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M. S. Gerber

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Westinghouse Hanford Company
P.O. Box 1970
Richland, Washington 99352

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DEACTIVATION COMPLETED AT HISTORIC HANFORD FUELS LABORATORY

Michele Gerber
Westinghouse Hanford Company

Deactivation work was completed as of March 31, 1994 at the 308 Fuels Development Laboratory (FDL) at the Hanford Site near Richland, Washington. The decision to deactivate the structure, formerly known as the Plutonium Fabrication Pilot Plant (PFPP), was driven by a 1980s Department of Energy (DOE) decision that plutonium fuels should not be fabricated in areas near the Site's boundaries, as well as by changing facility structural requirements.[1]

Removal of the building's working inventory of plutonium, used in making mixed oxide (MOX) fuel pellets for the Fast Flux Test Facility (FFTF) and other test reactors, took place over the course of a year beginning in mid-1991. Completed in May 1992, this work decreased the yearly security costs for the facility by approximately $3-million. During the peak of its years as a fabrication facility, the 308 Building held as much as 3 metric tons of encapsulated plutonium and approximately 200 kilograms (kg) of MOX powder.

Inventory transfer has been followed by the cleanout and stabilization of plutonium oxide (PuO_2) and enriched uranium oxide (UO_2) residues and powders in the facility's equipment and duct work. This additional effort, along with the transfer of all resident personnel from the building, is expected to lower the annual surveillance budget by another $1 million.

The Hanford Site, located in southeastern Washington state, was one of America's primary arsenals of nuclear defense production for nearly 50 years beginning in World War II. Approximately 53 metric tons of weapons grade plutonium, over half of the national supply and about one quarter of the world's supply, were produced at Hanford between 1944 and 1989. Today, many Site buildings are undergoing deactivation, a precursor phase to decontamination and decommissioning (D&D). The primary difference between the two activities is that equipment and structural items are not removed or torn down in deactivation. However, utilities are disconnected, and special nuclear materials (SNM) as well as hazardous and pyrophoric substances are removed from structures undergoing this process.

ALPHA CONTAMINATION STABILIZED IN GLOVE BOXES AND HOODS

Over the past three years, a small but dedicated crew, the remnant of a once-large FFTF fuel supply staff, has been working in the 308 Building to wipe, spray and seal the 50 glove boxes and six open-faced hoods that will be left inside the facility until complete D&D occurs at a future date. A majority of the glove boxes are approximately 8' long by 3' wide and 3.5' high (not including the approximately 4' high legs on which they stand). These glove boxes, in which MOX powders and pellets were pressed and then sintered into reactor fuel, also contain front and back windows, numerous glove entry ports about 8" in diameter each, equipment doorways and ports, and entryways for electrical and fluid/gaseous services.

However, six of the glove boxes are approximately 30' long by 3' wide and 3' high, with 40 entry ports and multiple windows, larger equipment ports, and other penetrations. These glove boxes held the furnaces and other large, pilot equipment pieces crucial in the many fuels fabrication research and development activities that were pioneered in the building. The open-faced hoods are approximately 4' long by 3' wide and 3' high, and stand on legs about 4' high. These hoods, although they accumulated alpha contamination, did not provide the level of confinement of a glove box, and so were used primarily for work with uranium materials and processes.

The deactivation crew, after removing much of the instrumentation and other small equipment from the building, donned special anti-contamination clothing and extracted small equipment from inside the glove boxes and hoods. They then performed multiple wipe-downs of the inner surfaces, using damp rags that later were dried and disposed as solid waste. Next, they sprayed the insides of the glove boxes and hoods with a modified acrylic latex, contamination fixant that appears cloudy at first but dries to a nearly clear state. Lastly, they covered all of the glove ports with specially fitted metal plates, and placed over them a polyolefin "shrink-wrap" material that contained an adhesive on the inside. The material is the same as that used to protect welds in industrial pipelines. Using a hot air treatment, they activated the tar-like adhesive so that it melted and flowed into all the crevices between the plates and the ports, thus creating a very rugged seal. The plutonium inventory currently remaining ("held-up") in this equipment totals less than 400 grams.

