Development and Testing of a First-of-a-Kind Process to Support Commissioning a New Hazard Category 2 Nuclear Facility (ID# 16573)

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ABSTRACT

The Department of Energy's Department of Environmental Management faces the complex task of cleaning up waste from nuclear weapons production. Often, the clean-up requires novel and untested technologies and approaches. In these cases, it is always necessary to provide some measure of assurance that the design engineers will be able to produce a design that will function in the means intended. Too many times we have seen first of a kind nuclear processing technologies put forth as commercially ready, only to be found insufficiently mature once attempted to be readied for operation. As now required by the DOE's Technology Readiness Assessment Process, it is necessary to demonstrate technologies in a similar environment to the current application and tested with a range of bounding simulants, or actual waste materials, if possible.

BACKGROUND

One example of a project at Hanford that requires new technology development is the removal of highly radioactive sludge from the engineered containers stored underwater at the 100-K West reactor fuel storage basin. The Department of Energy (DOE) and contractor CH2M HILL Plateau Remediation Company (CHPRC) are making significant progress toward the goal of removing the sludge out of the K West storage basin and away from the Columbia River by September 30, 2018. The sludge removal effort is part of a larger decommissioning project to attain closure under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) for the K Reactor area at Hanford. After the sludge is removed, the basin can be demolished and disposed. This will in turn allow for the cleanup of contaminated soils that are under the basin structure. Finally, the reactor building itself will transition to interim safe storage.

The sludge is a mixture of tiny fuel corrosion particles, fuel rod and metal fragments, and soil and sand less than ¼-inch in diameter. This sludge has chemical, physical and radiological characteristics that present significant difficulties in providing mobilization and motive force to ensure successful removal and transfer.

To ensure a high probability of project success, CHPRC established a cold test facility at the Material and Storage Facility (MASF), which is a facility located adjacent to the no longer operating Fast Flux Test Facility. At MASF, engineers created a full-scale mockup of the K West basin to simulate the project conditions, complete in every way physically and dimensionally.

The full-scale mock-up facility supported engineering and operation input into the design, familiarization with the production scale equipment, development of operational procedures and operator training. The final use of the facility will involve a full cold commissioning run on each and every component procured for installation into the operating K West basin retrieval facility. This will allow integration and grooming of the production scale equipment before it is installed in the basin, thus reducing time needed for these activities in the challenging work environment present in the K West basin environment. This will reduce worker exposure and reduce the time necessary to complete cold commissioning at the K West basin.

Ensuring these components work individually and in concert with each other in a non-nuclear environment will allow a much higher potential for success and will greatly help prevent the need for remedial design activities after installation, when they are much harder to perform and implement.

This paper will provide examples of the benefits discussed above, highlighting the positive impact on the project of such an extensive testing and development effort.

FACILITY DESCRIPTION

To ensure a high probability of project success, CHPRC has established a cold test facility at MASF. MASF is a maintenance facility that once supported operations at the Fast Flux Test Facility (FFTF), a DOE-owned, formerly operating, 400-megawatt (thermal) liquid-metal (sodium)-cooled nuclear research and test reactor. After the shutdown and eventual deactivation of FFTF in 2009, CH2M repurposed the high-bay facility to support the Sludge Treatment Project (STP) development and acceptance testing of sludge handling components and systems and training of operations personnel in using this this equipment.

The MASF complex consists of a main building and a two-story service wing (see Figure 1). The two-story service wing houses air handling equipment and administrative space, a load-out facility and a warehouse. STP project development activities occur primarily in the main building.

Figure 1. Maintenance and Storage Facility

The structure is 290-feet long by 95-feet wide and provides approximately 28,000 square feet of area for mockup fabrication and engineering scale testing. The entire area of the main building is serviced by a 60-ton overhead bridge crane (26-foot nine-inch hook height) with a ten-ton auxiliary hoist (29 feet three-inch hook height). The main building is divided equally into high- and low-bay sections with heights of 105 feet and 49 feet, respectively.

