Impacts of Oak Ridge's radioiodine accident in 1954

(As published in The Oak Ridger's Historically Speaking column on April 18, 2016)

Oak Ridge is one of the few places in the world where radioactivity is best understood and where the precautions associated with materials that are hazardous are routinely implemented. Yet, even in an environment where operations are tightly controlled, there have been occasions where unplanned and uncontrolled activities produced less than desirable results. One such occasion is described for us by Bill Yee as written by Carolyn Krause.

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Bill Yee, a retired chemical engineer who started his career at Oak Ridge National Laboratory in 1952, recalls seeing from Building 4500 that part of the lab's Main Street was roped off. Men wielding brooms were scrubbing the part of the street that was covered with Tide detergent suds. It was a Monday in May, and the area being scrubbed was the direct route to the cafeteria for employees in Building 4500.

Yee learned that, four days earlier, on Thursday, April 29, 1954, at 5 p.m., radioactive iodine-131 had explosively escaped the 3036-D building, where barium-140 was being extracted from spent uranium fuel slugs from the Graphite Reactor and a reactor at Hanford, Wash. Hearing air monitor alarms, the building staff donned their gas masks and evacuated 3036-D.

Members of ORNL's Chemical Technology Division were in charge of the barium-140 separation program. CTD's director was Floyd Culler (later deputy director of ORNL and CEO of the Electric Power Research Institute in California). He called a meeting in the 4500 auditorium and told staff that this problem must be immediately corrected and that his job could be on the line if such a serious accident happens again.

ORNL health physicists had the urine of the potentially exposed workers checked. The health physicists were also concerned that the radioiodine might have gone beyond the ORNL boundary and contaminated pasture grass and corn, as well as foods produced on farms, such as cow's and goat milk, cottage cheese, eggs and leafy vegetables. Tainted foods eaten by children could cause thyroid cancer in their adult years.

Why a barium separation program? What caused the accidental iodine-131 releases? Were they a health hazard to the area population?

In 1945 Robert Oppenheimer, director of Los Alamos Scientific Laboratory, asked Miles Leverett, director of the Technical Division, to lead the development of a process to isolate radioactive barium-140 from spent uranium-238 slugs. The slugs were placed in lead coffins that were loaded on a truck for transport to one of the chemical separations building on Main Street that Leverett's division built. ORNL researchers discovered a way to separate barium-140 from the slugs.

The decaying barium, which has a half-life of 12.5 days, was placed in a lead pig that was loaded in a truck. Two men drove the truck 1,500 miles nonstop to Los Alamos. On the way the barium-140 continued to decay into radioactive lanthanum (RaLa), which has a short half-life of 41 hours. At Los Alamos RaLa was separated from the remaining barium isotope.

The RaLa experiment at Los Alamos was a series of tests during and after the Manhattan Project, from 1944 to 1962. It was designed to study the ability of converging shock waves to achieve the spherical implosion needed to adequately compress the plutonium pit of a nuclear weapon. RaLa, a potent source of gamma rays, was required to simulate the behavior of plutonium inside a metal sphere. The test measured changes in absorption of gamma rays in the sphere's metal as it underwent compression.

In his history of the Los Alamos project, David Hawkins wrote: "RaLa became the most important single experiment affecting the final bomb design." The early RaLa tests determined the implosion design for the plutonium bomb dropped on Nagasaki, Japan, on August 9, 1945,

effectively ending World War II. The earlier gun-type design worked only for the atomic bomb fueled by uranium enriched in U-235 at the Oak Ridge Y-12 plant and dropped on Hiroshima, Japan.

At ORNL the freshly irradiated fuel slugs used in the RaLa process contained large amounts of short-lived fission products, especially noble gases and radioactive iodine-131. As the slugs were dissolved in nitric acid, much of the radioactive iodine dispersed as vapor but was removed from the off-gas stream by a condenser and chemical scrubber before the gaseous waste was vented to the stack.