ATTENTION ALSO GIVEN TO DUCT WORK, TEST REACTOR AND OTHER BUILDING COMPONENTS

In the meanwhile, non-destructive assay was performed on 2,000 feet of duct work in the 308 Building. Although only small amounts of contamination were found, the flanges were caulked with silicone sealants. Lastly, the fasteners on the gaskets were painted with a high-grade interior household sealant. Uncontaminated equipment in the building, such as wire-wrap machines used to spiral wrap the outside of each FFTF fuel pin, pulse magnetic welding (PMW) equipment, and profilometers used to make precise measurements of the outside diameter of finished fuel pins, were either excessed or sent to offsite storage.[2]

The deactivation of a 250-KW (kilowatt) TRIGA (Training Research Isotopes, General Atomics)[1] reactor that was emplaced in Room 162 of the 308 Building's Annex in the late 1970s will occur on a slower schedule. The reactor operated for 13 years to perform neutron radiography testing on fuel pellets and pins, to irradiate materials, and to provide reactor operator training. Currently, the TRIGA's 68 fuel elements have been removed from its core and placed in racks in the water-filled pit or reactor pool. An Environmental Assessment (EA) for the disposition of this spent fuel, which has been irradiated to only a low burnup level (less than 1 percent), recently went to DOE for review. However, final disposition decisions have not yet been made. (Fuel burnup refers to the amount of fissions that took place in the fuel over the time that it was in the reactor. A low burnup level means

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[1] TRIGA reactors are trademarked properties of the General Atomics Corp., of San Diego, California.

that very little fissioning took place, and therefore very few fission products were generated.)

Specially designed irradiated fuel shipping/storage casks are being designed by the staff of the Hanford Site's operating contractor, Westinghouse Hanford Company (WHC). Until the fuel leaves the 308 Building Annex however, regular surveillance of this area will be necessary. Following fuel removal, the control rods, other neutron sources, and some instrumentation will be taken out of the TRIGA and the water pool will be drained. Most of the large, fixed equipment will be left for future D&D.[3]

"ATOMS FOR PEACE" GAVE BUILDING ITS START

Throughout its active lifetime, the 308 Building was the scene of an almost dazzling array of pioneering developments in fuels technology and fabrication. Primarily a non-defense facility, the 308 Building was constructed during an expansive time in American nuclear history, when the belief was widespread that atomic/nuclear energy would be the fuel of the future for virtually all civilian and industrial power needs.

President Dwight Eisenhower's "Atoms for Peace" speech, delivered to the United Nations General Assembly in December 1953, initiated a host of proposals on how to fuel a whole new generation of reactors, given the fact that the worldwide supply of uranium was limited. The Atomic Energy Commission (AEC - predecessor agency to the DOE) located at Hanford it's largest research effort to demonstrate the effectiveness of various PuO_2 and MOX fuels. For this purpose, it constructed the Plutonium Recycle Test Reactor (PRTR), and, nearly next door, the PFPP. Both were completed in 1960.[4]

Because the 308 Building was designed to contain and fabricate plutonium, it had elaborate ventilation and contamination control features. Twelve supply/exhaust systems operated to protect workers and the public by providing a negative-to-atmosphere pressure gradient and redundant capabilities. There were separate exhaust fans for the hoods and glove boxes, and each hood and glove box had its own exhaust duct containing a High Efficiency Particulate Air (HEPA) filter. Additional HEPA filters were located in each laboratory room register and in large filter rooms at the rear of the building.[5] The building also contained a variety of specialized fabrication machinery for work with metal, ceramics, and ceramic metallic blends ("cermets").

BUILDING'S MISSION CHANGED AFTER FIRST 5 YEARS

The first fuel mixtures produced in the PFPP were metallic, but ceramic fuel blends were being worked in the facility within five years. The earliest PFPP fuels were irradiated in the PRTR, as planned, but operational problems and other issues brought major cutbacks in PRTR functions after 1965. For a brief time in the late 1960s, neptunium-aluminum alloy fuel target elements and lithium aluminate ($LiAlO_2$) fuel targets were produced in the 308 Building for defense production testing in Hanford's N-Reactor.

