Zirconium and hafnium separation at Y-12

When then Captain Hyman G. Rickover completed his nuclear reactor training at the Clinton Laboratories in 1947, he quickly saw the advantage of using highly enriched uranium reactors in ships. That was when it was first realized that there was a need to separate hafnium from zirconium for pure zirconium. Zirconium does not absorb neutrons and thus was excellent for cladding reactor fuel for navy reactors.

While the actual separation did not occur until the early 1950's this work was done in Building 9211 at Y-12. When Rickover was assigned to the Division of Reactor Development, U.S. Atomic Energy Commission in 1949, his main efforts were directed toward the design of a specialized nuclear reactor for the Navy. As director of the Naval Reactors Branch, he implemented the design. A portion of that work was the separation of hafnium from zirconium at Y-12.

Like the separation of stable isotopes using the calutrons in Building 9731 that began immediately after the calutrons were no longer needed to separate uranium, this unusual and highly difficult separation of hafnium from zirconium was readily undertaken by Y-12. However, this was a chemical separation process rather than an electromagnetic separation.

Finis "Pat" Patton told me the details of this process. When he came to Y-12 recently for a knowledge capture interview, he wanted to see Building 9211. I wondered at the time why that building held special meaning for him, but as he asked, I drove close to it and showed the building to him. Then he said, "That is where we separated hafnium from zirconium for Rickover's nuclear reactors." Of course I made a mental note to follow up on that.

Several days later I called Pat and we talked about the process. It was a highly corrosive process, so much so that some of the building steel had to be replaced after the process had operated for several months there. Pat mentioned several aspects of the process that required careful handling and knowledgeable personnel. He led the effort and was instrumental in the design of the process.

The main equipment used consisted of 20' tall glass extraction pulse columns and measuring pumps. The seal for the glass columns was difficult to design and required springs on the outboard portion of the seal to hold it in place. Pat designed this seal personally and was proud of the manner in which it worked. The stainless steel plates inside the columns were porous and consisted of several stages.

The separation of hafnium from zirconium required several steps and during some of the transition steps a very unpleasant gas, phosgene, was present. This required gas masks to be worn. Not all the workers wore the masks and Pat said those who attempted to hold their breath and make the necessary adjustments when the gas was present as often as not could soon be seen on the grass outside the building throwing up. He described this situation as being somewhat "macho" image of the men who did not like to wear the gas masks. This is hard for us to understand in today's safety conscious climate, but evidently was not perceived as all that unusual then.

Other chemicals present in the process area included carbon tetrachloride, sulfuric acid, nitric acid and hydrochloric acid. All these chemicals were nasty characters requiring careful handling to avoid burns or inhalation.

Many of the process operations were vented to the atmosphere through the roof of the building. Pat said that he once went on the top of the roof and found it filled with dead birds. The phosgene gas had taken its toll on the birds.

The name of the first nuclear submarine was another interesting story. It seems that then Captain Rickover had finished the Reactor School at Clinton Laboratories in 1947 and then had set about creating the nuclear navy. One of his main goals was to build the first nuclear submarine.

Pat told me the source of the name for this first atomic submarine. He said that then Captain Rickover named the first atomic submarine for the Nautilus built by Captain Nemo in the 1870 classic adventure tale, *20,000 leagues under the sea* by French author Jules Verne. Of course there was then a movie

made by Walt Disney in 1954 named *20,000 leagues under the sea* that used the same Nautilus submarine name.

Nautilus was authorized by congress in July, 1951. Construction took 18 months. The NAUTILUS web site notes the nuclear navy “was made possible by the successful development of a nuclear propulsion plant by a group of scientists and engineers at the Naval Reactors Branch of the Atomic Energy Commission, under the leadership of Captain Hyman G. Rickover, USN.”

Nautilus was launched on January 21, 1954, and on September 30, 1954, Nautilus became the first commissioned nuclear powered ship in the United States Navy. The reactor used zirconium clad nuclear fuel using the pure zirconium from Y-12 and the enriched uranium from K-25. The film by Walt Disney was released December 23, 1954.