From: Giacinto, Joseph
Sent: Tuesday, May 25, 2021 2:09 PM
To: AdvancedReactors-GEISDocsPEm Resource
Subject: ORNL - Ending the MSRE, A fabled reactor experiment's cleanup
Attachments: ORNL 1998EndingMSRE.pdf

Ending the MSRE

A fabled reactor experiment's cleanup project may be its crowning glory

In the MSRE's heyday: ORNL Director Alvin Weinberg (far left) and Atomic Energy Commission Chairman Glenn Seaborg (pointing) were on hand in 1968, when the Molten Salt Reactor began operating with uranium-233 fuel.

It's the final and somewhat ironic chapter of one of ORNL's largest and most storied projects. A successful but spurned and dormant experimental nuclear reactor is ending its days as a cleanup project.

The Molten Salt Reactor Experiment's fate is far from ignoble, however. The MSRE continues to teach, even in its throes, in the course of an environmental remediation project that has been a success in its own right.

In the 1960s, the MSRE demonstrated what many believed would be the optimal reactor technology. Initially conceived for the nuclear airplane project, the MSRE was fueled by a molten salt containing uranium tetrafluoride that circulated within the reactor. Proponents espoused it as one of the safest and most versatile reactor designs.

There are still quite a few true believers in molten-salt technology at Oak Ridge and elsewhere. However, decision makers passed over the concept and the MSRE shut down in 1969 after four years of operation. The MSRE's fuel salt solidified in holding tanks, where it was reheated once a year to maintain the fuel.

The reactor facility, called "Ole Salty" by some, was converted to lab and office space as the reactor lay in stand-by status. Then, in March 1994, samples of the off-gases in the process lines unexpectedly revealed uranium hexafluoride (UF_6) and fluorine, a highly reactive gas. Where surveyors expected to find part-per-million concentrations, they found concentrations of UF_6 of up to 8 percent and fluorine of 50 percent.

That, and the discovery of uranium deposits on a charcoal filter, prompted a precautionary evacuation of the MSRE buildings. Because the uranium had migrated outside the storage tanks, MSRE became a remediation project under federal and state auspices. But it was a brief disruption, and any risk of a criticality accident or release of radioactive gas was quickly minimized.

Engineers then had a more protracted challenge: How to remove both the UF_6 that had collected in the piping and the very radioactive and chemically unstable uranium-233 that had collected in charcoal-bed filters for off-gases. Those filters were surrounded by a water-filled chamber, raising concern of a criticality accident that could have spread contamination for miles.

Ole Salty may have been quiet for more than 20 years, but there had been ruminations in its old innards.

Now, four years later, more than half of the UF_6 has been removed, thanks to the concerted efforts of a number of ORNL organizations led by the Chemical Technology Division and including the Robotics and Process Systems, Instrumentation and Controls, Metals and Ceramics, Life Sciences and Plant and Equipment divisions, the offices of Radiation Protection, Nuclear Safety and Quality Services and Waste Management Operations, along with Energy Systems Engineering. In July, DOE signed a record of decision with the Environmental Protection Agency and the Tennessee Department of Environment and Conservation for removing the radioactive salt now stored in a closely monitored container at the facility.

In four years the MSRE cleanup has hit the long home stretch of removing the fuel salt from the site. No one is more delighted at the MSRE cleanup's progress than Jim Rushton, who in 1994 was picked to lead the project.

"We discovered a highly hazardous situation in 1994," Rushton says. "The uranium in the charcoal beds was in an unfavorable geometry that could have led to a chain reaction. If the system had burped, the contamination would have been dispersed over a wide area.

"The more studies we did, the more they showed that it could happen. There was a significant potential for disaster."

After ORNL project planners and engineers alleviated the criticality risk, they mapped out a remediation plan and had it approved. Bill Del Cul, Mac Toth, Lee Trowbridge and other Chem Tech chemists solved the chemical explosion risk by devising a process to combine ammonia with the fluorine gas trapped in the charcoal bed.

Next, Rushton says, came a long and careful process to flush the UF_6 from the MSRE's piping. Chem Tech's Richard Faulkner led a team of experts on UF_6 from K-25's gaseous diffusion operations, plus retired consultants from the MSRE's heyday, Dick Engel and Luther Pugh, were brought in for technical support.

The key was having people with a molten-salt background still around.

Clearing the closed piping system wasn't as simple as, say, flushing a car radiator. For instance, UF_6 had solidified in some of the pipes, creating blockages that had to be chemically treated or bypassed. Engineers and chemists were dealing with highly corrosive and radioactive substances, so all moves were carefully thought out: Poster-sized timetables of project starts and deadlines are displayed throughout the MSRE facility, scrupulously outlining when project decisions are to be made and tasks completed.

As Toth, a recently retired Chem Tech staffer, remarks, "If we had just plunged in, we could have had an explosion. The key was having people with a molten-salt background still around."

Thanks to that meticulous preparation, MSRE's remediation project has progressed to the point where "dilution purges" are being conducted to flush and trap the remaining traces of UF_6. The UF_6, which was an unanticipated product of the annual reheating of the fuel, will eventually be converted to a more stable oxide, U3O8, at ORNL's alpha hot cells in Building 4501. Alan Icenhour, Del Cul and Dave Williams are leading the project's conversion preparation activities.

However, retrieving UF_6 that migrated to the off-gas filtering system remains a major challenge to the MSRE project team. Uranium has collected in the first couple of feet of the 80 feet of charcoal-filled piping, which was the source of the criticality concern four years ago. Remote technologies and robotic equipment devised by Ken Walker and engineers from the R&PS Division will be used in removing the filter material.

MSRE's other big challenge is removing the highly radioactive fuel salt. The technical alternatives have been extensively analyzed, including an evaluation by the National Academy of Sciences. Fred Peretz, Tom Kring and David Vandergriff lead a team that will melt the salt in the drain tanks, separate and remove the uranium and remove the residual salt.

The uranium in the fuel salt is in the form of uranium-233, once a fuel material but now touted as a source of bismuth-213, an isotope useful in nuclear medicine. MSRE fuel—the overall inventory of uranium at

MSRE is about 17 kilograms— stands a good chance of saving lives in the form of radioisotope treatments. ORNL stores almost half the world's supply of U-233 and has some of the only hot-cell facilities suitable for processing the rare material for medical uses.

"We've been fortunate in a number of things," Rushton says. "For instance, the folks who shut down the MSRE sealed the pressurized piping system, so there were no leaks that could have caused a release. Safety issues have been addressed in an orderly fashion and we've alleviated the risks with a good safety record.

"This has been a tremendous example of a team effort and a remediation project that's gone right. Outside reviewers urged DOE to keep this team in place, and Bechtel Jacobs, the EM contractor, has been very supportive.

"Our role ends when all the fuel is out. Bechtel Jacobs will decide what to do with the facility, which has good offices and a high-bay area that is very strong structurally and could be used for other work."

But for now, Rushton says, "We're ready to go. We're ready to take it out of here."—*B.C.*