

## WHY THE MOLTEN SALT REACTOR (MSR) WAS NOT DEVELOPED BY THE USA

I was re-introduced to Molten Salt Reactors (MSRs) by Oak Ridge National Laboratory's (ORNL) Dr. Uri Gat in 1993 while researching Aqueous Homogenous Reactors, which ORNL had also built and operated. I say "reintroduced", because like many Nuclear Engineering and Physics students, I had briefly heard of MSRs, but whose introduction was followed with the caveat "... was a promising reactor that unfortunately suffered materials problems", or "... suffered from corrosion", which sounded reasonable given their "molten salt" name. Unfortunately, it is a myth that the MSR suffers materials problem; ORNL's extensive research conclusively solved them. Upon learning there were no corrosion or any other problems preventing the meltdown-proof MSRs from being successfully built and operated, as ORNL did in 1954 (Aircraft Reactor Experiment - ARE) and the Molten Salt Reactor Experiment (MSRE - 1965 - 1969), the intelligent person asks, "If they were so good, then why were they not fully developed and widely built?". I asked this question to many of the Molten Salt researchers in the early 1990s. They would usually either frown or smile ruefully and say something cryptic like,

'There were no technical reasons why the MSR was not pursued.'

When Dr. Alvin Weinberg's published his memoir book, "The First Nuclear Era", in 1994, most Oak Ridge National Laboratory's (ORNL's) MSR researchers were shocked when they read on page 200 that their Director of 18 years had been fired in 1972 for advocating the MSR instead of the Republican Party (AKA "GOP" - Grand Ole Party) selected Liquid Metal Fast Breeder Reactor (LMFBR) and reprocessing plutonium nuclear fuel for Mixed OXide (MOX) fuel elements in the already existing Light Water Reactors (LWRs). Alvin Weinberg clearly explains in his memoir, on pages 198 - 199 (ibid), how the Republican Party and the Nixon Administration had already selected the LMFBR:

*"At the time he [Milton Shaw] became director of reactors, the AEC, at President Nixon's direction, had made the liquid-metal-cooled fast breeder (LMFBR) the primary goal of its reactor program. Milt tackled the LMFBR project with Rickoverian dedication: woe unto any who stood in his way. This caused problems for me since I was still espousing the molten-salt breeder."*

*"And, although I found Milt pleasant enough, it was clear that he had little confidence in me or, for that matter, in ORNL. After all, we were pushing molten salt, not LMFBR."*

For Dr. Weinberg's support of the MSR and increased nuclear safety, he was fired in 1972:

*"I suddenly realized that my tenure as director of the Oak Ridge National Laboratory might be coming to an end. This was hinted to me by Bob Hart, the Oak Ridge area manager who let on, more or less directly, that 18 years as director may have been long enough. Wally Zinn, who was chair of our Laboratory Visiting Committee, tried to convince me that I should stay and that his committee had full confidence in me. But, despite these reassurances, my days at ORNL were numbered. Finally, late in 1972, John Swartout, my former deputy who by this time was vice president for research of the Union Carbide Corporation in New York, told me I had to go."*

I found myself increasingly at odds with the reactor division of the AEC. [The Director of the Reactor Division at the time was Milton Shaw. Milt was an amiable, but dedicated engineer. He was a graduate of the Oak Ridge School of Reactor Technology. (Once, when I became particularly annoyed with him, I looked up his grades at ORSORT—he was neither the best nor the worst student.) He had a very successful career with Admiral Rickover's naval reactor division and had been the program manager of the Shippingport project. Milt was cut very much from the Rickover cloth: he had a singleness of purpose and was prepared to bend rules and regulations in achievement of his goal. At the time he became director of reactors, the AEC, at President Nixon's direction, had made the liquid-metal-cooled fast breeder (LMFBR) the primary goal of its reactor program. Milt tackled the LMFBR project with Rickoverian dedication: woe unto any who stood in his way. This caused problems for me since I was still espousing the molten-salt breeder.]

Milt was like a bull. Extremely hard working, terribly demanding, singleminded. He enjoyed the confidence of Commissioner Jim Ramey, and of Rep. Chet Holifield—so his position within the AEC was unassailable. And, although I found Milt pleasant enough, it was clear that he had little confidence in me or, for that matter, in ORNL. After all, we were pushing molten salt, not

LMFBR. More than that, we were being troublesome over the question of reactor safety. Milt, and even Jim Ramey, seemed to be convinced that our concerns were not genuine, but rather were conjured up by us to increase the AEC's support of our work on reactor safety.

That something was seriously amiss became apparent to me around 1972. Floyd Culler and I were talking to Chet Holifield about our work on reactor safety. Chet was clearly exasperated with me, and he finally blurted out, "Alvin, if you are concerned about the safety of reactors, then I think it may be time for you to leave nuclear energy." I was speechless, but not Floyd: ever my

Fig 1. Above images from Dr. Alvin Weinberg's memoir, "The First Nuclear Era" (1994), pages 198 - 199, in Google Books (scanned books).

