Nuclear Quality Assurance for Universities

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INTRODUCTION

Quality assurance is an important programmatic requirement for all commercial nuclear engineering projects in the United States and internationally. In the United States, commercial nuclear power plants are required to maintain quality standards and records by the Code of Federal Regulations in Title 10, Part 50, Appendix A (10 CFR 50 Appendix A or "General Design Criteria"), with more detailed requirements found in Appendix B. The U.S. Nuclear Regulatory Commission (U.S. NRC) is responsible for maintaining and upholding these regulations. To provide more instruction and direction for these regulations, the NRC has issued guidance that endorses Part I and Part II of ASME NQA-1-2008 and the NQA-1a-2009 Addenda, "Quality Assurance Requirements for Nuclear Facility Applications," with minor additions and modifications [1]. NQA-1 (Nuclear Quality Assurance-1) is a quality assurance standard maintained by ASME (the American Society of Mechanical Engineers) and thus is used widely throughout the United States and for guidance internationally.

At Berkeley, we have implemented a quality assurance program following NQA-1 guidance (specifically NQA-1-2008 with the NQA-1a-2009 Addenda) to significantly improve the quality of work in our experiments and laboratory work, as well as to educate and train students in quality assurance for nuclear engineering projects. However, over time we have seen significant challenges with implementing a quality assurance program in our lab that have led to the degradation of our quality assurance practices. We recognize that many of these challenges are inherent in university laboratory environments and may be faced by other research programs and laboratories trying to implement good quality assurance practices that align with the goals of NQA-1 [2]. Given the benefits of good quality assurance practices and the reality of quality assurance requirements in commercial nuclear power plants in the United States and abroad, we are working to design a quality assurance program that addresses the fundamental challenges of experimental research in the university setting while achieving the high standards of industrial nuclear quality assurance standards, namely ASME NQA-1.

The purpose of this work is to produce a quality assurance plan and all necessary documents for implementation that satisfy the applicable requirements of Part I and Part II of ASME NQA-1-2008 and the NQA-1a-2009 Addenda, and thus satisfies U.S. NRC quality assurance regulations. Further, a primary goal for this quality assurance program and implementation documentation is to be reproducible by a general set of university nuclear engineering laboratories. This work has the potential to then help extend good quality assurance practices to more fundamental and applied nuclear engineering research at university laboratories in the U.S. and aid in educating and training students that work in these laboratories. Quality assurance education and training will better prepare students to go on to work in the commercial nuclear power industry in the U.S. and elsewhere, potentially improving work there as well.

CURRENT QUALITY ASSURANCE PROGRAM

Our lab, the Nuclear Engineering Thermal Hydraulics Laboratory at the University of California, Berkeley, uses the current quality assurance program specifically for the Compact Integral Effects Test (CIET) Research Program. The CIET Facility is a large integral effects test facility designed and built to study the integral steady-state and transient performance of fluoride-salt-cooled, high-temperature reactors (FHRs), particularly the effectiveness of natural circulation for emergency decay heat removal [3]. The CIET Research Program was initially funded in the beginning of 2012 and began experimental testing at the end of 2014. The current quality assurance program was used throughout the design, construction, and initial testing of the facility, and testing procedures are currently used for all experiments that produce data for later use. The quality assurance program was a requirement of the initial funding from the U.S. Department of Energy (DOE) and thus was rigorously designed and implemented to meet applicable NQA-1 requirements, as verified by annual audits from an NQA-1 specialist. However, in the years following the initial testing of the facility, the initial funding has expired, students and research staff have changed, and the quality assurance program has not been adequately maintained due to these and other challenges, many of which are inherent to the university research environment.

The current quality assurance program establishes requirements for the portions of the design, construction, maintenance, and operations of the CIET Facility that affect the integrity of the research. Applicable requirements from Part I and Part II of NQA-1-2008 with the NQA-1a-2009 addenda are invoked using a graded approach tailored for research. Additionally, requirements from 10 CFR 50 Appendix B are specifically considered for work that has the potential for future licensing decisions and specific attention was given to DOE and DOE Nuclear Engineering University Program (NEUP) quality assurance guidance documents. The

quality assurance program is specific in defining roles and responsibilities for the research staff and students, with a total of fourteen roles including the principal investigator. The quality assurance program includes twenty-five quality assurance specific documents, and in total 3,349 documents and records have been produced since the CIET Research Program began in 2012.

Challenges

There have been three primary challenges in using the current quality assurance program. Strictly defined roles and their responsibilities can be combined in the duties of specific research staff and students in the current quality assurance program. In practice, however, managing the assignment of numerous roles and responsibilities to changing research program personnel proved challenging, particularly as project leadership and management roles are fluid and change hands often. This speaks to an inherent challenge at universities in managing research programs with long lifetimes that include multiple generations of graduate and undergraduate students, especially regarding the day-to-day leadership and management by the students. Research programs like this must have strong institutional knowledge maintenance and transfer. This is challenging as the goals of university research programs are often aligned with more limited projects (i.e. single to a few students per project) and shorter project durations dictated by grant funding and student tenures.

A second challenge in using the current quality assurance program is the lack of transparency, intuitive organization, and ultimately usability. With a significant number of documents and records that are relevant to many personnel's work, effective organization that allows for efficient work is important. We have included the count of quality assurance specific documents and the total number of documents and records above not to make the argument that this is too much, too few, or somewhere in-between, but to emphasize the need for simplicity and clear organization for any single program user to navigate and use the quality assurance program effectively, efficiently, and in a satisfactory manner. This is particularly important for university students and research staff who have primary goals tangential to quality assurance and who don't necessarily want to or need to spend the effort to become expert users of the quality assurance program itself. Further, in our lab (and probably many others) there is no formal requirement for a formal quality assurance program, and certainly not one with the rigor of NQA-1, so there is no direct motivation to implement rigorous quality assurance practices.