However, the building lacked a full mission until the Hanford Site was chosen in 1970 as the location for the DOE's prototype advanced sodium cooled reactor (the FFTF) that would develop and test fuels for "breeder" reactors. (A breeder reactor is one that transmutes, or creates, more fissionable material -- or fuel -- than it burns.)

Beginning at that time, the PFPP was renamed as the FDL, and its main mission became to qualify (ie., develop the standards for) and test FFTF fuel components, fuel pins, and fuel assemblies. For this purpose, two additions were constructed in the 1970s, bringing the total 308 Building area to just over 94,000 ft^2.[6]

The earliest fuels made in the 308 Building for potential use in the FFTF were vibration packed ("vi-pack") powders, but testing demonstrated a low density. At nearly the same time, in the very early 1970s, micro-sphere pellet fuel made at an offsite location also was tested for possible use in the FFTF. Both concepts soon were discarded in favor of oxide pellet fuel made in the shape of cylinders approximately 3/10" high and 2/10" in diameter.

PELLETIZED FUEL FOR FFTF AND OTHER TEST REACTORS BECAME MAINSTAY OF 308 WORK

The function of the 308 Building then became how to demonstrate the most cost effective methods of making the tiny cylindrical pellets, while at the same time minimizing waste and meeting tight (rigorous) specifications completely new to the industry. For example, the tolerance (margin for error) in making an acceptable pellet was plus or minus 1.5 mil. (A mil is equal to one one/thousandth of an inch.) Porosity and grain size within the pellets, as well as density, were additional factors with tight specifications.

With nearly 150 pellets per fuel pin, 217 pins per driver fuel assembly, and 73-75 assemblies per core loading, the need to standardize a high quality process became crucial. Yet, work in the 308 Building was so precise that almost no FFTF driver components have failed over its 11 years of operations (although some other test assemblies were built purposely to "fail" in run-to-clad-breach, run-to-melt, and other experiments). Additionally, FFTF driver fuel "burn-up" times and yields have surpassed earlier, offsite records in the commercial reactor industry by a factor of four! (Fuel burn-up, as stated earlier, is a measure of the number of fissions over time, with longer burn-up times resulting in higher energy yields per unit of fuel.)[7]

The pellet-making process was complicated by the fact that each step had to occur within a glove box, as the raw material was a mixture of UO_2 and PuO_2 powders. The powders first were blended, then mixed with an organic binder-lubricant, then cold pressed to achieve the desired density, then heated in a pre-heat device (also located within a glove box) to drive off the organic, and then sintered in a high-temperature furnace. Since the pellets shrank when sintered, a key variable became how to achieve the desired size before firing, to allow for shrinkage but not to leave extra material that would have to be ground off afterwards. The grinding process created transuranic (TRU) waste, along with the expense of disposal, as well as the added cost of using unnecessary amounts of the original powders. "Sinter to Size" became one of the crucial challenges for the high quality control that was sought and achieved in 308 Building work.[8]

Once fuel pellet specifications were set for the original FFTF core loading, contracts were let to commercial vendors to produce the more than 2.3 million of the tiny components needed. With guidance from 308 Building personnel, whole new levels of quality assurance (QA) and process control were introduced to the fuel-making industry. Eventually, throughout the FFTF's operating lifetime, over 14 million fuel pellets were manufactured under these closely-controlled conditions.

FFTF FUEL PINS, COVER GASES AND ASSEMBLIES NEEDED CLOSE ATTENTION

At the same time that fuel pellet development was going forward, new methods and standards were being pioneered in other components of FFTF fuel. The fuel pins themselves, eight feet long and .230" in overall diameter, needed to have high integrity, with few or no surface defects, tight dimensional control within the alloy material itself, and minuscule tolerances for straightness. A "316" stainless steel alloy containing small amounts of molybdenum and more nickel than some of the other available choices was selected. Inside and outside diameters of the fuel pins, as well as overall length, were specified to within one mil.[9]

After commercial manufacture, the fuel pins for four full core loadings for the FFTF (nearly 75,000 pins) were brought back to the 308 Building for a series of rigorous inspections, including visual, dimensional (using profilometers and other specialized equipment), and those using X-Ray and neutron radiography. It was for the latter type of precise inspection, as the commercially made fuel pellets, pins and other components began to arrive at the Hanford Site, that the TRIGA reactor was procured for the 308 Building in the late 1970s.[10]

