SODIUM-BEARING WASTE

Produced for the Leadership in Nuclear Energy (LINE) Commission and residents of the State of Idaho by the Energy Policy Institute with contributions and review by Idaho National Laboratory, Fluor Idaho, and Boise State University.

Summary

This report on sodium-bearing waste is part of a series of technical reports that was completed on nuclear waste and spent fuel. Special emphasis is on the relevance of the topics for Idaho.

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1. Definition: What is sodium-bearing waste?

Sodium-bearing-waste (SBW) is an acidic aqueous (water-based) solution that has a complex chemical composition that includes dissolved sodium; potassium, aluminum, nitrates, and nitric acid; radioactive elements; and some elements, such as mercury and cadmium. These elements are known to be hazardous, according to the Resource Conservation and Recovery Act (RCRA). SBW is both radioactive and hazardous, and so is considered a "mixed" waste.

The former Idaho Chemical Processing Plant, now the Idaho Nuclear Technology and Engineering Center (INTEC), used to reprocess spent nuclear fuel to recover a highly valuable type of uranium. This process first dissolved the spent fuel in nitric acid and water solution, and then used organic-based solvents to separate the uranium and other desired elements from the radioactive waste elements that remained in the nitric acid solution. This process produced two different kinds of liquid, high-level radioactive waste: sodium-bearing and non-sodium-bearing.[1]

Sodium-bearing waste contains radioactive impurities removed from the solvent which is used to recover the uranium from the dissolved spent nuclear fuel. While most of the components in the SBW are dissolved in solution, the SBW also contains a relatively small amount of undissolved solid (UDS) particles. Specific to the SBW at INL, the overall radioactivity is decreasing. However, the dissolved and undissolved solids' concentrations of radioactivity have increased relative to the initial period when the SBW was generated. During the initial period of SBW generation, evaporators were used to decrease the total volume of SBW.

The concentrations of the main components vary somewhat between three tanks in which the SBW is stored. The primary components in order of decreasing concentration are: nitrate, sodium, aluminum, and potassium. The SBW also contains lower concentrations of dissolved chloride, fluoride, phosphate, and sulfate; about 20 other non-radioactive elements; various organic species; and about 20 radioactive elements, at very low concentrations.

The radioactivity of the SBW is decreasing over time as the amounts of short-lived radioactive cesium and strontium, which contribute most of the radioactivity in the waste, decreases. The amount of radioactive ^{137}Cs decreases by one-half every 30 years (the radioactive half-life for ^{137}Cs). The amount of radioactive ^{90}Sr decreases by one-half every 29 years (the radioactive half-life for ^{90}Sr). Some other radioactive isotopes at very low concentrations in the SBW have much longer half-lives, and so take much longer to decay. (See Section 2 for more discussion relative to high-level waste.)

2. Source: Where did sodium-bearing waste that is in Idaho come from?

Idaho National Laboratory (INL) is an intermediate storage facility for many types of nuclear waste from the US Navy Fleet, nuclear test reactors worldwide, and spent nuclear fuel (SNF) from a variety of US sites. The former Idaho Chemical Processing Plant (now INTEC), used to reprocess spent nuclear fuel to recover a highly valuable type of uranium. This process first dissolved the spent fuel in nitric acid and water solution, and then used organic-based solvents to separate the uranium and other desired elements from the radioactive waste elements that remained in the nitric acid solution. This process produced two different kinds of liquid, high-level, radioactive waste: sodium-bearing and non-sodium-bearing.

The non-sodium-bearing, liquid, high-level waste (HLW) contains most of the radioactive waste elements in the nitric acid solution. All of the non-sodium-bearing HLW has been converted from the liquid form into a safer, solid granular form called calcine, now stored in calcine bins at INTEC.

As outlined above, the second type of liquid, high-level waste, sodium-bearing waste, contains radioactive impurities removed from the solvent used to capture the uranium, when the solvent was recovered for re-use. This waste was mixed together with other liquid radioactive wastes from equipment decontamination, and residues from ion exchangers, off-gas systems, and laboratory analyses. This waste was not produced in the first "cycle" of nitric acid and organic separation, and so it contains less radioactivity than the non-sodium-bearing HLW. It is called SBW because it contains dissolved sodium from processes that added sodium hydroxide, sodium carbonate, and sodium peroxide to the waste.

