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Tell EPA not to shortcut its review of the Department of Energy's proposed Waste Isolation Pilot Plant (WIPP) expansion

The Waste Isolation Pilot Plant (WIPP) in New Mexico was to remain open designated to dispose of dangerous legacy waste resulting from past nuclear weapons production only until 2033. Now the Department of Energy wants to increase the size of the repository, dispose of far more concentrated and dangerous waste, dispose of far more curies of long-lived waste, and keep WIPP open decades longer.

Citizens in New Mexico and various groups in New Mexico [1] [2] are asking that the EPA conduct a formal Rulemaking on the Planned Change Request and take safety in New Mexico seriously.

The Department of Energy long claimed that the largest category by volume of transuranic waste destined for WIPP consisted of scrap materials, cleaning agents, tools, piping, filters, plexiglass, gloveboxes, concrete rubble, asphalt, cinder blocks, and other building materials. And the typical description of TRU wastes sent to WIPP was that the waste consisted of clothing, tools, rags, residues, debris, soil and other items contaminated with plutonium. [3]

The transuranic waste sent to WIPP was often laden with hazardous chemicals and toxic sludges, containing unknown amounts of americium, plutonium and other radionuclides.

The new wastes to be sent to WIPP will be more challenging to the WIPP repository than ever before. The Department of Energy is now seeking to dispose of vast quantities of surplus plutonium at WIPP and also to dispose of newly generated transuranic waste from ongoing nuclear weapons production, all while legacy waste remains unsafely stored at DOE sites around the country.

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[1] See Stop Forever WIPP Coalition at https://stopforeverwipp.org/home and others including Southwest Research and Information Center, Conservation Voters New Mexico, Nuclear Watch New Mexico, Veterans for Peace, Citizens for Alternatives to Radioactive Dumping (CARD), and Concerned Citizens for Nuclear Safety (CCNS).

[2] Letter to Lee Ann B. Veal, Environmental Protection Agency, on behalf of numerous New Mexico organizations, explaining why EPA needs to conduct a formal rulemaking, June 24, 2024. See Stop Forever WIPP Coalition at https://stopforeverwipp.org/home

[3] National Academies of Science, Engineering and Medicine, *Review of DOE's Plans for Disposal of Surplus Plutonium in the Waste Isolation Pilot Plant*, Washington, DC, 2020: The National Academies Press. https://doi.org/10.17226/25593

There are regulations regarding the WIPP repository but even without disposal of surplus plutonium at WIPP, the Environmental Protection Agencies regulations for WIPP are inadequate, unsafe and unlike any regulations used anywhere in the world.

The EPA regulations apply an inadequate 10,000-year time frame not just to WIPP but for all radioactive waste disposal sites in the U.S., except Yucca Mountain. The original studies for waste migration from Yucca Mountain were expanded to the time of peak discharges beyond 10,000 years. The EPA's inadequate regulations for WIPP enable WIPP to meet compliance standards but do not adequately ensure safety during waste emplacement or after repository closure.

The radioactive half-lives of the waste, including plutonium-239 (24,000 years), neptunium-237 (2.1 million years), and others, far exceed the regulatory considerations for only 10,000 years.

Regarding nuclear criticality, the EPA's regulations may have been acceptable before but certainly are not adequate for disposal of surplus plutonium. The EPA regulations allow a high probability of nuclear criticality at WIPP, and by the way, are also inadequate for other repositories. The criticality risks for concentrated fissile material such as in surplus plutonium or spent nuclear fuel persist far beyond 10,000 years. The EPA regulations only address criticality for 10,000 years and allow criticality to be dismissed with quantitative hand-waving. Criticality events in WIPP must be required to be controlled so that they are physically precluded, now and in the distant future. The EPA must not rely on voluntary standards regarding surplus plutonium, and the EPA must require independent and comprehensive criticality review.

The transuranic waste that had been allowed in WIPP was far lower is fissile material content, and much of the waste below 200 fissile gram equivalents (FGE) of plutonium-239 than what the DOE is now seeking for surplus plutonium disposal, above 380 FGE.