The high-bay section is serviced by a 115-ton overhead bridge crane (approximately 82-foot hook height) with a 25-ton auxiliary hoist (approximately 82-foot hook height) and below-grade cells for specialized test activities. The high-and low-bay overhead cranes incorporate control circuit interlocks to prevent movement of either crane unless one crane is in the stowed position.

FACILITY DEVELOPMENT FOR STP TESTING PURPOSES

In this facility, engineers have created a full-scale mockup of the K West basin to simulate the project conditions, complete in every way physically and dimensionally.

Figure 2. Modification of MASF for K West Basin Mock-up

CH2M created a mock-up fuel storage basin at MASF by modifying one of MASF's preexisting below-grade cells (Figure 2). Adding grating, suspended from above, and other infrastructure (Figure 3) to enable workers to use long-reach tools to access mock-up sludge storage canisters underwater at MASF has allowed engineers and workers to design, develop, test and train on sludge retrieval technology.

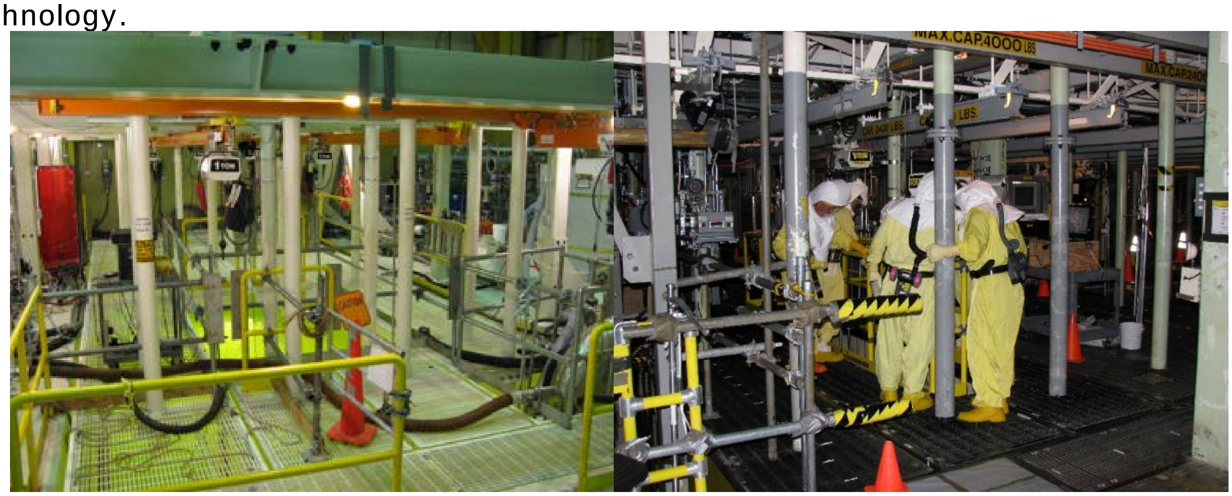

Figure 3. K West Basin Mock-up at MASF (Left) – K West Basin (Right)

SYSTEM DESIGN DESCRIPTION

The sludge in the K West basin sits in six specially designed engineered containers, stored underwater to provide adequate radiation shielding.

To facilitate longer-term storage of the highly radioactive sludge away from the Columbia River, the sludge will be retrieved from the engineered containers and transferred as a sludge/water slurry to specially-engineered stainless-steel Sludge Transport and Storage Containers (STSC) located in the newly-constructed Modified KW Basin Annex. The sludge-filled STSCs will then be moved to shielded storage at T Plant in the 200 West Area using the Sludge Transport System (STS) Cask and Trailer.

The system that is utilized for sludge retrieval and transfer is the Engineered Container Retrieval and Transfer System (ECRTS). This system consists of multiple mechanical subsystems including the Retrieval System, Transport System, Transfer System, Decant/Filter System and Ventilation System. It also includes various supporting utility systems and an Instrumentation and Control System to monitor and control the process.

