Long Term Operation of the Advanced Test Reactor

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The Advanced Test Reactor (ATR) is a key nuclear facility at the Idaho National Laboratory (INL). This year, ATR celebrated 50 years since initial criticality was achieved on July 2, 1967. This milestone is significant because of the many nuclear materials research programs supported over the past five decades but also as a waypoint because ATR is expected to continue operation out to at least 2050. The strategy for long-term operation includes a comprehensive age and reliability management program and engagement with government funding agencies to support the program. When considering the operation of a reactor facility beyond 80 years it is important to look beyond those systems required to simply keep the reactor operating and include inspections and condition evaluation of support infrastructure. This infrastructure evaluation must include water sources, waste disposal pathways, electrical substations and distribution, support facilities, and roads. ATR is evaluating reactor and non-reactor systems and executing a long-term operation and age management plan that may serve as a model for other facilities considering long term operation.

The Advanced Test Reactor (ATR) is a 250 MW light water cooled, beryllium reflected reactor designed to provide irradiation testing of reactor materials and fuels utilizing large volumes and high intensity radiation fields. The ATR began operation in 1967 and is located at the Idaho Nuclear Laboratory (INL) which is the U.S. Department of Energy's lead nuclear research lab. The ATR's unique serpentine core design (Figure 1) allows the reactor's lobes to operate at different power levels with a power split of three to one across the reactor core possible. Over the 50 years of ATR's operation it has supported major nuclear research and develop programs and many current ATR users have forecasted their programs will continue until at least 2050. Over the past five years, ATR staff have developed and utilized a program that evaluates current system and equipment condition or health to assess operational and safety risk and prioritize replacement or refurbishment of equipment or individual components. This program, called the Plant Health and Equipment Reliability Program, has been used to support successful funding requests to key stakeholders. The original strategy was focused on near-term ATR operational and reliability improvement but has expanded to support an overall age-management program that will allow ATR to continue to operate safely and reliably for decades into the future.

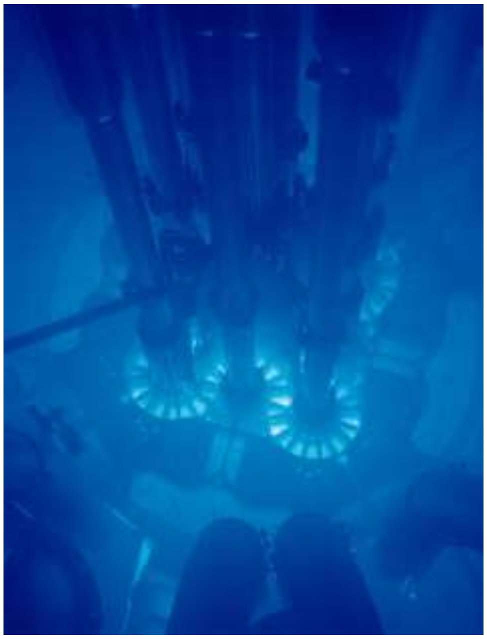

Figure 1 Advanced Test Reactor

The ATR was designed specifically as a materials irradiation platform but also for a long lifetime. The ATR reactor vessel is solid 304 stainless steel with a large diameter (~4 m) to minimize fast neutron damage from the compact reactor core. Over decades, the ATR maintenance strategy was to perform routine preventative maintenance and equipment repairs as necessary to sustain safe operation while maximizing the reactor availability for the irradiation mission. Approximately every ten years or more, due to irradiation damage and cracking of the beryllium reflector, the beryllium and reactor internals located directly in and around the fuel and reflector region were required to be replaced. This core internal change-out (CIC) effectively “zeros the age clock” on the ATR reactor internal materials. As some systems, primarily instrumentation and controls for the reactor and experiment monitoring, became obsolete it is necessary to upgrade these systems to more modern technology. The time period for obsolescence has grown shorter for electronic systems that utilize computers but fortunately there continues to be a supply chain (albeit with its own finite lifetime) that supports maintenance of legacy systems.

As the ATR approached fifty years of operation the age of some systems had begun to impact the reliability and; therefore, the operational availability of the reactor. As with any nuclear facility, nuclear or personnel safety systems and those required by the regulator are always given first priority for immediate repair or replacement or the reactor cannot operate until these systems are repaired. At some point in a facility’s lifetime, the number of age issues begin to overwhelm the resources available to correct the issues and the reactor must remain shutdown until such time as the safety issues are resolved. Thus, the number of operating days for ATR had begun to decline around 2010 and ATR management resolved to take a different maintenance approach to sustain the long-term operation of the ATR.

