Curation of Educational Content on Safety Culture for Use with University Training Reactor

Mary Keen[a], Amber Johnson[b], and Michelle Bensi[c]
[a] University of Maryland, College Park, United States, mkeen331@umd.edu
[b] University of Maryland, College Park, United States, ajohns37@umd.edu
[c] University of Maryland, College Park, United States, mbensi@umd.edu

Abstract: The Maryland University Training Reactor (MUTR) has a strong safety culture; however, it lacks formal safety education documentation, and many publicly accessible safety supplements lack direct examples from research and training reactor operations. This study aims to use insights from the safety analyses and operating experience at the MUTR, coupled with broader industry experience, to develop and curate educational content tailored to reactor-specific operations, safety risks, and technical specifications.

This study reviews historical safety violations, reportable occurrences, and safety analysis results to identify the most safety-relevant scenarios and link them to NRC safety culture standards and MUTR training goals. By leveraging potential safety-relevant scenarios associated with the MUTR reactor, we can create safety-culture education modules for our reactor operators. Our method for creating instructional resources is to produce scenario-based modules with supplemental materials that are both relevant and unique to the MUTR. This content can serve as a framework for other reactors and be adapted to serve the same purpose across other reactor types based on their own safety analysis results, ensuring a skilled, diverse, and prepared pool of nuclear power workers for the future. We plan to leverage these modules as part of the requalification and education of Nuclear Reactor Operator candidates. These efforts will foster a positive, connected learning environment that enhances safety culture at our reactor.

1. INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) defines nuclear safety as “the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment.” To ensure clear understanding and communication, the NRC uses nine traits, such as personal accountability and a respectful work environment, to describe an effective safety culture [4]. One of the NRC’s nine traits is continuous learning, which is defined as “opportunities to learn about ways to ensure safety are sought out and implemented.”

The Maryland University Training Reactor (MUTR) was constructed in 1960 and upgraded to a TRIGA (Training Research Isotopes General Atomics) core in 1974. It is a water-cooled, pool-type nuclear reactor that uses uranium/zirconium hydride fuel. The MUTR is licensed by the NRC to operate at thermal powers up to 250 kW and is used to support the University of Maryland's educational goals and to provide neutrons and other radiation for research applications [7].

The MUTR has a strong safety culture that prioritizes the NRC's nine traits. This safety culture training leverages publicly available NRC documents and case studies. However, these existing materials lack direct examples from research reactor operations.

This study is conducted under the SUSTAIN (Supporting Strategic Training of Adaptable and Integrated Nuclear Workforce) project, which executes strategic research to develop a plan to ensure a skilled, diverse workforce for nuclear power generation in the United States [3]. The final task of the project is to create educational content to support workforce development.

As part of that broader educational content development effort, this study aims to use insights from annual reports and operating experience at the MUTR, coupled with broader industry experience, to develop and curate educational content designed for research reactor-specific operations, safety risks, and technical specifications, and to make it publicly accessible. Specifically, this study reviewed historical safety violations, reportable occurrences, operating experience, and annual report results to identify the most safety-relevant scenarios and to link them to NRC safety culture standards and MUTR training goals, with a focus on creating content that is both relevant and educational.

2. METHODOLOGY

The first step in developing educational content was to review annual reports and conduct interviews with operators to identify safety-relevant occurrences, as described in Section 2.1. The overall methodology for creating content involved producing scenario-based modules with supplemental materials to support comprehension and enhance retention [5], as described in Section 2.3.

2.1 Identification of Safety-Relevant Occurrences

To identify potential safety-relevant occurrences at the MUTR reactor, this study reviewed past annual reports and conducted interviews with current reactor operators. For example, conversations with operators revealed an instance of confinement bypass when the exhaust fans were momentarily activated after the reactor key was inserted. When confinement bypasses occur, this is considered a reportable incident because Technical Specifications require that confinement be maintained if the key is inserted and the reactor can operate. When the fans are turned on, there is no longer control over the air movement into and out of the facility.