The ECRTS equipment, panels, and skids have been constructed as modules for ease of installation and decommissioning. The design life for ECRTS and required facility upgrades is five years with the exception of the STSCs, which have a 30-year design life. The expected mission life is one year.

Sludge is retrieved from engineered containers in K West basin by operators using the XAGO Retrieval Tool (XAGO) and pumped to an STSC in the K West Basin Modified Annex by the Booster Pump Skid, via the Ingress/Egress Assembly and Transfer Line Service Box (TLSB). After the sludge settles in the STSC for 2 to 16 hours, supernate is decanted from the STSC, passed through the Sand Filter Skid to remove sludge fines, and pumped back to KW Basin. The process is then repeated. After several cycles of sludge retrieval and transfer, settling, and supernate decanting, the STSC is filled with sludge to the specified STSC Buoyant Load Weight setpoint, depending on the sludge type. Following the final decant, the sludge fines in the sand filter are backwashed into the STSC. The transfer lines are flushed, drained, and the STSC is filled with ion exchange module (IXM) water to the final-fill level for radiation shielding. The piping to the STSC is disconnected and the STSC headspace is inerted with nitrogen. The STS Cask Lid is placed on the STS Cask, over the sludge-filled STSC, and the STS Cask headspace and annulus is inerted and pressurized with nitrogen. The STS Cask with the sludge-filled STSC is then shipped to T Plant.

At T Plant, the STS Cask Lid is lifted off the STS Cask and the sludge-filled STSC is removed from the STS Cask and remotely placed into a cell in T Plant, which has been modified to store STSCs. An ECRTS simplified PFD is provided as Figure 4.