There are over 500 active oil or gas drilling wells within 2.5 miles of the boundary of WIPP. Well drilling can be very deep vertically and horizontal drilling is also conducted. Pressurized brine pockets can bring waste to the land surface. Water ingress from fracking can more in unpredicted ways, moving vertically and horizontally. It is possible for releases from WIPP to occur.

Increased well drilling and increased waste inventory are increasing the probability of a WIPP release, so the Department of Energy's contractor, Sandia National Laboratory, has "tweaked" the Culebra groundwater modeling transmissivity values to lower the accident consequences. [4] Plutonium solubility is another likely area where pressure may be applied to

[4] Sarah Brunell, Sandia National Laboratories, Presentation: Summary of Changes to WIPP Performance Assessment for the Replacement Panels Planned Change Request, December 7, 2023. See epa.gov.

lower estimated releases from WIPP estimated from the performance assessment and this will also require independent review. [5]

EPA regulations require Performance Assessment analyses to estimate the cumulative releases of radionuclides from WIPP for both undisturbed repository and disturbed repository performance. Disturbed repository performance considered human intrusion by inadvertent and intermittent drilling and mining. Culebra groundwater flows above the WIPP disposal area and pressurized brine is below the WIPP disposal area.

More waste is already slated for WIPP than is allowed, even with the recently contrived modification via "volume of record" accounting. [6] Even so, the Department of Energy continues to claim WIPP is the disposal solution for every problem waste stream. In addition to the surplus plutonium, [7] the DOE continues to identify WIPP as the potential disposal site for the nation's Greater-Than-Class-C Low-Level waste, DOE's 10,000 metric tons of mercury, high-level waste from Hanford and West Valley, [8] and high-level waste from the Idaho National Laboratory's calcine and treated sodium-bearing waste. [9] Even if the new counting method is approved, the amount of TRU waste already destined for WIPP from Energy Department generator sites would overfill its limited space.

In addition, the DOE continues generic spent nuclear fuel repository research, including for a salt repository and has noted that the SNF containers for commercial spent nuclear fuel don't fit in the existing WIPP facility. The attempts to locate "interim" consolidated storage of commercial spent nuclear fuel near WIPP in New Mexico and in nearby Texas [10] [11] suggest an unstated intention to dispose of the nation's spent nuclear fuel in salt in New Mexico.

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[5] Letter to Lee Ann B. Veal, Environmental Protection Agency, on behalf of numerous New Mexico organizations, explaining why EPA needs to conduct a formal rulemaking, June 24, 2024. See Stop Forever WIPP Coalition at https://stopforeverwipp.org/home

[6] National Academies of Science, Engineering and Medicine, *Review of DOE's Plans for Disposal of Surplus Plutonium in the Waste Isolation Pilot Plant*, Washington, DC, 2020: The National Academies Press. https://doi.org/10.17226/25593

[7] Public Comment Submittal from Tami Thatcher to the U.S. Department of Energy and National Nuclear Security Administration (NNSA) regarding the Draft Environmental Impact Statement for the Surplus Plutonium Disposition Program (Draft SPDP EIS) (DOE/EIS-0549), February 2023 at http://www.environmental-defense-institute.org/publications/CommentSurplusPu2023.pdf

[8] Southwest Research Information Center, "Current DOE Proposals to Expand WIPP," 2017, http://www.sric.org/nuclear/docs/2017_09_15_WIPP-expansion-proposals.pdf

[9] Energy Communities Alliance, "Waste Disposition: A New Approach to DOE's Waste Management Must Be Pursued," September 2017. The Department of Energy gave this document to the Idaho Cleanup Project Citizens Advisory Board in June 2018. https://static1.squarespace.com/static/55c4c892e4b0d1ec35bc5efb/t/59ce7384cd39c3b12b97f988/1506702214356/ECA+Waste+Disposition+Report.pdf

[10] U.S. Nuclear Regulatory Commission, *Federal Register*, Vol. 86, No. 178, "Interim Storage Partners, LLC; WCS Consolidated Interim Storage Facility; Issuance of Materials License and Record of Decision," September 17, 2021. This is the consolidated storage facility proposed for Andrews County, Texas. (The consolidated storage facility could store up to 40,000 metric tons heavy metal.)