[1] Both are described in the following sections.

3. Quantity: How much sodium-bearing waste is there in Idaho?

As of June 2017, there were approximately 900,000 gallons of SBW stored at INL in three separate tanks numbered WM-187, WM-188, and WM-189 (Figure 1).

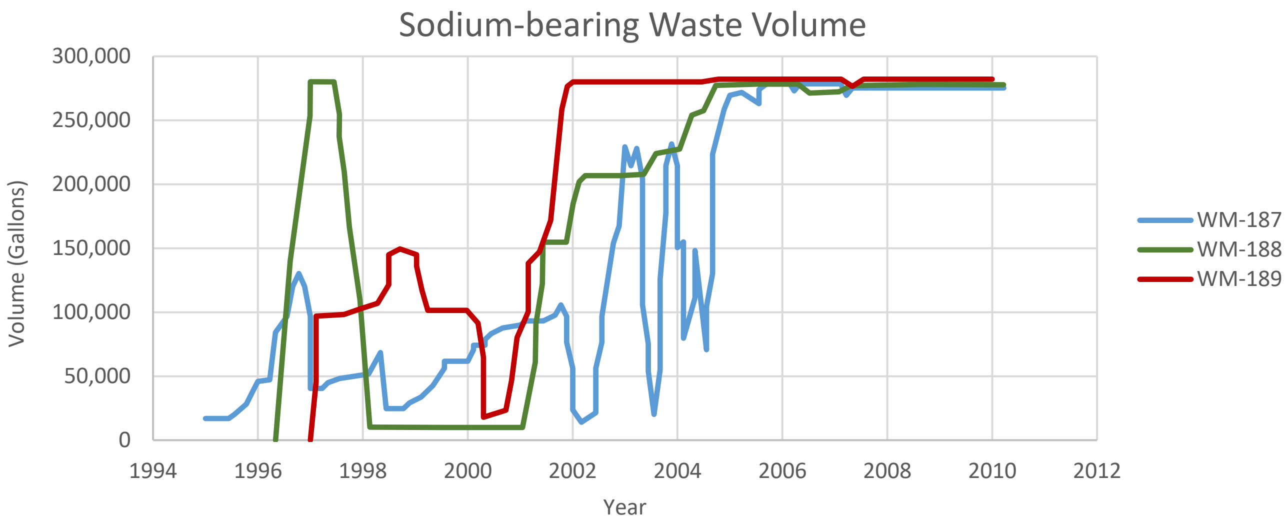

Fig 1. Historical sodium-bearing waste stored in tank WM-187, WM-188, and WM-189. *Source: [7].*

4. Storage: How is sodium-bearing waste stored?

The SBW is in interim storage at the Tank Farm Facility (TFF) located at INTEC. The TFF contains eleven separate 300,000-gallon capacity, cylindrical, stainless-steel tanks for waste storage that are 3/16 to 5/16 in. thick and have a 50 ft. diameter. Four other 30,000-gallon tanks are directly buried at the TFF and have been emptied, cleaned and grouted under RCRA.

The eleven individual 300,000-gallon capacity tanks are located underground within concrete vaults to provide additional structural integrity (Figure 2). Seven of the eleven 300,000-gal tanks are no longer in service, and have been emptied, cleaned and grouted (filled with cement to stabilize the tanks and reduce any remaining hazards) under RCRA.

The remaining four 300,000-gal tanks are in use. Three tanks (WM-187, WM-188, and WM-189) are still nearly full of SBW; the fourth tank (WM-190) is empty but available for use, if needed. These four tanks were constructed between 1958 and 1964 (Figure 3). The tanks containing the SBW are adjacent to each other within a monolithic square concrete vault. The square concrete vaults are approximately 32 ft. tall and cover an area of 14,600 ft^2 (0.34 acre). Figure 4 shows the dimensions and orientation of these four tanks.