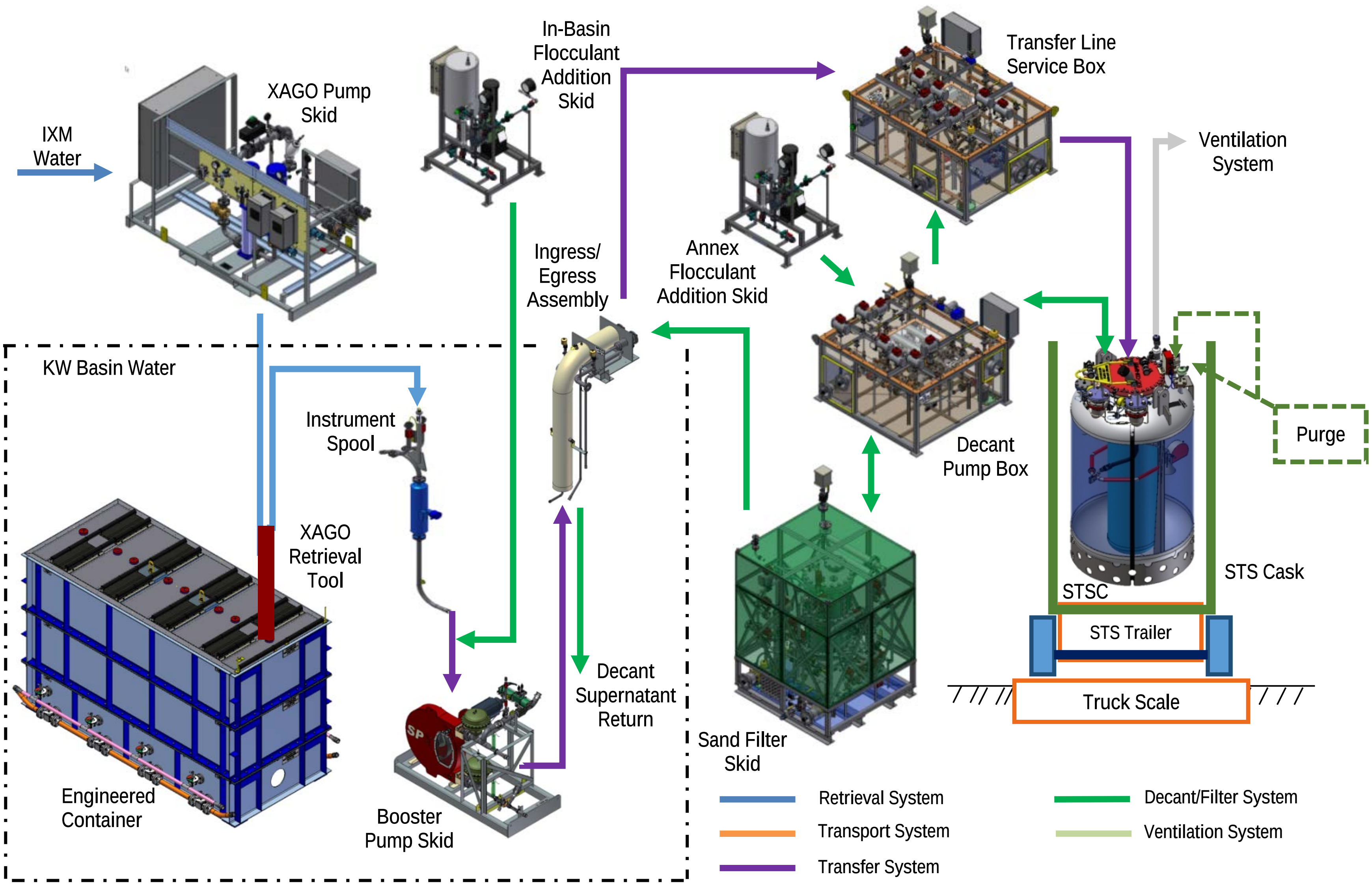

Figure 4. ECRTS Simplified Process Flow

INITIAL TEST AND DEVELOPMENT ACTIVITIES

Testing is integral to the design process, and the complete STP life-cycle has effectively utilized testing to validate design features and functions.

From 2009-2015, a system was developed to remove, transport, and interim store chemically reactive and highly radioactive sludge material from the Hanford K-West Fuel Storage Basin. The sludge in the K West Basin is a legacy issue resulting from the storage, washing, and packaging of decayed spent nuclear fuel. In 2013, the final design of the system was completed.

In 2012, a system comprised of six (6) Critical Technology Elements was developed, tested and successfully evaluated at a Technology Readiness Level of 6 (technology system validated in a relevant environment.) The application of the Technology Maturation Plan and Technology Readiness assessment process has resulted in significant improvements in the design of the STP. For example, more than 100 individual problems were found and efficiently corrected during testing. Had these problems been found during startup testing at the production facility, it would have resulted in significant cost increases, schedule delays, and increased radiological dose for workers.

A key element of the technology development and maturation has been the use of a full-scale prototype of the ECRTS at MASF. The prototype includes a full-scale (depth) mock-up fuel storage basin, sludge retrieval and transport system, sludge storage container, filters, decant, and flocculant systems. Full-scale integrated testing of these systems has resulted in the successful maturation of the sludge management technology, and provided opportunity to obtain input from end users to improve system operability.

The other key element was the development and maintenance of a range of simulants validated by laboratory testing and characterization of the sludge materials. Together, these allowed full-scale testing of the prototypical system utilizing a range of simulant materials in a relevant environment.

Below is a diagram illustrating how MASF supported process optimization demonstrations, testing and procedure development, training and acceptance testing for hardware.

