Aging Infrastructure: Application of System Health Monitoring at the Defense Waste Processing Facility – 16069

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ABSTRACT

The disposition of high level waste (HLW) into borosilicate glass canistered waste forms began at SRS in 1996. Since that time, the Defense Waste Processing Facility (DWPF) has produced nearly four thousand HLW canisters. The DWPF is now approaching 20 years of radioactive service and 25 years of operation since the commencement of nonradioactive testing in 1990. Many facility systems are challenged by equipment or component obsolescence, which places a premium on proper work planning, engineering, and maintenance resource allocation to ensure facility reliability. To this end, Savannah River Remediation (SRR) implements programs and procedures for performance monitoring of structures, systems, and components (SSCs) within all of its processing facilities. As these programs have matured, they have helped to identify vulnerabilities within facility systems and provided a framework for ranking system assets to ensure correct priority is established and maintained.

This paper provides an overview of how SRR structures and implements system performance monitoring with specific focus on the recent replacement of the DWPF Safety Grade Purge Flowmeters. This case study will discuss:

1) How the performance monitoring process identified an availability risk due to the minimal vendor support for the in-use flow transmitters,
2) The design changes developed as part of the project to transition to a different measurement technology, which includes operational lessons learned from the original installation,
3) The execution of the replacement effort, which was complicated by the fact that the purge system is a Vital Safety System (VSS) and not easily taken out of service for extended maintenance, and
4) The need to consider future maintainability, particularly given that continued acceleration in technical innovation will likely increase the frequency of equipment obsolescence.

INTRODUCTION

When the DWPF was commissioned for cold-chemical startup runs in 1990 it was the newest processing facility at SRS, a site where most processing and waste storage facilities dated from the 1950s. Combining state-of-the-art design and materials of construction with a strong technical baseline, DWPF represented the flagship facility among several process areas used to implement an integrated flowsheet for waste retrieval, treatment, and disposal. While additional waste treatment processes have been subsequently introduced at SRS (notably the Actinide Removal Process [ARP] and Modular Caustic Side Solvent Extraction [MCU] facilities), DWPF has retained its perception as the “new” facility in the SRS Liquid Waste processing flowsheet.

However, after processing several million liters of high level waste sludges and pouring thousands of vitrified-glass canistered waste forms, DWPF is approaching twenty years of radioactive operation and faces challenges now that were unusual or absent from its early processing history. Facility conditions due to age and radiological contamination have increased the level of effort required for maintenance in parts of the facility, and equipment obsolescence has begun to complicate repair efforts. While these issues are expected at this point in a facility life-cycle, it underscores the need for pro-active management to ensure that DWPF will continue to operate at a high level of reliability for years to come.

TECHNICAL APPROACH

The issues facing the DWPF are not unique and have been identified as potential risks at a variety of sites within the DOE complex [1]. Savannah River Remediation, the Liquid Waste contractor at SRS, implements a performance monitoring program [2] with a stated goal of:

> *“…the identification, testing, collection, and analysis of performance data for Structures, Systems and Components (SSC) in order to improve their reliability and availability through early detection of degradation. Early detection of SSC degradation results in better planning and scheduling of maintenance work, which further results in a significant improvement in predictive and preventive maintenance, better use of manpower, improved reliability of SSCs, and an improved spare parts program.”*

Aging infrastructure management is included as a part of general system health and performance monitoring under a related program [3]. The net effect of these programs is to implement a graded approach which considers asset value (safety function, importance to production support, etc.), design details (active vs. passive component, materials of construction, redundancy), service environment and degradation mechanisms, and the applicability of existing management programs (preventive maintenance, structural integrity, etc.) to determine whether residual vulnerability exists and define additional actions necessary to ensure that components will perform their function in a manner consistent with the period of expected operations.

The Engineering organization is charged with the management and implementation of these programs, but ultimately multiple organizations are involved in the process. Facility management is routinely briefed on system performance at a summary level, and detailed reports are provided annually for systems considered to be either Vital Safety Systems or provide important defense-in-depth functions. Maintenance organizations, work planning, and outage scheduling groups are included to aid in prioritizing work and driving task-readiness of intrusive maintenance activities.

DWPF PURGE SYSTEM REPLACEMENT

DWPF recently completed a significant overhaul of one of its safety systems, which provides a representative case study of how these programs work to ensure reliable performance. Chemical processing of HLW sludges within DWPF can generate substantial quantities of hydrogen, which represent a flammable hazard if allowed to accumulate in vessel vapor spaces. The DWPF uses a forced purge system (supplied by either compressed air or nitrogen) which sweeps the vapor spaces of affected tanks and prevents flammable gas accumulations.

In the original design for this system, the purge gas flowed through redundant measurement instruments located within a personnel service corridor before reaching the remotely-located process vessel. One of the instruments was a locally-indicating rotameter, while the other was a thermal element with monitoring and alarm functions which were output to the distributed control system (DCS). The simple mechanical design of the rotameter required relatively little service beyond calibration verification, but the more complex operation of the thermal element necessitated off-site vendor support for periodic maintenance and calibration. As years passed, the manufacturer continued to update the design of their flow instruments and began to indicate that they would likely cease offering service on the older units. The performance monitoring reports associated with the safety-related purge system identified that a vulnerability existed in which the facility would be unable to satisfy safety basis requirements for periodic calibration. In that event, the required actions would result in the shutdown of active processing operations in the affected vessels.

