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by Ian J. Slater

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THE SLOWPOKE NUCLEAR RESEARCH REACTOR - A BRIEF HISTORY

by

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June 1998

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Abstract

This Paper is based on a series of interviews carried out by the author with engineers and scientists involved with low power Slowpoke reactors and on material originating with Atomic Energy of Canada Limited (AECL). The basic questions answered are related to the design and construction of Slowpokes and their international sales in competition with the American Triga reactors, which were on the market before the Slowpokes, and the Chinese MNSR reactors, which were essentially copies of Slowpoke. Most of the 'action' took place in the 1970s.

The two illustrations on pages 14 and 15 originated with AECL.

This Paper was presented by the author at the CSME History Committee Seminar at Ryerson Polytechnic University on 22 May 1998.

About the Author

Ian Slater began his university career at Carleton University in aerospace engineering. But after two years he left engineering and transferred to the bachelor's program at the University of Toronto, where his subject was the history and philosophy of science. After graduating, he returned to Carleton where he obtained a master's degree in philosophy, with concentration on the philosophy of science. He is currently in the first year of a doctoral program at the Institute for the History and Philosophy of Science and Technology (IHPST) at the University of Toronto. His area of research interest is the history of early 20th century nuclear technology and, specifically, non-military applications and questions concerning the relationship between technology and society.

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This paper is based upon a series of interviews with engineers and scientists that have been involved with the Slowpoke nuclear research reactor. My initial interest in this subject was sparked by the planned shutdown of the Toronto Slowpoke facility. When I heard about the closure, I decided that a history of the reactor could be timely and interesting. Some of the information you will be hearing today is anecdotal, and some is based upon AECL material. The question that has focussed my research from the beginning is a simple one: what factors (both + & -) contributed to the distribution of the Slowpoke, nationally and internationally?

In order to provide context for the later historical details, I want to briefly run through a few technical details about the reactor. The Slowpoke (an acronym for Safe Low Power (K)ritical Experiment) has an operating power of 18-20 kW, it uses approximately 1100g of low enriched (~ 20%) U^{235} Uranium Oxide fuel, it has a beryllium reflector (which can be augmented to extend the life of the core), and uses light water as a moderator.

Presently, the reactor has several standard applications. Its primary application is Instrumental Neutron Activation Analysis, which involves irradiating samples in the reactor's neutron flux and taking a gamma ray spectrograph of the irradiated sample. Elements produce "spikes" on the spectrograph, and up to 74 elements can be "read off" by identifying the spikes so produced. Trace elements in substances can be identified in this manner, and substances of unknown composition can also be analysed. This analysis can be non-destructive (by making the radioactivity of the samples short lived), and is of considerable use to those who wish to retain their samples (analysts in forensics or archeology for example)

Slowpoke can also produce short lived isotopes by irradiation, that can be used as tracers in pharmacological and medical research. The RMC Slowpoke has been rigged for neutron radiography, by use of a special neutron screening device, and it has been used to successfully radiograph small aircraft parts. The Jamaica Slowpoke is used for geochemical mapping, where soil and rock samples are taken from mapped areas to determine trace amounts of valuable subterranean metal deposits. The high sensitivity of the Slowpoke makes this application very valuable. The Saskatchewan Research Council Slowpoke is used primarily for uranium purity analysis. Finally, the reactor is used for undergraduate training, due to its inherent safety and relative simplicity of operation.

The reactor is inherently safe. It has negative temperature and void coefficients in the core, which means that the light water moderator boils off when the reactor overheats, slowing the reaction down. Thus, if the cooling system completely failed, the reactor would simply settle down to an extremely low operating power. Additionally, the reactor has low excess reactivity, and the core is sealed, access being restricted to licenced AECL engineers. It is physically impossible for the reactor to explode or melt down, barring the planting of explosives around or in the reactor core.

The fuel rods in the Slowpoke are a uranium / aluminium alloy, and are highly radioactive once installed. Thus, in order to "steal" the uranium from a Slowpoke to make a bomb (a concern that has been voiced by foreign governments and various environmental groups), the core would have to be unsealed (which is difficult, as it would be highly radioactive at the time), and the aluminium / uranium alloy rods (which would also be radioactive) would have to be chemically separated (which is a difficult process even when the two substances are not irradiated). All of these factors make proliferation concerns somewhat irrelevant. Due to the inherent safety of the reactor, it is licenced for unsupervised operation (under remote surveillance) for up to 24 hour periods.

Presently there are 8 Slowpoke's at large, at Dalhousie University, Ecole Polytechnique, Royal Military College, the University of Alberta, the University of Toronto, the University of the West Indies, the Saskatchewan Research Council, and at AECL Kanata. The AECL Kanata reactor was decommissioned in 1992, and the U of T reactor is scheduled for decommissioning by January of 2000.

The history of the reactor can be traced back to Eisenhower's "Atoms for Peace" movement in the 1950's. Due to the U.S. government's desire to find peaceful uses for nuclear power, research reactors were distributed worldwide. The American research reactor of choice in the 1960's was the "Triga", and the Americans gave away most of the 60-70 Triga research reactors that are now in use as part of "Atoms for peace."

