MAJOR REFURBISHMENT OF THE UNIVERSITY OF FLORIDA TRAINING REACTOR

K.A. JORDAN*, B. SHEA, AND M. BERGLUND
University of Florida Training Reactor
University of Florida, Gainesville, FL 32611 USA

*Corresponding author: kjordan@ufl.edu

ABSTRACT

The research reactor fleet is aging with few replacements being built. At the same time the technology for refurbishment of the older reactors has advanced well beyond that of currently installed equipment. The disparity between new and old technology results in an inability to find simple replacements for the older, highly integrated components. The lack of comprehensive guidance for digital equipment adds to the technical problems of installing individual replacement parts. Up to this point, no U.S. facilities have attempted a complete modernization effort because of the time commitment, financial burden, and licensing required for a total upgrade. The University of Florida Training Reactor is tackling this problem with a replacement of nearly all of the major facility sub-systems, including electrical distribution, reactor controls, nuclear instrumentation, security, building management, and environmental controls. This approach offers increased flexibility over the piece-by-piece replacement method by leveraging modern control systems based on global standards and capable of good data interchange with higher levels of redundancy. The UFTR reviewed numerous technologies to arrive at the final system architecture and this "clean-slate" installation methodology. It is this concept of total system replacement and strict use of modular, open-standards technology that has allowed for a facility design that will be easy to install, maintain, and build upon over time.

1. Introduction

The UFTR Digital Control and Protection System (DCPS) project is a major upgrade to UF's 100kW Argonaut reactor, which was first licensed and operational in 1959. The purpose of the DCPS project is to replace the heritage analog control and protection system, which consists of components from the 1960s and 1970s. The new system will be a digital reactor control system (RCS) and reactor protection system (RPS), with a redundant analog trip system. In addition to the upgraded control system, the UFTR has undergone several physical infrastructure improvements. These recent upgrades are described below.

2. The Digital Control System

The UFTR DCPS consists of two separate Siemens Power and Process Automation T-3000 (SPPA T-3000) digital control systems, including operating software: one T-3000 system for each of the Reactor Protection System (RPS) and Reactor Control System (RCS). These systems will operate independently to process inputs from the UFTR instrumentation and operational equipment and return control signals to various plant functions and equipment.

There is also a redundant analog hard trip system (ATS). The ATS consists of bistable relays. Almost all input signals will be first wired through the UFTR analog hard trip system, then to the digital RPS as well as to the digital RCS, except for signals only used by the digital RCS. Figure 1 gives an architectural diagram of the proposed system architecture.