In 2012, a program that formally evaluated the ATR plant condition or health system by system was established. Prior to this year, there was no single location of information to track equipment maintenance or performance issues and no single group focused on evaluating ATR's health holistically while still looking down to the component level for correction. A Plant Health Committee (PHC) and an Equipment Reliability Working Group (ERWG) were established to be responsible for an integrated risk assessment process and to recommend equipment repair priorities and estimated costs to management. The PHC directed responsible system engineers to review current information sources (maintenance requests, separate engineering documents, deferred maintenance, etc.) to establish a single database of material condition issues. Specific codes were created that would help risk rank system issues as well as provide a planning prioritization that was based more on fact rather than opinion or emotion. These ranking codes include numeric weighting if the issue was safety related, impacted reliability, provided experiment support, was an operator burden, affected productivity or program growth, or was required by operational requirements and the regulator. These factors provided a single numeric result that created the initial risk ranking and prioritization for ATR. This process emulated the Institute for Nuclear Power Operations (INPO) AP-913, Equipment Reliability Process Description, but was modified based on ATR needs, resource availability to manage the program, and the unique differences of a test reactor to power reactor. Over the subsequent five years, the PHC has created a database of key systems and equipment with priority as a function of risk to the ATR's operation or to the irradiation mission. The PHC continues to meet monthly to update system health reports and evaluate any changes to the list of priority systems. Occasionally, a piece of equipment that is showing rapid degradation or exhibits potential failure indications is moved higher in the prioritization.

In 2015, it became evident that current levels of operation and maintenance (O&M) funding was not sufficient to address some of the more significant equipment issues and it was only a matter of time before an equipment failure caused an extended shutdown as repairs occurred or a replacement was fabricated. In fact, two equipment issues in 2014 and early 2015 would have kept the reactor shutdown for over year each if replacement components had not been available by coincidence. A funding strategy was proposed that addressed the top equipment needs over a five-year period which would result in the largest reduction in programmatic risk in that time. The proposed strategy would not address all the equipment needs but provide a path that would create the largest improvement in reliability in the shortest period with the lowest relative cost. The strategy included purchasing of replacement equipment for some systems that were operating beyond original design life and key spares for critical systems that had long delivery times.

With the support of ATR and INL sponsors, additional funding to address plant health has become available and ATR has been executing procurements and equipment replacement or refurbishment as appropriate. Although the overall ATR reliability has improved, the maintenance or replacement of some major equipment items requires longer outage lengths than have traditionally been scheduled in a ATR operational year. This has conflicted with the experimenter's irradiation needs so ATR has been working to improve outage performance to complete the planned work in less time or break large projects into phases that reduce operational impact.

As INL and the Department of Energy look to the future it is clear that the national and international nuclear material irradiation needs are growing. ATR provides a vital irradiation service to the world and will be required to operate reliably for several decades more. Because of this realization, the current 5-year planning horizon for plant health and equipment reliability has been modified to support the ATR age management and sustained operation strategy. This change requires making equipment upgrade, replacement, or refurbishment decisions based on a planning horizon of three or more decades into the future without losing sight of the current equipment conditional environment and addressing near-term and long-term issues in the work planning process.

When stand-alone nuclear research facilities are built the infrastructure supporting those new facilities are also built and usually age at the same rate as the primary facility. The word usually is used here because often the support systems and infrastructure have looser maintenance requirements and may not be on a priority list with limited funding which could minimize preventative maintenance performed. In 2017, ATR performed a fence to fence infrastructure and support systems health evaluation that would inform long-term site plans for water, sewer, electrical, and building condition. It was soon realized that the true condition of some of these systems was unknown because they could not be directly evaluated. Some buried water, sewer, and air piping had never been fully inspected since originally installation and it was noted that excavating to inspect aged or degraded piping could cause unexpected leakage as the surrounding soil moved. A determination was made to perform internal inspections and investigate technologies that allow buried piping repairs without access to the outside of the pipe or plan full replacement of the piping. Additionally, due to past limited funding, several well pumps that provide water to ATR had not been refurbished in nearly two decades. With the primary focus of the PHC on immediate ATR reactor equipment reliability needs, the infrastructure issues did not rank high on the prioritization listing and it could be nearly a decade before planning for equipment replacements would occur. The emphasis for ATR's plant health investments remain on the immediate equipment issues but the 5-year planning window now includes addressing infrastructure issues well in advance of the need.