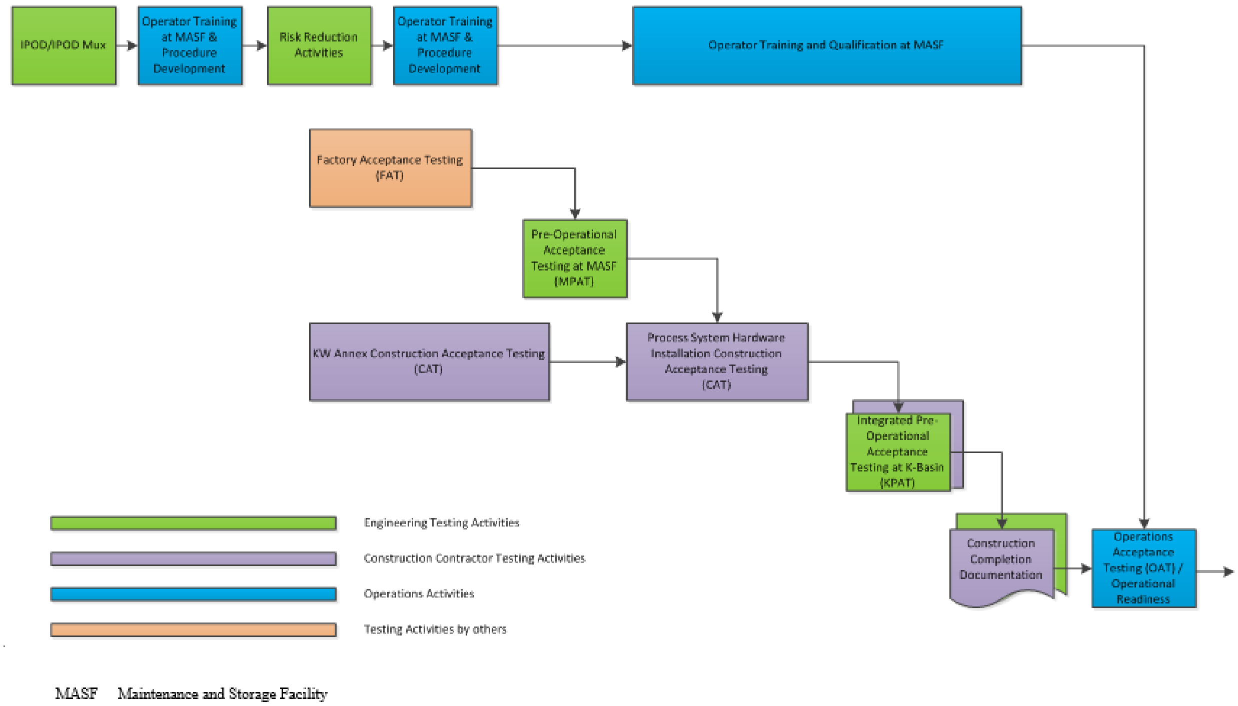

Figure 5. ECRTS Test and Demonstration Activities

The planning and execution of this project demonstrated how the application of DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, DOE-STD-1189-2008, *Integration of Safety Into the Design Process*, and DOE G 413.3-4, *U.S. Department of Energy Technology Readiness Assessment Guide* can positively affect the outcome of project implementation in the DOE Complex.

COLD COMMISSIONING OF OPERATING HARDWARE

The final use of the facility will involve a full cold commissioning run on each and every component procured for installation into the operating K West basin and retrieval facility. Ensuring that these components work, both individually and in concert with each other, in a non-nuclear environment will allow a much higher potential for success and will greatly help to prevent the need for remedial design activities after installed, where they are much harder to remedy.

Currently, vendors are fabricating process equipment, which bundled into 20 independent procurement packages. Nearly all of the equipment will be delivered to MASF where it will be installed in place of the test articles. There, a cold commissioning project will be conducted over the course of three to four months to confirm operability.

SUMMARY

MASF has so far played an integral role in making significant progress in the effort to move sludge away from the Columbia River, reducing risk to human health on the Hanford Site. The coming months will further demonstrate MASF's benefit, with the installation of production equipment at MASF for testing and cold commissioning before that production equipment is moved to the 100 K West area for installation and eventually the first shipment of sludge away from the river by September 30, 2018.