Digital Control and Safety System Modernization for the Penn State TRIGA Reactor

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ABSTRACT: Penn State has historically been a leader in reactor control for the research reactor community. The current console, installed in 1991, continues in operation to this day with only minor updates of computer components. However, as is the case with all operating nuclear plants, obsolescence issues must eventually be addressed which require replacement of hardware and software. The present system is a hybrid system - digital control and monitoring and analog safety system. This instrumentation and control (I&C) replacement proposes to replace the existing digital equipment (26+ year-old technology) with more versatile and supportable state-of-the-art technology. Additionally, the existing analog safety system will be incrementally phased-out, replaced with a 1E certified digital safety system used in the commercial nuclear power industry. PSU proposes to partner with Schneider-Electric subsidiaries Foxboro Controls and Invensys Automation to implement this first-of-a-kind safety and control system upgrade to a university research reactor. It is expected that this work will be the model for other university research reactors throughout the United States. As a first step in assessing the capabilities of the new system, Schneider-Electric donated Foxboro Process Automation I/A System and a TRICON 1E digital safety system, valued at $276,194.00, to the RSEC to develop a laboratory for the staff to become familiarized with the equipment and conduct preliminary control experiments. Many of the aspects of a full-scale control system are demonstrated on a small-scale with the laboratory equipment provided - from specification development and factory acceptance testing, to preliminary testing on the TRIGA using an Auxiliary Control Rod. This equipment would ultimately be used as a staging area for assessing future software and hardware changes on an upgraded console. The PSU TRIGA control system replacement would avert the possibility and negative impact of the existing, obsolete system failing prior to replacement, and provide continued support all of the personnel and activities currently performed at the RSEC. The proposed replacement will maintain the full-functionality of the present digital control system using modern digital technology. The Foxboro I/A control equipment will be the interface between the reactor operators, the TRICON and the TRIGA, and will be housed in the existing control console enclosure to retain the same "feel" as the existing system (and to minimize costs). Similarly, the graphical user interface will retain the same form, fit, and function as the existing system to minimize impact to reactor operations. The flexibility to easily update control code and incorporate new features, such automated nuclear instrument and control rod worth calibration, would be cost-effectively enhanced by use of the interactive software development environment and modular hardware architecture of the Foxboro I/A and TRICON systems. The code and equipment architecture developed for the Penn State TRIGA control system upgrade would be "open source", in that all technical and regulatory content would be shared among the TRIGA Reactor User's Group, and potentially serve as an open-source model for power reactor control system upgrades. Additionally, the console will be incorporated into the nuclear engineering curriculum at Penn State, demonstrating to senior-level and graduate engineering students state-of-the-art control engineering concepts and implementation. It is anticipated that the PSU RSEC will provide training opportunities in digital instrumentation and control to the Nuclear Regulatory Commission, Department of Energy, and nuclear utilities and service providers using the new control system as the focal point. The total cost of the project is $1,333,773.00, for a system which includes replacement of

the digital control and analog safety system. This includes hardware, custom software, software verification and testing, and installation of equipment. The Penn State COE will contribute $250,000.00, making the amount requested from the Department of Energy $1,083,773.00.