URL: <http://books.google.com/books?id=otQDyt9PeswC&pg=PA198&dq=GOP+LMFBR+President+Nixon%27s>

## MSRs and Thorium Nuclear Fuels since Dr. Weinberg's firing

'The best way to stop a Revolution is to shoot the leader', or in a civil or commercial arena, fire the innovator. After Dr. Weinberg was fired as Director of ORNL, there was no MSR development during the remaining Nixon and Ford Presidential terms besides the publishing of ORNL's final reports. MSRs got a brief look as part of President Carter's Nonproliferation Initiative. However, in 1977, President Carter's main nuclear project was Admiral Rickover and his nuclear core designer, Dr. Alvin Radkowsky's re-coring the first American Pressurized Water Reactor (PWR) at Shippingport, Pennsylvania with thorium-uranium nuclear fuel in a Seed and Blanket Unit (SBU) design. This culminated in the highly successful demonstration of long lived thorium fuel and nuclear Breeding in a Light Water Reactor (LWR), called the Light Water Breeder Reactor (LWBR), completed in 1982.

In 1981, President Reagan stopped all further development on thorium nuclear fuels, LWBR, and MSR development. It would not be until the President Clinton Administration that an American sponsored thorium fuel project would revive the LWBR's SBU fuel elements as a way to destroy excess Russian military plutonium in their PWRs (called VVER). This inexpensive demonstration was necessary to validate the extremely long fuel lifetime claims of the SBU (10 years versus a typical 3 year PWR fuel lifetime) and high burn-ups (100 - 150 MWd / kg versus a typical 33 - 50 MWd / kg for PWR fuel elements). This partnership with Russian nuclear interests, their military, Raytheon, and Dr. Radkowsky's corporation, Thorium Energy, was overseen by Brookhaven National Laboratory (BNL). The Clinton Administration also supported Los Alamos National Lab's (LANL) Spallation nuclear energy and built ORNL's Spallation Neutron Source (SNS).

In 1981, at the end of the Clinton Administration and the first year of President Bush's Administration, the US Department of Energy (DOE) released their review of nuclear energy systems, and selected 6 candidate Nuclear Reactor Designs for the next Generation of nuclear power reactors; the Generation IV Reactors, of which the MSR was one of the selected designs. In December 2002, DOE published "A Technology Roadmap for Generation IV Nuclear Energy Systems" with a timeline and estimated budget for each design. President Bush did not fund the MSR, and instead started his Global Nuclear Energy Partnership (GNEP) which revived the old Republican LMFBR, now renamed various other names (e.g., Sodium Cooled Reactor - SCR, Liquid Metal Fast Reactor - LMFR, GE's Power Reactor Inherently Safe Module - PRISM, Advanced Liquid Metal Reactor - ALMR), and reprocessing plutonium into Mixed OXide (MOX) fuel elements for use in existing LWRs. The Bush Administration terminated Thorium Energy's project to use Radkowsky's SBUs to destroy excess Russian military plutonium in 2006.

Recently, despite canceling GNEP in April 2009, and perhaps due to President Obama's campaigning and continued support of Nuclear Energy's utility to the USA, ORNL hosted the Fluoride High-temperature Reactor (FHR) conference in October 2010 to explore molten salt cooled reactors capable of temperatures (700° C - 1300° F). There is also growing International interest in MSRs, especially among Chinese, French, Czech, and Russian nuclear specialists, who remain baffled as to why the USA abandoned Molten Salt Nuclear Reactors (MSRs) in 1972.

## References

“The First Nuclear Era: The Life And Times Of A Technological Fixer”, by Alvin M. Weinberg, (1994), 324 pages, ISBN-10: 9781563963582.

URL: <http://www.amazon.com/First-Nuclear-Era-Times-Technological/dp/1563963582>

Light Water Breeder Reactor (LWBR)

URL: <http://www.world-nuclear.org/info/inf62.html#LWBR>

Example of President Carter’s Nonproliferation Initiative examination of MSRs:

ORNL-TM-7207, “Conceptual Design Characteristics of a Denatured Molten-Salt Reactor with Once-Through Fueling”, Engel, et. al., July 1980

URL: <http://www.moltensalt.org/references/static/downloads/pdf/ORNL-TM-7207.pdf>

Radkowsky Thorium Seed and Blanket Unit (SBU)

IAEA's "The Non-Proliferative Commercial Radkowsky Thorium Fuel Concept", by M.J.

Higatsberger, Institute for Experimental Physics, University of Vienna, Austria, URL: [http://](http://www.iaea.org/inis/nkm/nkm/aws/fnss/fulltext/te_1319_31.pdf)

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World Nuclear Organization’s General overview of thorium and Radkowsky’s SBUs

URL: <http://www.world-nuclear.org/info/inf62.html#Radkowsky>

Generation IV Roadmap, December 2002, DOE published “A Technology Roadmap for

Generation IV Nuclear Energy Systems” (URL: <http://www.gen-4.org/PDFs/GenIVRoadmap.pdf>)

History of Oak Ridge National Laboratory (ORNL) Spallation Neutron Source (SNS)

URL: <http://neutrons.ornl.gov/facilities/SNS/history/>