Although these tanks were constructed as early as 1958 to contain other types of waste, they did not contain SBW until the early 1990s. Prior to the early 1990s, they contained other types of waste such as zirconium fluoride and aluminum waste.

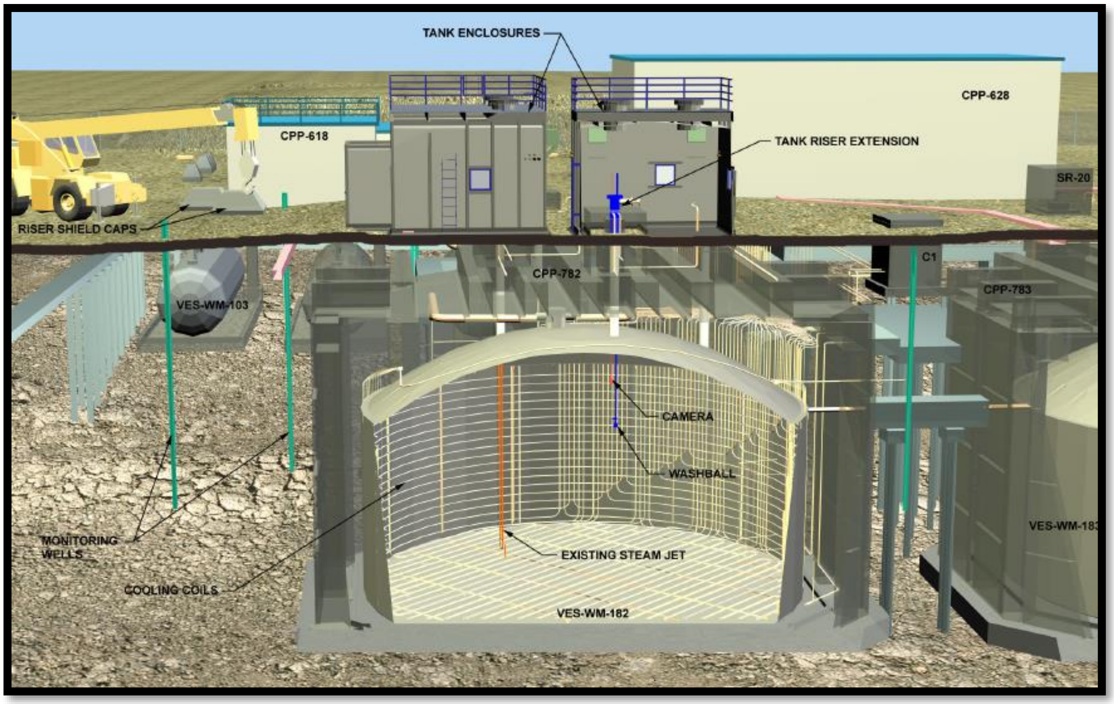