[11] U.S. Nuclear Regulatory Commission, *Federal Register*, Vol. 88, No. 92, "Holtec International; HI-STORE Consolidated Interim Storage Facility," May 12, 2023. This is the consolidated storage facility proposed for Lea County, New Mexico. (The consolidated storage facility could store up to 100,000 metric tons heavy metal.)

The changes DOE proposes making to WIPP are very significant changes from the existing WIPP approval by the Environmental Protection Agency (EPA). The DOE has submitted a Planned Change Request to the EPA to expand WIPP. [12] In a "death from a thousand cuts" approach, DOE is emphasizing the addition of just two additional panels, Panels 11 and 12, to make up for lost panel space due to the accident DOE caused in 2014.

DOE's revised Performance Assessment is basically doubling the size of WIPP to a total of 19 panels when only 10 panels were in the original WIPP certification. **Does the EPA think that doubling the size of WIPP is not a significant change?**

The Department of Energy operates WIPP and, unlike other Department of Energy facilities, the U.S. Environmental Protection Agency plays a special role in approving changes to WIPP. Congress required EPA to certify that the DOE's WIPP facility complies with the waste disposal regulations at 40 CFR Part 191, Subparts B and C as well as 40 CFR Part 194. [13] The EPA originally certified WIPP in 1998 and WIPP began defense waste disposal in 1999.

Plutonium-laden waste from various Department of Energy facilities involved in nuclear weapons production have been shipped to WIPP for disposal. These facilities include Hanford, Oak Ridge National Laboratory, Savannah River Site, Los Alamos National Laboratory, Idaho National Laboratory and others. Much, but not all, of the defense waste from the Idaho National Laboratory that is shipped to WIPP came to Idaho from the DOE's now closed Rocky Flats Plant in Colorado. The waste has included transuranic radionuclides such as plutonium, americium, curium and neptunium, and often includes large quantities of toxic chemicals associated with plutonium processing.

The incompatible combination of chemicals and high loading of radioactive waste caused the explosion of a waste drum inside WIPP in 2014. The Los Alamos National Laboratory (LANL) had packaged transuranic waste destined for WIPP and included forbidden liquid absorbent material from organic kitty litter in many TRU waste drums laden with nitrates. The Department of Energy failed at LANL and failed at WIPP to prevent the forbidden incompatible constituents in the waste. Systemic and widespread safety problems were found to be pervasive at WIPP following a vehicle fire in WIPP and then the unrelated drum explosion.

WIPP's original safety basis had been extensively reviewed, more than any other DOE facility. Reviews by the Environmental Protection Agency and by the Defense Nuclear Facility Safety Board had been conducted. But subsequent changes to the WIPP safety basis, approved by DOE had reduced safety significantly. They made the assumption that a roof fall would never occur in an open panel and had no accident analysis for this. WIPP experienced a roof fall within a couple months of not bolting the ceiling in the underground mine.

The accident investigation report also discovered that far more plutonium/americium was released from a single drum in the February 12, 2014 event than the safety analysis

[12] See https://www.epa.gov/radiation/wipp-news#WIPP-PCR
[13] See https://www.epa.gov/radiation/certification-and-recertification-wipp

predicted was possible. [14] This emphasizes the inadequate characterization of waste drum contents and this does not appear to have been adequately addressed by the EPA.

The explosion of a single drum resulted in closing some storage panels before the panels were filled to capacity. It is also important to also understand that the single drum that exploded in WIPP contained many times more radioactive material than DOE's safety analysis deemed possible to be contained in a single drum.