Each sealed pin was wrapped with a thin spacer wire that ran from end to end in a spiral.[11] The assembly of a fuel bundle began when a nozzle assembly was welded onto a large duct tube containing the 217 fuel pins. Each driver (normal) fuel assembly measured about 12' long and weighed approximately 360 pounds. Because each assembly would generate nearly 6 megawatts (MW) of heat in the reactor, the duct tubing had to be very straight and had to meet tolerance specifications so close they could be measured only by laser. Over the years, approximately 300 such bundles were assembled in the 308 Building.[12]

CDE AND OTHER TESTS MAKE HISTORY

In addition to the qualification and testing of FFTF driver fuel components, fuel configurations and test assemblies for the FFTF and for a variety of offsite reactors were produced in the 308 Building. Among the reactors used to irradiate these test materials were the TREAT (Transient Reactor Test Facility), the EBR-II (Experimental Breeder Reactor II) and the ETR (Engineering Test Reactor), all at the Idaho National Engineering Laboratory (INEL), the PFR (Plutonium Fast Reactor) in England, and the GETR (General Electric Test Reactor)[2] in California.[13]

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[2] The GETR was the property of the General Electric Corporation, located in Vellecitos, CA.

Assembly of test fuel pins in the 308 Building took place inside a glove box, and began with the welding of the bottom end cap. Next, the internal components were inserted, including the active fuel, the "cover" or "tag" gas capsule used to detect fuel failures within the FFTF, and other constituents. (Thousands of gas capsules, with accompanying penetrator mechanisms, one for each FFTF fuel pin, also were built in the 308 Building.) Lastly, the "fill" gas (mostly helium) was inserted into each fuel pin, and the top end cap was welded on in a helium atmosphere.[14] The spiral wrapping and assembly processes then took place outside of a glove box, and proceeded in a similar manner to those processes used on driver fuel. By 1976, over 2,000 fuel configurations had been produced in the 308 Building for the FFTF and other reactors.

Other special instrumented test articles for the FFTF also were built in the 308 Building, including some wherein thermocouples (in-reactor temperature wires) were placed in the wire wraps around the fuel pins or in the fuel itself. Known as FOTAs (Fuels Open Test Assemblies), such trials also involved varying the parameters of fuel pins, the composition of the depleted UO_2 pellets used as insulators within the pins, and even the use of sodium-bonded metal fuel pins. Perhaps the most important experiment fabricated in the 308 Building for the FFTF was the Core Demonstration Experiment (CDE) of 1984-1990. Its purpose was to demonstrate the value of a low-nickel, magnetic stainless steel alloy known as HT 9. The testing of this alloy in the CDE virtually solved one of the most crucial problems that has plagued fast reactors throughout nuclear history -- that of the swelling and distortion of internal components that occurs under neutron bombardment.[15]

LAST MISSIONS FOR 308 BUILDING

The last new plutonium oxide fuels to be fabricated in the 308 Building for the FFTF were completed in October 1986. During 1988-1989, MOX pellets made offsite were loaded into fuel pins in the facility, and fuel pins and assemblies were fabricated for six FFTF tests using enriched uranium metal alloy fuel. The "downloading" (removal) and re-loading of oxide pellets into different fuel rods for a test assembly known as UO-1, used for a Pu-238 demonstration project, was completed in the 308 Building in January 1990. The UO-1 test included enriched uranium oxide fuel pellets that had been fabricated in the 308 Building in December 1989. Repackaging work involving MOX powders, for purposes of consolidation, took place from late 1991 through early 1992. By that time, glove box lay-up and removal of the working inventory of fuel-making materials was well underway.[16]

Watching and supervising the closeout has been Jim Steffen, a 20-year participant and manager in 308 Building missions. With some sense of nostalgia, he states: "The FFTF fuel development and manufacturing mission of the 1970s and early 1980s embodied a mix of camaraderie, productivity, total quality and safety consciousness. Those of us who are left will always remember the great opportunity of being part of a very successful mission."

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