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Beyond Nuclear Briefing Paper

"Nuclear Autopsy": The missing link between decommissioning reactors and operating license extensions

Decommissioning includes the process of dismantlement (DECON) of nuclear power stations that can begin within the first decade following permanent closure and the remediation of radioactive contamination and hazardous materials to return sites to host communities for unrestricted or restricted use. But decommissioning has another critical role. The majority of nuclear power stations that remain operational have been extending their operating licenses from the original 40 years to 60 years and now the first applications to operate even longer for 60 to 80 years. Decommissioning is recognized as an increasingly important opportunity at the end-of-reactor-life-cycle to harvest aged materials for the scientific analysis of the destructive effects of age-related degradation to inform the reliability of safety margins during these extended operating periods. This is particularly critical for the material analysis of large irreplaceable components with areas inaccessible to inspection and monitoring that include containment structures and liners, reactor pressure vessels and internals and thousands of miles of electrical cable, jacketing and insulation.

The United States Nuclear Regulatory Commission's (NRC) Office of Nuclear Reactor Research and Pacific Northwest National Laboratory (PNNL) are calling on industry to prioritize and provide input through the "strategic harvesting" for the laboratory analysis of aged material samples (steel, concrete, electrical cables, etc.) taken from safety-related reactor systems, structures and components in permanently closed reactors. The requested analysis of aged samples aims to reduce significant scientific knowledge gaps and help researchers learn more about operation-induced cracking, fatigue, corrosion, embrittlement caused by decades of exposure to extreme environments of radiation, temperature, vibration, humidity and fatigue. An "autopsy" by destructive examination and the laboratory testing of samples is critically important to establish confidence in equipment reliability during the license renewal period, acceptance criteria for industry safety standards, benchmarking the impacts of age degradation on actual safety margins and accurately calibrating computer models for accelerated aging.

To date, according to the NRC, harvesting and testing opportunities have been significantly limited to small sample sets taken from the decommissioning Zion (IL) and Crystal River (FL) nuclear stations, both pressurized water reactors. The NRC explains that the dearth of harvesting is due to few nuclear power stations being decommissioned, even though to date ten U.S. reactors have completed decommissioning operations, seven units are currently in decommissioning and 14 units have been indeterminately mothballed in "SAFSTOR" potentially for decades to come.

More reactor closures are scheduled to begin in the summer of 2019. The nuclear industry has

largely relied on opportunistic sampling and testing of components removed for replacement and simulated accelerated aging of original materials. Industry has mothballed closed units for decades without analysis. DECON has resulted in burial of large components without harvesting scientifically valuable archival materials or performing aging analysis.

For example, during the initial license renewal program in the 1990s, NRC sought industry samples of irradiated base metal and weld material excavated from radiation embrittled reactor pressure vessels at the closed Yankee Rowe (MA) and Trojan (OR) nuclear power stations. Instead, the operators dismantled the reactors without taking archival samples, and transported the vessels whole for burial at Barnwell, SC and Hanford, WA, respectively, without analysis.

More recently, Exelon Corporation's Oyster Creek, which operated for 49 years as the world's first Fukushima-style reactor design, closed in 2018. This GE Mark I boiling water reactor is a prime candidate for the NRC and PNNL combined call to "*require further research to understand and quantify aging mechanisms*" by autopsy. However, Exelon has refused to investigate age degradation in what was the oldest operating reactor in the US, only now surpassed by Exelon's still operational GE Mark I boiling water reactor at Nine Mile Point Unit 1 in upstate New York. Meanwhile, Exelon has filed an application before the NRC for the second license renewal (60 to 80 years) of two GE Mark I boiling water reactors at its Peach Bottom nuclear station in Delta, PA.

Under current license renewal regulations, the NRC and the nuclear industry are required to address age-related safety issues to reasonably assure the reliability of essential passive systems, structures and components through the projected license extension period. The critical challenge at hand is to sufficiently understand how materials and safety margins deteriorate and increase hazardous operations with potential catastrophic failure. Gathering the observable and measurable scientific evidence from reactor operating experience is a requirement in developing effective age management programs to monitor the degree and rate of aging degradation throughout the license extension period.

Arguably, without prioritizing and requiring industry input with harvesting and testing materials through an autopsy of decommissioning facilities, reactor closures will continue to narrow the availability of operating experience needed to sufficiently inform safety margins, making current and extended reactor operations more unpredictable and hazardous.

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