Despite the paperwork on the contents of each drum and the radiation monitoring programs, alpha radiation in transuranic waste is easily shielded and the contents of waste drums is often not adequately known. Drum sampling is expensive and contents are not necessarily homogeneous throughout the waste drum. **The existence of a limit in WIPP does not mean that the limit has been met and this improper loading of waste drums must be considered in safety analyses and the Performance Assessment.**

The 2020 NAS report also discussed the Defense Nuclear Facilities Safety Board (DNSFB) concerns over how the material at risk (MAR) methodology may underestimate the quantity of material at risk within disposal areas in WIPP. Basically, the DNFSB found that in the WIPP panels, there are **clusters of containers with higher radioactivity source terms**. This means that accidents at WIPP may have higher radiological consequences than stated by the Department of Energy, both in the near term and in the long term.

DOE is seeking to dispose of vast quantities of surplus plutonium waste not previously slated for WIPP. DOE wants to dispose of 48.2 metric tons of diluted surplus plutonium that would take up 33,740 cubic meters of volume. But using the new contrived "volume of record" calculations that New Mexico's environmental department NMED should never have approved, the volume of surplus plutonium shrinks to only 2,056 cubic meters.

The so-called "diluted" surplus plutonium waste is still so concentrated and creates such a high criticality risk that to obtain the necessary separation of fissile material, a 6-inch diameter, 26-inch-long containers rests inside each 55-gallon drum. **So, the proposed surplus plutonium would take a large number of drums, 160,667 drums, a large number of shipments and takes up a huge amount of space in the repository. And the diluted surplus plutonium will be 85 percent of the plutonium-239 in WIPP, see Table 1.** [15]

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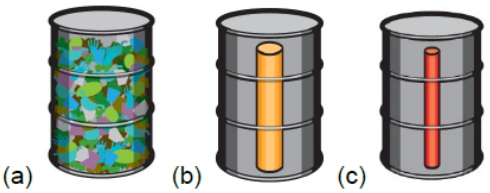
[14] Department of Energy Office of Environmental Management, Accident Investigation Report, "Phase 2 Radiological Releases Event at the Waste Isolation Pilot Plant February 14,2014," April 2015. http://wipp.energy.gov/Special/AIB_WIPP%20Rad_Event%20Report_Phase%20II.pdf See Sections 7.1 and 7.2. The release was found to have been from a single drum with stated inventory in plutonium-239 equivalent curies of 2.84 PE-Ci. But based on contamination on filters at Station A of 0.1 curies PE-ci far from the exploded drum in Panel 7, using conventional safety analysis assumptions the expected amount of material released to Panel 7 would not have exceeded 2.84E-4 PE-Ci — far less than what was measured downstream at Station A. The inventory in the drum appears to have been much higher than stated for WIPP drum and the release fractions may also be incorrect and DOE does not conservatively bound the radionuclide contents in the drums.

[15] National Academies of Science, Engineering and Medicine, *Review of DOE's Plans for Disposal of Surplus Plutonium in the Waste Isolation Pilot Plant*, Washington, DC, 2020: The National Academies Press. https://doi.org/10.17226/25593



Characteristics	(a) Direct-loaded	(b) Pipe Overpack Container	(c) Criticality Control Container/Criticality Control Overpack (CCC/CCO)
Inner dimension	N/A	12-inch-diameter pipe	6-inch-diameter pipe
Physical volume	0.21 m^3	0.21 m^3	0.21 m^3

Table 1. Contact-handled TRU waste drums compared Pipe Overpacks and to Diluted surplus plutonium waste drums.

	CH TRU Waste	**TRU Waste in Pipe Overpack Containers (POCs)**	**Criticality Control Containers/Criticality Control Overpacks (CCC/CCOs)**
Waste Composition	Variable; contaminated clothing, tools, rags, residues, debris, soil, and other items	Plutonium residues, heterogeneous debris, salts, and sealed sources	Diluted Surplus Plutonium
Physical volume (outer container)	0.21 m^3	0.21 m^3	0.21 m^3
Total number of emplaced containers	97,928	27,025	160,667
Total amount of plutonium-239	1.6 MT	3.2 MT	48.2 MT
Percentage of plutonium-239 at 10,000 years	15	(included in CH TRU)	85
Fissile gram equivalent (FGE) per container	14.4 g/ <200 g, FGE	117 g/ <200 g, FGE	300 g (nominal)/ <380 g, FGE
Actual volume of waste containers	175016 m^3	(included in CH TRU)	33,740 m^3
After contrived "volume of record" calculations that include only inner container volume	130186 m^3	(included in CH TRU)	2,056 m^3