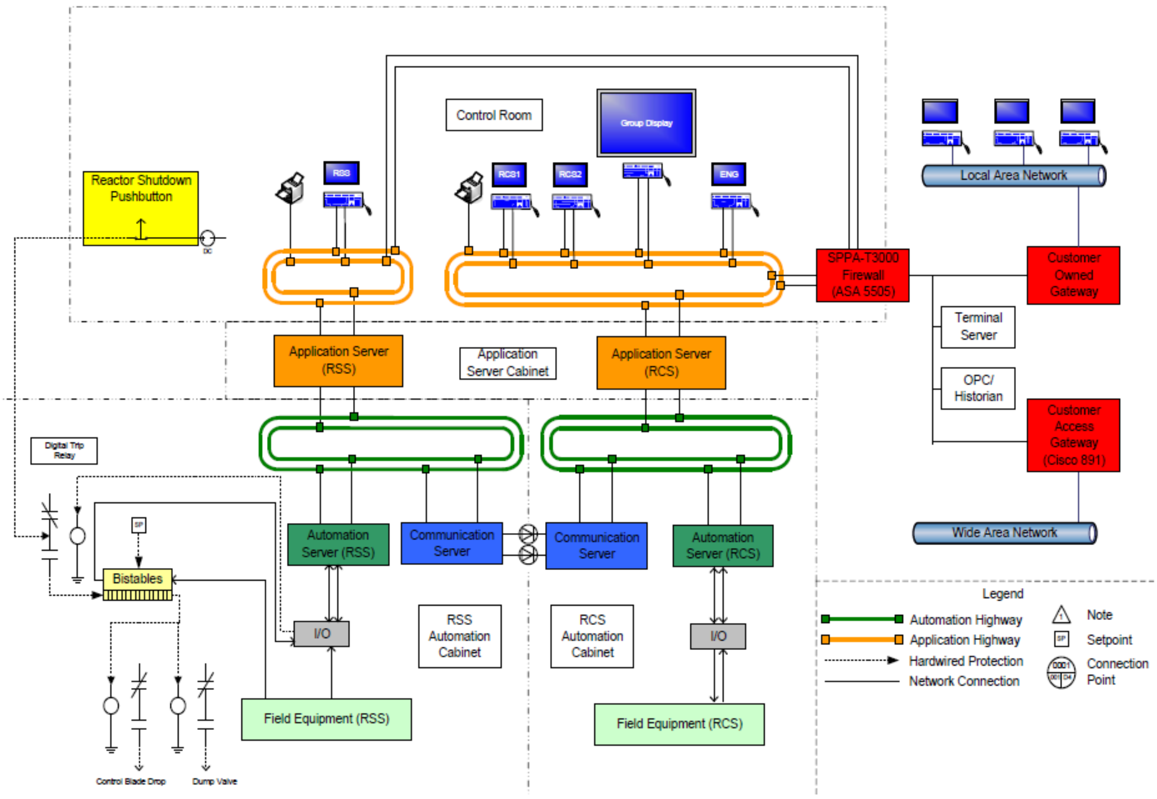

Fig 1: System level diagram of the upgraded UFTR digital control and shutdown system.

2.1 Reactor Protection System

The RPS T-3000 shall process various signals to monitor the status of UFTR systems, including reactor power, primary and secondary cooling loops, and reactor cell auxiliary systems. The RPS will determine whether to continue reactor operation or cause a trip to shut down the reactor, per the UFTR Spec and SOPs. Two independent Nuclear Instrumentation (NI) channels, operating simultaneously for a high degree of confidence, monitor reactor power. The reactor is tripped if either NI Channel yields an invalid signal.

The primary coolant loop temperatures (at the inlet/outlet and at the top of six fuel boxes) and flow rate are monitored to provide further confidence in the safe operation of the reactor core. The secondary coolant loop inlet/outlet temperatures and flow rate are monitored. In the reactor cell, three of the four containment area radiation monitors are required, to monitor for any release of radioactivity, primarily Argon-41. The operation of the reactor core ventilation fan and exhaust stack dilution fan are also monitored.

2.2 Reactor Control System

The RCS T-3000 shall provide the capability to monitor and operate all plant equipment necessary to the safe operation of the UFTR, from reactor startup through manual shutdown. The RCS monitors all devices for system feedback. The RCS also provides the reactor operator (RO) with control functionality for all four control blade drive motors (three control blades and one regulating blade), the core dump valve, core vent fan, exhaust stack dilution fan, shield water recirculation pump, primary coolant pump, demineralizer pump, secondary coolant well water pump, and secondary cooling valves (well water vs. city water). The RCS also provides various safety inhibits (i.e. on control blade withdrawal) and interlocks used for proper control of the reactor during startup.

2.3 System Architecture

The system architecture includes the digital Reactor Protection System (RPS) and Reactor Control System (RCS), as well as the independent analog hard trip system (ATS). The digital systems together are called the UFTR Digital Control and Protection System (DCPS). The UFTR DCPS receives plant inputs and operator inputs, and performs the desired RCS or RPS functions. A general arrangement of the UFTR system architecture is shown in Figure 1. This figure also shows the system boundaries.

3. Physical Infrastructure Upgrades

3.1 HVAC

The Heating, Ventilation, and Air Conditioning system has undergone a major replacement in 2013. Surrounding subsystems and equipment have been replaced, including piping, lift pumps, and strainers. When the heat transfer system was removed the corrosion products found in pans and internal tubing indicated a system that was operated beyond its design lifetime. The new system is designed to defeat these mechanisms with better filtration and maintenance processes to assure filter cleanliness and at least the 50 year life of the old system.