In 1967, a paper published by George A. Jarvis and Carroll B. Mills of the Los Alamos Scientific Laboratory suggested that the lowest value for critical mass in a reactor assembly was 250 grams of ^{235}U in a polyethylene core surrounded by a thick beryllium reflector. Based on this information, John Hilborn (the inventor of the Slowpoke) and R.B. Lyon submitted a proposal later that year for a low-cost neutron source that could compete with the accelerators that were popular at the time. The proposal was not immediately pursued.

Bob Jervis, an engineer at U of T, had worked on Neutron Activation Analysis at Chalk River (with the NRX and NRU), and was interested in getting a research reactor for the University of Toronto Department of Chemistry and Chemical Engineering. Dr. Jervis had worked with John Hilborn at Chalk River, and he sent Dr. Hilborn down to General Atomics in San Diego to make a technical evaluation of the Triga reactor on behalf of U of T in 1969-1970. Although technically excellent, the Triga was and is expensive. After some digging, Dr. Hilborn determined that the operating costs (basically the cost of fuel + supervision) were too high. Dr. Hilborn returned to U of T with the news, and the Slowpoke concept was given a boost.

By 1971 a prototype Slowpoke reactor had been built and was brought to the University of Toronto for analytical testing. This was a much smaller reactor than the "commercial" Slowpoke that is used today. Work was then commenced on upgrading the power and flux of the Slowpoke to meet the needs that would have been filled by the Triga, and in 1975 AECL Commercial Products built a prototype commercial Slowpoke at Tunney's pasture in Ottawa to determine feasibility. Five were built at the same time, four to be installed in Canada (at Toronto, Dalhousie, Ecole Polytechnique and Alberta), and one was earmarked for the University of Cologne in Germany. By 1976 federal funding was obtained for the four initial Canadian reactors, and they were installed over the period of 1976-1977. The Saskatchewan Research Council obtained their reactor in 1981, the AECL's reactor was moved from Tunney's pasture to Kanata in 1984, and was subsequently decommissioned in 1992. The Slowpoke at the University of the West Indies was commissioned in 1984, and RMC obtained their reactor in 1985.

That is the basic story of the startup of the reactor. At this point I want to delve into a bit more detail about the attempts to sell the reactor internationally. The sale in Jamaica was the only successful international sale of a Slowpoke. This seems odd, things got off to a fast start, there were initially many candidates for international sales (U.S., Mexico, Europe, South America and China to name a few), and in the beginning AECL was aggressively marketing the reactor. So what happened? I will start with the story of the reactor planned for the University of Cologne in Germany, which was built with the original four reactors in 1975.

Negotiations were started with the University and the German government in 1975, 7-8 years later (the figure varies depending on where you draw the line) the deal was abandoned by both parties. What had happened, and what took so long?

Briefly, there were several factors that combined to frustrate the sale. The post WWII German government had extremely strict nuclear proliferation regulations, which caused delays. Additionally, there were three separate levels of government nuclear regulation: Federal, "state" and regional, and one independent technological regulatory organization called the "TUV", all of whom had to approve the deal. Both the strong "green" movement in Germany, and the government itself, treated the Slowpoke as they would have treated a power reactor, under the assumption that all nuclear technology is equally problematic due to the potential consequences. This led to extra safety features and considerable concerns about "containment", which are obviously irrellevant considering that the reactor simply cannot explode. All of this drove up costs and caused delays.

By the time the 7-8 year negotiation period was over, the University was told by AECL that the price had gone up considerably (there was high inflation in Canada at the time and thus the costs to AECL were high). AECL (specifically Commercial Products) was not willing to lower the price to the original level, treating the reactor as a "loss leader"for example, as they felt that the European market was not promising. The deal was then closed. The failure of the German deal was a result of misunderstanding of the nature of the reactor, and fairly strict government anti-proliferation legislation. My next story, related to the failed Chinese Slowpoke sale, is even more interesting.

There were indications in the mid-70's that China was interested in purchasing several Slowpoke reactors from AECL, and Commercial Products sent over customer information concerning the reactor and its support infrastructure to the Chinese government, as they would for any potential client. Around this time, a graduate student from the University of Ottawa phoned George Burbidge at Commercial Products and told him that he (the graduate student) had been chosen by the Chinese government to study research reactors to determine which one to purchase, and that he wanted to obtain information on the Slowpoke. The student was given a tour of the reactor, along with the standard handouts and promotional literature.

Soon after the student started calling and asking detailed questions about the reactor fuel system. For example, he asked for exact measurements of the distance between fuel pins in the core, and for exact distances between certain elements of the reactor assembly. After several weeks of these sorts of questions, Commercial Products decided to stop answering his questions. Unbeknownst to the people at Commercial Products, at the same time other visiting students and professors were making similar inquiries at several of the other Slowpoke installations in Canada, with varying amounts of success. Then, the questions stopped and nothing more was