In response, DWPF Engineering initiated a long-term effort to modify the metering equipment used to measure and supply purge flow to several processing vessels. In the years since the original installation, several other tanks had been added to the purge system by tying into the common supply manifold in the corridor. These vessels used a different configuration which had redundant trains of air filters, pressure control valves, and differential-pressure flowmeters. This alternate design had been adopted to address several shortcomings of the original design. In the initial installation, the vessels did not have tank-specific pressure regulators. As a result, flow adjustments to one tank would slightly impact manifold pressure and alter flows to the other vessels. Several iterations of adjustments would then be necessary to ensure that the system was properly balanced and all flows were within acceptable ranges. The differential-pressure flowmeters did not allow for continuous remote monitoring like the thermal elements, but had switches that could provide alarms to the DCS and did not require electrical power to perform their measurement function. The engineering team decided to replace the older style equipment with the new design to achieve consistency across all the vessels and realize the benefits of the new configuration as well.

The forward-looking aspect of the viability assessment proved to be important. The equipment was part of a Vital Safety System, and it is assumed to be available at all times. The equipment is qualified to withstand earthquakes and Technical Safety Requirements (TSRs) required the facility to repair the system within hours to a few days (depending on processing conditions) if the system became inoperable. The facility modifications were forecasted to require up to three weeks of a purge system outage. In order to accomplish this task, the design implementation was broken into intrusive and non-intrusive segments. The design changes were developed and non-intrusive work was performed while the original equipment continued to operate. Meanwhile, extensive hazards analysis activities were performed to determine the conditions under which the purge system could be safely isolated for the duration of the activity. Ultimately this resulted in a significant effort to manage the implementation of two subsequent safety basis changes. The final intrusive modifications and startup testing were completed over the span of a few weeks in the spring of 2015. The successful execution of this modification required the integrated effort of almost every line organization within the DWPF. From start-to-finish the effort required more than two years of preparation and planning, and was completed with a minimum impact to processing operations. While this could have been accomplished on a reactive rather than proactive basis, the work would have been much more disruptive to facility processing. By applying principles of performance monitoring and viability assessment, DWPF was able to ensure a disciplined approach to the process and avoid the error precursors associated with reacting to unplanned equipment failures.

LESSONS LEARNED

The most general implication from the DWPF experience of the purge system flow instrument replacement is the value added from aging infrastructure management programs in facilities which have significant remaining life-cycle. Due to the differences in design and environment from facility to facility, the programs implemented by SRR describe basic programmatic features and delegate specific implementation of those features to the operating facilities. Thus, the Liquid Waste

(LW) Tank Farms may choose to implement field walkdowns at a higher frequency than DWPF given that a much higher proportion of its SSCs are located outdoors. As a result, implementation costs are likely to vary based on a number of factors.

While a detailed consideration of return on investment is beyond the scope of this paper, it seems clear that significant cost avoidance can be attained with minimal capital investment in monitoring capabilities and relatively small operating costs associated with periodic assessments. DWPF operation represents a program annual cost impact of about $131 million for the 2016 fiscal year (FY16). Additionally, the DWPF cannot operate independently of several other support functions needed to provide feed streams or disposition secondary waste products. The total LW program cost for FY16 is approximately $540 million. Thus, aging infrastructure management programs which can avoid even a few days or weeks of outage time each year can result in substantial savings over project life-cycles.

The team also noted the opportunity to consider obsolescence and end-of-life replacement as a design element in the future, particularly for important-to-safety systems which are expected to perform an essentially continuous function. The primary focus for most designs entails initial constructability and maintainability during operation. The replacement of the purge instrumentation was substantially complicated by the duration of outage time required for physical work, and serious consideration was given to the potential for using a temporary, alternate supply of purge gas. Ultimately the facility determined that this strategy did not offer sufficient advantages to justify the effort required, but it is possible the opposite conclusion would have been reached had certain design features of the existing system been different. A somewhat similar circumstance has been observed with degradation of some underground utilities in the LW Tank Farms. Excavations to repair leaks on below-grade compressed air lines are highly disruptive to Tank Farm operations, and as a result the facility has been forced to abandon rather than repair parts of the system. Although at present no programmatic changes to the design development process have been recommended, this is an area for further consideration going forward.

Planning for future obsolescence might also gain importance in the future due simply to the rate of technological change occurring within industry. This potential has been highlighted lately in the area of instrumentation and controls, where the options available for communication between measuring devices and remote monitoring and control systems have expanded significantly in a short period of time. However, as companies continue to demand increased efficiency and improved process control, innovation is occurring across all sectors and resulting in new products being brought to market. Those same economic forces push suppliers toward consolidation of product lines and minimizing support of legacy systems. While this experience is not new, it is possible that it may become increasingly frequent as industrial technologies continue to advance.

CONCLUSION

SRR facilities at SRS have implemented programs to identify vulnerabilities associated with aging infrastructure. These programs have demonstrated the capacity to return significant value in the example of the purge system flow instrumentation replacement at DWPF, which allowed the facility to minimize outage time needed to replace obsolete safety equipment. Asset management programs will likely continue to evolve as further operating experience is gained in legacy facilities.

REFERENCES

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