In a 1955 report ORNL's Art Rupp described the April 29, 1954, incident as "the most serious accidental release of radioactivity in the history of the process." According to a 2007 report for the National Institute for Occupational Safety and Health by a team led by Oak Ridge Associated Universities, ORNL "logbooks indicate that 161 Hanford slugs [shipped from at least one reactor run at a higher power level than the Graphite Reactor] had been loaded in the dissolver and three batches had been processed successfully during Run 56.

"After the third batch dissolution, liquid did not cover the slugs in the dissolver tank for approximately 28 hours and the slugs became thermally hot due to radioactive decay. When the fourth batch addition of acid was poured in the dissolver to initiate additional dissolution, a violent reaction forced dissolver solution up the slug-loading chute and solution addition lines. Air monitors immediately sounded an alarm indicating elevated airborne radioactive material."

The I-131 release from building vents, windows, and other openings lasted from 10 minutes to two hours before the scrubbers could recover and begin filtering radioiodine from the building. Los Alamos continued to increase its demand for RaLa; as a result, the Graphite Reactor was operated at a higher power level than it was designed for. By October 1956, ORNL completed its 68th and last RaLa run. It had processed more than 30,000 uranium slugs and shipped by truck more than 500,000 curies of radioactivity to Los Alamos.

In 1954, partly because of the ORNL accident, the Atomic Energy Commission decided to build the Materials Testing Reactor (designed at ORNL) on a remote site where Idaho National Laboratory is now located. The MTR's main purpose was RaLa production.

Were there any known thyroid disorders traceable to the 1954 iodine-131 releases? In the 1990s the Tennessee Department of Health (TDOH) hired ChemRisk to carry out dose reconstructions – estimates of radiation doses received by a population from accidental exposures – to determine if enough radioiodine had spread outside the ORNL boundary as far as 24 miles to cause thyroid cancer in children in agricultural areas. In March 2008 the Agency for Toxic Substances and Disease Registry (ATSDR) issued a study titled "Evaluation of Iodine-131 Releases from the Oak Ridge Reservation Public Health Assessment."

A complication mentioned by the two reports was that another contributor of iodine-131 to any thyroid disease that might have developed in the Oak Ridge area was atmospheric testing of nuclear weapons in 1953, 1955 and 1957 at the Nevada Test Site. As the radioactivity drifted across the country, some of it was deposited in Oak Ridge. Also PCBs, pesticides and other compounds known to be in the area can cause thyroid dysfunction.

ATSDR reviewed the 1999 TDOH study, which included dose reconstruction of modeled past exposures to radioactive iodines released from the Graphite Reactor site. ATSDR also included recently available historical data, such as continuous air monitoring data for ORNL during the RaLa processing, as well as radioactive iodine concentrations in deer harvested from ORNL.

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ATSDR reported that it "could not determine conclusively that exposures to radioactive iodine occurred off the ORNL property at levels that could cause harmful health effects."

According to Dr. Elaine Bunick, endocrinologist in Oak Ridge who treats thyroid disorders, thyroid cancers caused by exposure to radioactive iodine do not show up in people for 20 to 40 years. She came to Oak Ridge in 1978 but did not see any increase in thyroid cancers among her Oak Ridge patients between the late 1970s and the 1990s.

She noted that in the 30-year period following the Chernobyl reactor accident in 1986 in the Ukraine, a large spike in thyroid cancers has been observed. "We expect a similar jump in the number of thyroid cancers in Japan some 20 to 40 years after the Fukushima reactor accident in 2011. Fortunately, thyroid cancers caught early can be cured."

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Thanks to Carolyn and to Bill for compiling this history of an unfortunate release of radioactive iodine. Thanks also that Carolyn included the results of research that determined the release did not adversely impact the public.

We, in Oak Ridge, realize the value to the world of the work done here. From the "most important experiment" of RaLa to the advances in technology mentioned in last week's Historically Speaking, we find work done in Oak Ridge is truly tremendously important on the world stage.

Bill Yee

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A large gathering for important and world changing radioactive nuclear isotopes created in the Graphite Reactor to be transferred to industrial and medical research facilities