.

2.1. Root Cause Analysis

Further investigation of the organization's procedures revealed there was no real standard to which the procedure authors were expected to conform to. This meant that authors had no guidance to follow in writing their procedures, and as such each procedure had wildly different writing styles, particularly levels of verbosity and usability, in their text. Tools and equipment were not contained within the procedure meaning these items may be gathered ad hoc during an evolution. This even extended to critical procedures such as the fuel latching procedure, which was the direct contributor to the February 3rd incident. The only critical procedure that was adequate was the Reactor Startup procedure, which was reviewed by the U.S. Nuclear Regulatory Commission (NRC) annually.

Procedures have been in use at the facility since 1968, and there is a steady decrease in the amount of verbosity of procedures from then to 2021. This decrease in verbosity was shored up, but also likely contributed to, by personnel experience. While a 20-year veteran operator had the experience to operate the plant, this kind of experience is becoming harder and harder to find and maintain within the organization. As of 2021, the average years of experience for an operator was down to 5 to 7 years, with 8 new operators coming in to be licensed in 2020 alone. To further shore up staffing deficiencies, several Reactor Engineers were licensed to reach the minimum number of staff to operate the plant.

2.2. Standards

The only standards that were being followed for procedures were contained in less than one page on the plant's technical specifications, which was only marginally expanded on in the organization's Administrative Rule (AR) 5.0 procedure. This procedure only defined that procedures will be used for critical plant evolutions, such as the startup of the reactor, fuel loading, and emergency plan implementation. This procedure however does not include any standards for writing procedures and instead stipulates that they must be reviewed and approved prior to their use.

3. Metholodogy of Procedure Overhall

The outcome of this overhaul meant the organization staff has had to rewrite all procedures in use at the organization, starting with ones critical for the startup of the reactor. As of April 21st, 2023, the organization has rewritten 459 procedures, the results of much higher quality than the previous iterations. The organization has hired many new operators undergoing training, and they have been using the rewritten procedures to great success.

3.1. Procedure and Regulatory Compliance

Procedures used at the organization have been written to comply with standards put forth by the Institute of Nuclear Power Operations (INPO), particularly INPO 11-003, Guideline for Excellence in Procedure and Work Instruction Use and Adherence, and PPA AP 907-005, the Procedure Writer's Manual. The organization incorporated these standards into its internal " Procedure Use and Adherence" procedure, which has been expanded from the single AR 5.0 document into 6 documents, listed in Table 1 Procedure Guidance Documents in the Organization The organization has been using these standards for writing and following procedures since November 2021.

Table 1 Procedure Guidance Documents in the Organization

AR 5.0	Procedure Use and Adherence
AR 5.1	Procedure Writer's Guide
AR 5.2	Document Routing Policy
AR 5.3	Creating and Routing a Procedure in the Electronic Document Management System (EDMS) for Review and Approval
AR 5.4	Observation Program and Checklist
AR 1.1	Human Performance Tools

3.2. Operational Efficiency

3.2.1. Procedure Structure

As a result of the procedure overhaul, all procedures now have a standard to which they can be written. Along with general writing guidelines, procedure structure has been defined to reduce cognitive load when reading procedures and ensure all necessary information is contained in a procedure. These sections include the procedure's purpose, any nonstandard definitions, and personnel and equipment requirements. Another section that was added is the procedure's Limitations and Precautions, where important safety information as well as any hazard reviews can be listed. This ensures the procedure is maintained from a safety perspective, while also actively stimulating the questioning attitude which is paramount to the organization's response to February 3rd.

3.2.2. Roles and Responsibilities

Before the procedure overhaul, the expectation was that a procedure only reflected on the author, putting an exceptional load on personnel. The responsibilities of each procedure are now shared amongst all authors, reviewers, and approvers.

The author can be anyone who wishes to draft a procedure, though they are normally operations personnel. Reviewers now are defined by their role within the organization, and each one performs key checks to ensure safe operation. Each procedure needs an operator

who checks for technical specifications or operating needs and an engineer who checks system parameters evaluated in the Updated Final Safety Analysis Report (UFSAR). As needed, Instrumentation and Controls (I&C) technicians and Health Physicist (HP) and their technicians can be assigned reviews for procedures as well. I&C technicians will ensure proper instrumentation and signal analysis, while HP personnel will evaluate for any radiological concerns that may stem from the procedure.

For safety-related equipment or systems, procedures undergo a further elevated review process, where team leads review the procedure. After the team leads, the chairperson of the organization's Safety Evaluation Committee (SEC), an oversight committee established to ensure safe operation of the reactor, reviews on behalf of the SEC.

Finally, one or more of the team leads previously listed is tasked with approving a procedure. These approvers are assigned based on which organization the procedure belongs to. For instance, operating instructions will be approved by the team lead for Reactor Operations, while Calibration Procedures are approved by the team lead of Aging Reactor Management. If the procedure had to undergo the elevated review process, the group lead is assigned approval of procedures after the team leads finish their review.

3.2.3. Questioning Assumptions

One aspect that was made clear during this procedure overhaul effort was how one would write procedures for themselves is very different from how one would write for others. While the former had been the root of the procedure inadequacies at the organization, the latter would prove a difficult change not just in procedure writing, but also in the culture of the organization. To effectively tackle this problem, training on procedure drafting and a questioning attitude had to be adopted at the organization, beginning with questioning one's assumptions when writing.

A consequential outcome of this lack of questioning our assumptions came from the fuel-latching procedure. Tribal knowledge was not captured in these procedures, and experienced personnel who left the organization no longer could provide this knowledge during evolutions. It became clear that the organization needed a common repository to capture the institutional knowledge held within its personnel. An Electronic Document Management System (EDMS) was selected and designed to contain the organization's procedures, also implementing custom scripts to route the document to the personnel selected for review.

3.3. Continuous Improvement

The organization is committed to constantly improving the work done, which of course extends to this procedure overhaul. This effort has resulted in multiple conflicting viewpoints meeting each other head-on.

3.3.1. Conflict Resolution

One of the key determinations when writing a procedure is what exactly is written down. There is not simply a switch between more and less verbose; rather there is a sliding scale that can easily become untenable on the former end, and unhelpful on the latter. Many expect training to shore up the difficulties that the procedures introduce. The key to solving these conflicts is free discussion and clearly defining who the target audience is for the procedure.

Questioning our assumptions becomes more important as time goes on and is instrumental in maintaining procedure usability in the long term.

3.3.2. Procedure Audits

To prevent a return to the procedural posture that was found after February 3rd, 2021, the organization has implemented two new programs to ensure procedures are continuously improved. The observation program has an uninvolved member of personnel to observe the plant evolution from start to finish, finding deficiencies in the procedures to then update at a later date. For any issues that arise from the observation or execution of the evolution, a corrective action program has been developed to document the problem, its following root cause analysis, and corrective actions. This corrective action program does also include procedural updates as prescriptions from their root cause investigations as needed.

4. Discussion

The organization has laid the foundation to continuously improve its operations. Throughout the life of the facility, assumptions will be questioned at all levels of staff to ensure that institutional knowledge stays with the institution, whether through written procedures or training programs. This paper lays out the standards by which procedures are now written within the NCNR and explains the importance of staying conscious of those standards. With this, we allow operators to excel at their jobs and fully understand the system they are working with daily.

5. Acknowledgments

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6. References

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[2] INPO, “INPO 11-003: Guideline for Excellence in Procedure and Work Instruction Use and Adherence”