Severely clogged piping in the heating and cooling lines have been cleared and the heat transfer system has been entirely replaced. This new heat transfer system is comprised of several major components. First, the old support structure was not capable of properly supporting the new heat transfer system and was modified to meet those requirements. The dual variable speed motor fans provide ventilation flow. Filtration is handled by disposable paper filters augmented with high intensity ultraviolet lights to deal with microbial contaminants. All ducting has been replaced with insulated duct. A new Siemens control system has been incorporated into HVAC. This control system was designed to integrate seamlessly with the new digital control systems that will used to control the reactor. The new system is being used now with a simple control interface that will be transferred to the digital reactor control system after its implementation.

The core vent system at the UFTR is unique in that it is required to analyze air that has come into direct contact with the core. This system consists of piping, HEPA grade filters, and a Geiger-Mueller detection system. The GM system is antiquated and Canberra scintillation system capable of providing better detection has been purchased. This system was selected partly because of its ability to integrate into the upcoming digital reactor control system. This system is in the mechanical design phase and will be installed alongside the original system and is expected be installed by the end of November 2013.

3.2 High Plume Exhaust Fan and Stack Monitoring

In concert with the core vent system, the stack dilution system is undergoing a significant modification. The ductwork is being extended to provide a higher exhaust point. An additional dilution fan is being installed which will raise the effective stack height from approximately 35 feet to nearly 75 feet with a 10 mph cross-wind. This improvement also increases the dilution factor by 5. This modification also comes with better measurement capability. These two systems combined provide instantaneous measurement of the Argon emissions from the reactor. Currently this is accomplished every six months by sampling. The ability to know reactor Argon output instantaneously should allow for longer run-time per year and open experimentation options that were previously unavailable to the UFTR.

Fig 2: The high-plume exhaust fan and monitoring equipment as installed.

3.3 Nuclear Instrumentation

The three channels of Mirion Instruments manufactured nuclear instrumentation (two DWK 250 wide range and one DGK 250 Power range) were purchased last year and have undergone a modified site acceptance test completed in July 2013. The instruments performed as expected and this allowed our local experts to work with the Mirion field engineer to assess the site characteristics and evaluate the final installation of the channels. This test also allowed for construction of a student designed and built test board, which can be used to evaluate the equipment after deployment. Currently, a Moxa NPort 5630 Modbus converter is being programmed and evaluated for use in the larger digital controls system. This device will provide the controls link between the reactor control process busses and the three channels during maintenance and operation. This link may also provide a redundant data link to the devices. Programming and operational understanding of this pairing is expected to be complete by March 2014.

3.4 Security Upgrades

The UFTR Security Upgrades have progressed as planned with completion of the basic system installation in August 2013. The system has performed up to expectations in preliminary testing and it appears as that it may provide additional benefits beyond the original security considerations. Improvements include the introduction of cameras, replacement of wooden doors, and superior access controls. The security staffs available at the University of Florida are working with contractors to provide testing above and beyond what is conventionally performed at this level. The final configuration and testing is expected to be complete by end of 2013.

The opportunity to use this system for operational benefit in access control and facility monitoring was explored, but only after installation is the full potential for these ancillary benefits being realized. The system may allow, monitored directly by and under the control of the reactor operator, temporary personnel access to spaces within the facility without the issuance of keys. Long term monitoring of experiments is another possibility, with cameras in all the locations where experimentation is likely to take place. Finally, the system may be incorporated into UFTR procedures as a second check option for the operator where a less well trained second person might have performed a reading for the operator and reported back to him or her.

3.5 Network Upgrades

The UFTR has also completed the final stages of the installation of the Wall Plate program. This program provides a unified network entry point in each building, and in the UFTRs case, assured redundant data connections out to the university network. This replaced the ad-hoc network that was installed previously. The final aspects of the network were completed in the June time frame and with that the business or "Front Office" portion of the UFTR network is complete. This network will not connect to the "Engineering" network, which will be used to support the reactor control system. This network has gone into the first stages of engineering with the Digital Controls Project.

4 Conclusions

The UFTR will recommissioning at the end of 2014 as a fully modernized nuclear research and operations facility. The chosen path: a full modernization and refurbishment of all reactor infrastructure, with the lynchpin upgrade to a digital controls system, will ensure the useful life of the UFTR will continue well into the future.