Fig 2. INTEC Tank Farm Facility tank WM-182 side view. *Source: [14].*

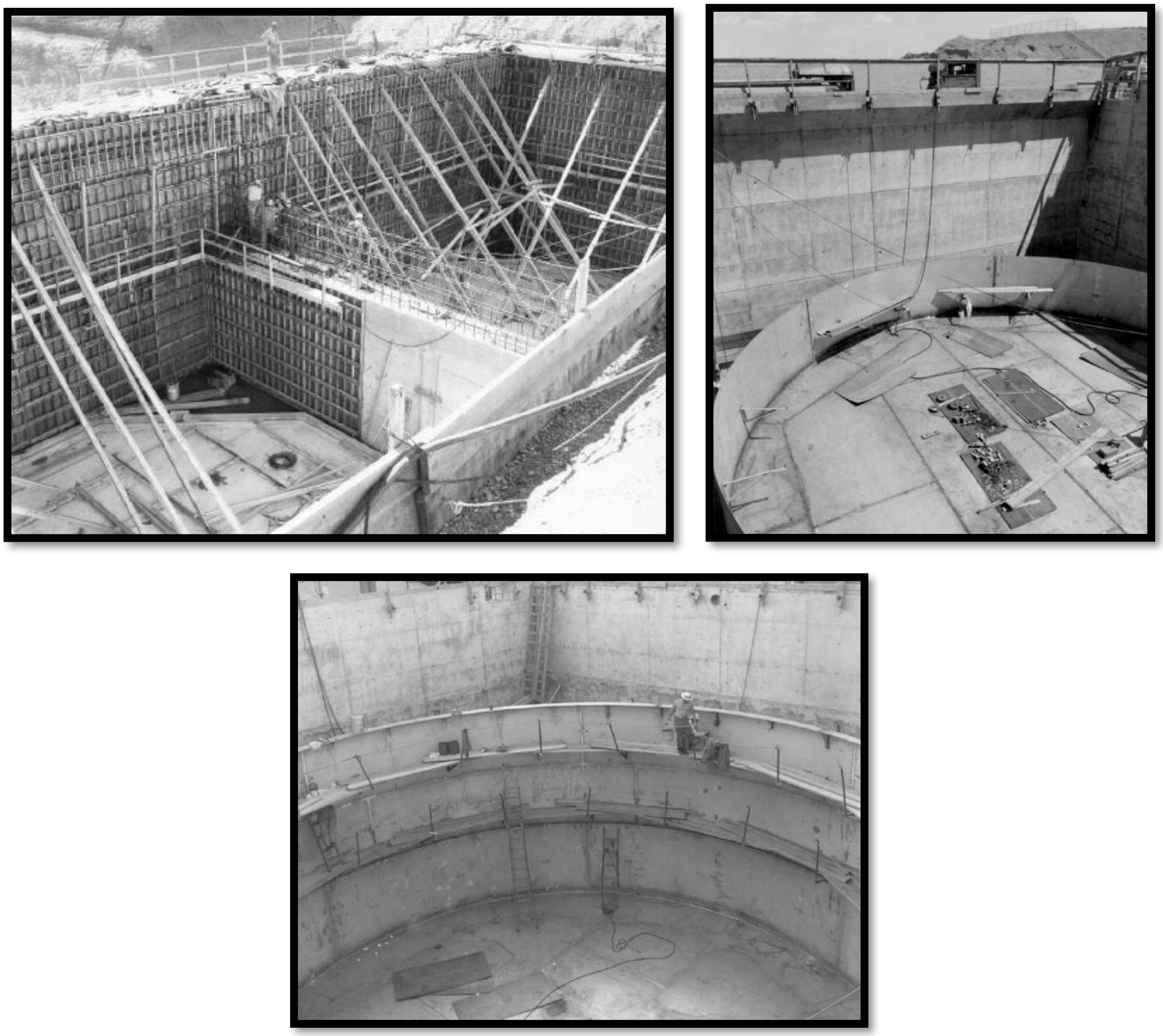

Fig 3. Construction of SBW concrete vaults tanks WM-187, WM-188, WM-189, and WM-190.
Source: [2].

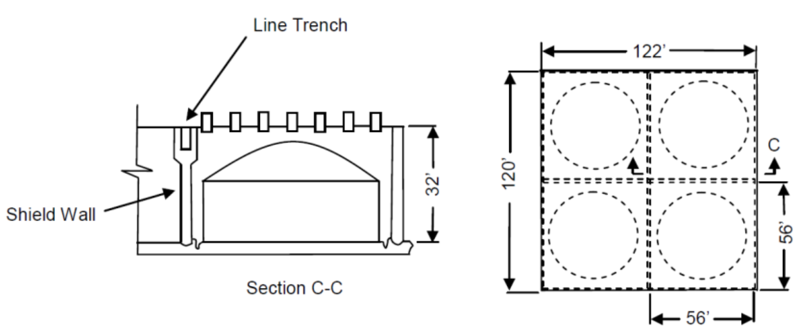

Fig 4. Diagram of square vaults containing SBW tanks WM-187, WM-188, WM-189, and WM-190.
Source: [7].