Training and indoctrination is a third challenge that is closely related to the challenges above. Training and indoctrination in the quality assurance program is especially important because of the importance of training and education for students, but this training has been particularly challenging to implement well due to changing leadership and lack of a regular, rigorous training program. Quality assurance in general is directly dependent on the commitment of the personnel, which requires rigorous and regular training and that the personnel receive a high degree of satisfaction from implementing the quality assurance program.

NEW QUALITY ASSURANCE PROGRAM

To address these challenges and to continue providing the benefits of good quality assurance practices, a new quality assurance program is under development for the CIET Research Program. We're organizing the new quality assurance program to closely match and meet the applicable requirements of Part I and Part II of NQA-1-2008 and the NQA-1a-2009 Addenda. After meeting this first goal, we will consider additional quality assurance requirements, such as quality assurance requirements in 10 CFR 50 Appendix B and in DOE quality assurance requirements for research (e.g. 10 CFR 830, Subpart A: "Quality Assurance"). The new quality assurance program will follow the structure of NQA-1, with specific procedures implemented to meet the requirements for specific activities, for example: experiments, facility maintenance, buying new test equipment, designing new facility components, etc. The procedures will be as simple as possible while including all applicable requirements and instructions to reduce the documents needed for each activity and to provide the most guidance to personnel working on the activity. Emphasis is being placed on program effectiveness, efficiency, and the personnel's satisfaction in the performance of the program.

Solutions

The first challenge will be addressed by generalizing the research program and quality assurance program roles and responsibilities to all program personnel, grouped into three groups in ascending responsibility: undergraduate students, graduate students/research staff, and the principal investigator. Graduate students and research staff are clearly the most active personnel in day-to-day research and project work, while the principal investigator maintains final authority and responsibility for the research program as a whole. Undergraduates are an integral part of the CIET Research Program but are not generally given the authority and accompanying responsibility for major decisions as compared to graduate students and research staff. Generalizing project roles and responsibilities into three categories of research project personnel that exist naturally is much simpler than the previous plan. Records of the names and active status of personnel will be recorded and maintained through the training program rather than a separate roles and responsibilities record that then must be often updated.

The second challenge will be addressed through a simpler and more transparent quality assurance program structure as briefly described above. Ideally, the quality

assurance program structure is intuitive to use and reflects the requirements of NQA-1, allowing research program personnel as well as external quality assurance reviewers and auditors to use the program effectively and efficiently. Further, by emphasizing simplicity, the overall document overhead should be decreased and the number of documents per activity should be streamlined. This should allow program personnel to identify and use the single or couple documents (most likely a procedure(s)) as quickly and effectively as possible without the need for searching for several documents in several locations that may have overlapping functions/requirements. Streamlining the necessary document flow combined with effective documents that benefit research program work will also add to personnel satisfaction in the performance of their work, adding to the usability of the quality assurance program and the motivation of program personnel to continue to use the quality assurance program.

The third challenge highlights the need for a rigorous and regular training and indoctrination program. Training and education is an essential function of the university environment, so including training and indoctrination for quality assurance should be a natural extension of this environment. This addition to the university research experience is a welcome one for the purpose and benefit of the quality assurance program, research in our lab, and even work in the commercial nuclear power sector. As students are trained in good quality assurance practices and graduate into this workforce, quality assurance will be the expected norm. Important qualities of training and indoctrination are that it rigorously includes training in quality assurance in general as well as the specific quality assurance program for the CIET Research Program, and that training and indoctrination occurs regularly so that there is no lapse in training, institutional knowledge transfer, and personnel leadership as personnel transition into and out of the research program.

The new quality assurance program is being created and designed specifically for the CIET Research Program in the Nuclear Engineering Thermal Hydraulics Laboratory at the University of California, Berkeley. However, a primary goal of this work is to be as transparent and accessible to others as possible to allow and encourage other university nuclear engineering laboratories to implement quality assurance programs similar to ours. Eventually this work may be generalized to be a generic quality assurance program template that satisfies major requirements from NQA-1-2008 and the NQA-1a-2009 Addenda for universities to implement, but that will require significant additional effort. The creation of a generic university nuclear quality assurance template is an exciting idea to us and is certainly a significant secondary goal of this work.

RESULTS AND FUTURE PLANS

At the end of 2017, the new quality assurance program for the CIET Research Program was audited by an NQA-1 specialist to assess its compliance with applicable requirements in NQA-1-2008 and the NQA-1a-2009 Addenda. At that point, the new quality assurance program consisted of drafts of a quality assurance plan and a set of implementation documents or procedures that would be used in the research program to satisfy quality assurance requirements. The rating from this audit was, "Marginally Effective/Meets Some Requirements," because the new quality assurance program was still in draft form, didn't address all the applicable requirements from NQA-1, and had not been implemented in the CIET Research Program. These are all correct findings and are as expected.

Moving forward, the findings and judgements of need from this audit will be the first list of items to be addressed in the revised draft of the new quality assurance program for the CIET Research Program. After sufficient review, the new quality assurance program will be implemented in the CIET Research Program for a significant duration before undergoing a second quality assurance program audit. At that point the goal is for the new quality assurance program to be judged, "Effective/Meets All Requirements." This future work is also planned to be published in detail to allow for the transparency and detail needed for other nuclear engineering research laboratories at other universities to replicate our efforts.

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