In investigations of the annual reports, it was also identified that multiple unscheduled shutdowns occurred due to an undercount in the bridge or exhaust radiation area monitors (RAMs) [1]. Undercounts over a specific period occasionally occur due to the stochastic nature of radioactive decay, but can also result from a detector failure or from machinery that requires an upgrade. In response to this occurrence, the MUTR investigated and identified that machine error was the primary cause and upgraded to correct the undercounts.

These scenarios offer an important insight into reactor facility safety: that both human and machine errors can introduce uncertainty into day-to-day operations, and that it is important to understand how to approach both known and unknown scenarios. To highlight these insights, training materials developed under this project include modules that describe these scenarios and questions about safety culture traits, the scenarios themselves, and ways to mitigate risk.

2.2 Creation of educational modules

The educational content developed under this effort focuses on modules that address the safety-relevant occurrences identified above, as well as general safety-culture best practices. Modules include educational videos and instructor support materials, in which instructors facilitate engagement with operators through open-ended conversations that invite questions. The open-ended questions allow students to develop their own responses or solutions to problems, without fear of answering incorrectly or scoring poorly. Responses to open-ended questions also provide broader insights into how operators think and respond to problems, while highlighting their strengths and weaknesses. The learning modules include a guide for a group discussion, which enhances comprehension and reinforces the material [7].

These discussions will be led by Director Johnson, who facilitates the requalification training meetings for current reactor operators [8].

3. MODULE DEVELOPMENT

These modules were developed based on the findings in Section 2. Each scenario is introduced in a video that includes a description and corresponding stop-and-answer-style questions. An overview of each video, the exhaust louver scenario in Section 3.1, and the machine error scenario in Section 3.2, is provided.

3.1 Scenario 1

The first scenario introduces a Technical Specification violation in which an operator performs the start-up checklist and unintentionally opens the exhaust fan during the second exhaust RAM check. The trainees are asked to explain how this process violates confinement and to identify the most at-risk traits during a repetitive task. It is then explained that repetitive tasks increase the likelihood of errors, articulating the relevance and importance of this training. The final question asks trainees to think critically about how to mitigate errors in repetitive tasks like this. This is to familiarize operators with human error and the possible safety-significant scenarios that arise from it.

3.2 Scenario 2

Scenario two is based on an unscheduled shutdown from a machine error in the MUTR bridge RAM, which causes an undercount. In this scenario, the operator has identified an undercount in the bridge RAM as the trigger that caused the external scram indicator light to illuminate. The trainees are then asked to identify the possible cause of the undercount from the RAM and to identify the most critical safety trait when faced with a possible machine error. The video explains that undercounts in RAM can result from both random noise and machine error. The final question asks trainees to consider ways to distinguish human error from machine error, ensuring that operators consider the health and functionality of their systems.

4. MODULE IMPLEMENTATION

The first step in implementing these learning modules in the MUTR requalification training is to conduct a pilot program and develop a plan. Section 4.1 describes the implementation method and how the modules' effectiveness will be reviewed.

4.1 Implementation Plan

After Director Johnson approves the learning modules, a date for their presentation will be selected. At the agreed-upon requalification meeting, the videos will be piloted for the reactor operators. To ensure these training videos are effective learning tools, feedback from both trainees and instructors will be requested, along with responses to the module document. This feedback will be reviewed by Director Johnson and other members of the radiation facilities, if necessary. After final review and discussion, the videos will be modified and polished. If no changes are needed, they will be officially added to the requalification training program.

4.2 Conclusion

Section 3.9 of the International Atomic Energy Agency (IAEA) Guidelines for the Review of Research Reactor Safety provides the objective and basis for evaluating safety culture within organizations. These modules will be implemented to address the documentation gap by combining individual assessments of the safety culture at the MUTR with a reflection paper that will provide the operator's answers to the supplemental questions. Both strategies will provide official documentation and address the IAEA's guidelines to ensure that "the subjects of safety and safety culture are part of regular meetings" and that "safety culture improvement actions are identified" [6].

This content introduces trainees to the complexities of safety-significant scenarios and encourages them to take a critical approach to risks that span human and machine errors. These modules remind operators of the importance of continuous learning and a questioning attitude, while pushing them away from complacency. Administrators in the reactor will have recorded evidence of efforts to cultivate safety-culture traits that meet the NRC's initiatives while also strengthening the current and future nuclear workforce.

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