5. Risks: What key risks are associated with sodium-bearing waste?

As with many other liquid radioactive waste types, a compromised tank due to localized corrosion is always of concern. Corrosion over time can lead to leaking waste. If a tank leaks, the leak would likely flow into the concrete vault and remain isolated from the exterior soil, thus keeping radioactive elements contained. A leak-detection system is in place that continuously monitors for leaks into the concrete vault. In addition, the SBW level in each tank is monitored for level changes. In the unlikely event of a leak, an audible alarm would sound in the Liquid Waste Control Room, which is monitored 24 hours per day, 7 days per week. Leakage would be captured in a sump in the vault and returned to the tank. The SBW in the tank would be transferred to the empty tank (WM-190), should a leak occur. There have been no indications of leaks occurring at the TFF, and the chemical composition of the SBW has been found to have low corrosivity on the stainless-steel tanks. A service life assessment performed in 2002 estimated a minimum remaining life span of 48 years, out to 2050.

6. Transport: What needs to occur in order for sodium-bearing waste to be transported out of Idaho?

In October 1995, the State of Idaho, U.S. Navy, and U.S. Department of Energy (DOE) reached a settlement agreement, which required DOE to commence calcination of SBW by June 1, 2001. According to the 1995 Settlement Agreement, the treatment of the remaining 900,000-gal SBW through calcination had to be finished by December 31, 2012. Subsequently, a decision was made to use steam-reforming technology, which is based on a fluidized bed to process the SBW, converting the waste from a liquid to solid because the existing process (discussed below) was unavailable.

As of 2018, the treatment of the remaining SBW is still pending. Both the 2001 and 2012 deadlines, as well as several other deadlines since 2012, have been missed. Two major issues contributing to the delays have been the lack of an operational treatment facility and questions concerning the radiological waste classification of SBW.

In recent decades, there is an ongoing discussion about classifying SBW as either mixed-transuranic waste or HLW. The classification is important because it ultimately determines the final disposition of SBW. Currently the only geological repository licensed for underground nuclear waste disposal in the US is the Waste Isolation Pilot Plant (WIPP) in New Mexico. WIPP only accepts transuranic waste, thus if SBW is not classified as transuranic waste it will have to remain in interim storage until an HLW geological repository is operating. In addition, WIPP currently does not accept tank-related waste, requiring the facility to undergo a significant permit modification before the SBW would be considered as a candidate for disposal at the site.

DOE had been performing on-going assessments to identify SBW's proper waste classification.
In 2005, following a multi-year evaluation of technologies for treating the SBW, and with concurrence from the State of Idaho, DOE selected steam-reforming instead of calcination. This change was made because the existing New Waste Calcining Facility (NWCF), used through 2001 to calcine HLW and SBW, could no longer operate without modifications to make it comply with new Hazardous Waste (HW) Maximum Achievable Control Technology (MACT) standards for air emissions.

As a result, the first-of-a-kind Integrated Waste Treatment Unit (IWTU) was designed and built to treat the remaining SBW using steam reforming (Figure 5). The IWTU will convert the liquid SBW to a solid granular material, pack it into stainless steel canisters, and store the containers in concrete vaults at the site until a final determination of shipment to WIPP or other geological repository is made.

IWTU startup operations began in 2012, using non-radioactive simulants of SBW. Several demonstration runs have been done at this first-of-a-kind facility. These runs indicated that a series of mechanical, chemistry, and operating changes were needed. Operating outages were performed, some longer than one year each, to make various equipment changes and modifications primarily focused on the fluidization/steam-reforming process. Radioactive SBW treatment operations are not expected to start until successful facility operation is demonstrated using non-radioactive simulants of SBW. Consequently, the treatment of SBW is still pending and until it is treated, it will remain in the stainless-steel storage tanks at the TFF.