Source: National Academies of Science, Engineering and Medicine, *Review of DOE's Plans for Disposal of Surplus Plutonium in the Waste Isolation Pilot Plant*, 2020, Washington, DC: The National Academies Press. https://doi.org/10.17226/25593 Note: the ever-evolving and full amount of waste to be emplaced at WIPP is not included here. The comparison of typical TRU waste and diluted surplus plutonium is the focus of the table. Also, it should be noted that the legislated capacity for WIPP is 175,564 cubic meters even though the normal way of computing the waste volume has been manipulated by the DOE to allow more waste to be placed in WIPP.

The TRU waste with lower fissile grams fissile material per container pose far less criticality risk than the surplus plutonium the DOE wants to dispose of in WIPP. The surplus plutonium disposal in WIPP greatly increases the importance of independently reviewed criticality evaluations as well as overall migration of the waste that assure safety in the near term and over the long term.

The review by the National Academies of Science in 2020 belatedly obtained some of the criticality studies for WIPP but concluded that they did not have the time and budget to conduct comprehensive independent technical review of those criticality reports. "Nevertheless, reasonable doubt or concern over stated assumptions or assessments with the reports may be noted by the committee." Some of those criticality analyses are still not available to the public. The EPA must see that independent reviews of the criticality evaluations of WIPP are conducted, with the addition of surplus plutonium, and available to the public.

There are many variables that influence nuclear criticality, especially over the lifetime of the repository. The bags of magnesium-oxide, MgO, that are placed inside WIPP are intended to absorb CO2 produced by the decay of carbon-based materials such as wood, paper, plastic, rubber, etc. But the MgO also makes a good neutron reflector and/or moderator, according to a study by Brickner at the Oak Ridge National Laboratory. [16]

The rooms in the excavated storage panels at WIPP are dry initially, but the salt tends to compress the rooms vertically more than horizontally. Roof collapse can occur, as can entry of brine. The plutonium spacing between the drums will be reduced. Typically, water ingress is a moderator that increases the change of nuclear criticality, but chlorine in the salt brine can reduce the likelihood of criticality. The iron in the steel of the material surrounding the plutonium can also influence the likelihood of criticality. **Beryllium enhances the ability for the fissile material to go critical and while the WIPP has limits on beryllium in the waste, beryllium is not detectable inside the packages.**

The Idaho Cleanup Project deliberately ignored the possible beryllium in some of its waste packages [17] because failure to meet the WIPP limits on beryllium would have meant expensive repackaging or inability to dispose of the waste at WIPP. The inadequate control of waste barrel contents was not random — it was to avoid the inconvenience and cost of compliance.

For adequate safety, it cannot simply be assumed that WIPP limits on beryllium content have been met. **There needs to be positive verification before that waste is placed in WIPP or conservative analyses showing that the present of forbidden material or excess quantities is acceptable.**

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[16] Bret D. Brickner, Oak Ridge National Laboratory, *Post Placement Nuclear Critical*ity Evaluations Involving 6- and 12-Inch Pipe Overpack TRU Waste Containers at the Waste Isolation Pilot Plant, ORNL/TM-2019/1222, October 2019. Note that this report addresses containers limited to 200 fissile gram equivalents (FGE) and does not address the surplus plutonium disposal which is a higher fissile content per container of 380 FGE.

[17] Idaho Cleanup Project Core, "Formal Cause Analysis for the ARP V (WFM-1617) Drum Event at the RWMC," October 2018. https://fluor-idaho.com/Portals/0/Documents/04_%20Community/8283498_RPT-1659.pdf

A study by Saylor at the Oak Ridge National Laboratory found that the addition of 50 g of B4C per container intermixed with the plutonium waste form would be able to maintain subcriticality. [18]

If boron carbide (B_4C) is added to the surplus plutonium, will the proper addition of boron carbide be verified? Can the boron carbide addition create any other hazards such as flammable gas problems during any phase of operation, including transportation?