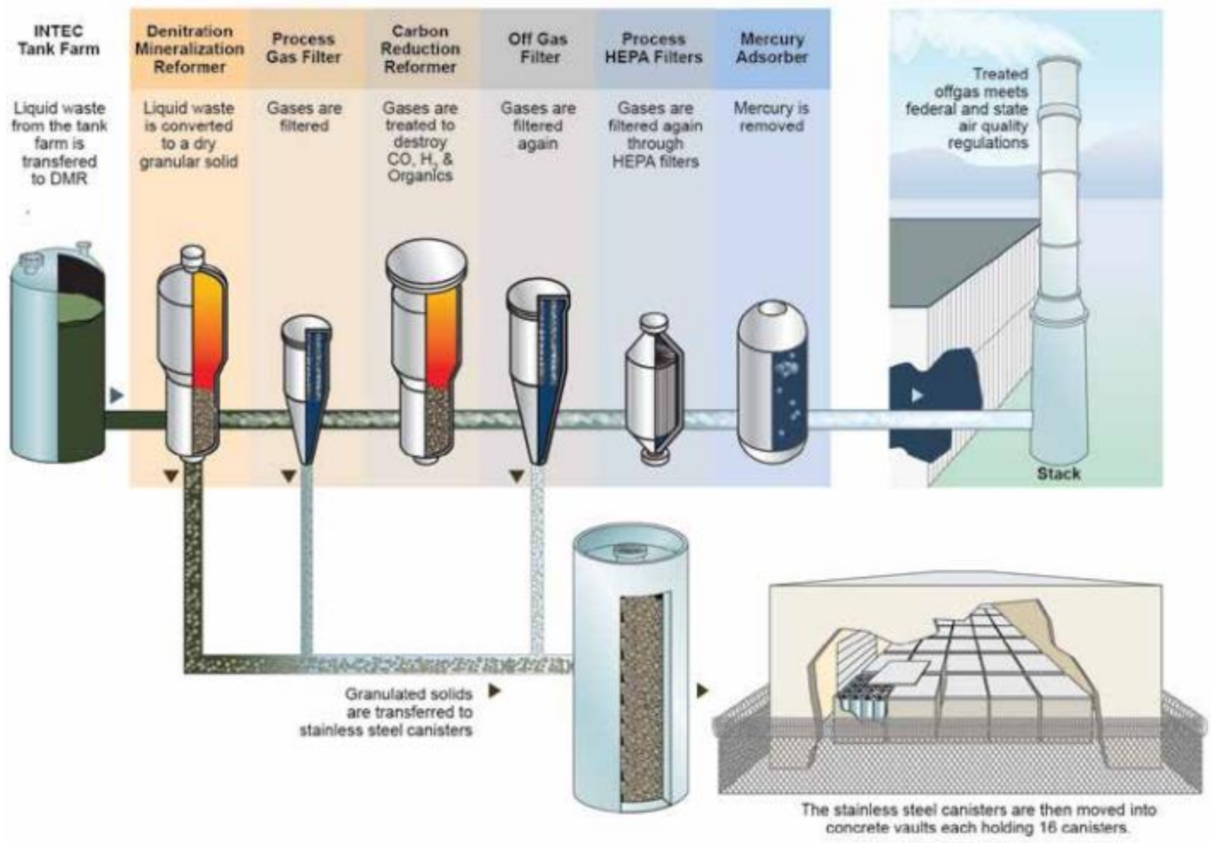

Fig 5. Simplified Integrated Waste Treatment Unit (IWTU) process flow. *Source: [11].*

7. Status/Next step: What is the status and/or next step for sodium-bearing waste?

A simulant run in 2018 demonstrated satisfactory fluidization, solids transfer, and process chemistry in the main processing vessel, the Denitration/Mineralization Reformer (DMR). An extended simulant run of 50 days was successfully completed in May2019. The run demonstrated proper plant operation as well as completion of a dry run of the system operability test that will be required under the permit. The plant is currently in an outage to install plant modifications that will focus on safe, reliable radioactive operations. A final short confirmatory demonstration run will be performed prior to introduction of SBW into the plant. An initial performance test will be completed as per the permit granted by the State, followed by processing of the SBW if the performance test is successfully completed.

8. REFERENCES

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