Regarding the inadequate EPA regulations for WIPP, are the strange "EPA Units." [19] The DOE's Performance Assessment is a contrived analysis using "EPA Units" as a sliding metric for 10,000 years after WIPP's closure. **The more waste disposed of at WIPP, the more waste the EPA's regulations allow WIPP to release.**

The post-closure performance criteria for WIPP from 40 CFR 191.13 set normalized standards for cumulative radionuclide releases to the accessible environment over 10,000 years. **Unlike any other repository in the world, WIPP's performance is not keyed to radiation protection standards based on dose limits.** As if the bar for repository performance was not low enough already, the EPA regulations are created such that the more waste disposed of in WIPP, the higher the allowed radiological releases.

The fact that plutonium-239 has a 24,000-year half-life and the EPA's period of interest is only 10,000 years is not just arbitrary, but contrived. The excuse by the EPA is that geologic stability is too hard to know, past 10,000 years, so EPA argues, why try? The EPA and the DOE apparently don't think anything matters after their short life times end.

The truth is that the EPA's lousy regulations allow pollution of our air, soil and drinking water now, today, from the nuclear industry. It's not just plutonium-239. The decay products of plutonium-238, and curium-242, are like that of uranium-238 and include radium-226 and radon-222. The decay products of plutonium-240 and uranium-236 are like that of thorium-232 and include radium-224 and radon-220. The Department of Energy already has a policy of ignoring its and nuclear industry contributions to **elevated levels** of various radionuclides, including radium in drinking water. The EPA already allows unidentified alpha-emitting radionuclides in our drinking water and around southeast Idaho, the unidentified alpha is often americium-241 and plutonium-239. Monitoring programs for WIPP assure the public that americium and plutonium detected near WIPP are simply not attributed to WIPP.

The 2020 NAS report suggests that because of the tremendous changes to the waste composition from the proposed disposal of surplus plutonium, the elevated criticality risk, the greatly increased radioactivity of the waste, and the challenges of extending WIPP's operation for decades, there should be the resurrecting of the Environmental Evaluation Group (EEG). It is

[18] Ellen M. Saylor, Oak Ridge National Laboratory, *Nuclear Criticality Safety Assessment of Criticality Control Containers without Moderation Control at the Waste Isolation Pilot Plant*, ORNL/TM-2020/1713, September 2020.

[19] Environmental Protection Agency, *The Geochemistry of the Waste Isolation Pilot Plant*, EPA-402/R-21/002, November 2021. https://www.epa.gov/radiation/epas-role-waste-isolation-pilot-plant-wipp

important to understand that the contractors like Sandia National Laboratory strive hard to come up with the answers desired by the DOE. There are important examples from the Yucca Mountain repository effort that found contractor assumptions and modeling changes gave DOE desired answers but were documented by independent review as being technically indefensible. DOE simply withheld the independent reviews from the state of Nevada and went forward with technically indefensible and non-conservative modeling.

The need for massive redo of the Performance Assessment for WIPP should be considered a significant change by the EPA. The pending changes to the underground configuration of WIPP should be considered a significant change to WIPP. The EPA needs to take safety seriously and needs to take transparency seriously. More independent technical reviews are needed and the EPA must conduct a full rulemaking on WIPP.

The EPA held informal and non-transcribed meetings in Santa Fe on August 28 to discuss the technical issues and listen to public comment. The EPA claimed that its regulations for WIPP are conservative. That statement alone speaks volumes about the EPA.

It appears that the EPA plans to approve DOE's Planned Change Request (PCR) without any rigorous review of the Department of Energy's claims or its Performance Assessment for WIPP and with minimal transparency.

Numerous unrealistic and non-conservative assumptions are typical of DOE Performance Assessments that seek to achieve a very low bar – that of making a plausible cause for reasonable assurance of adequate performance of the waste dump.

WIPP was called a "pilot" plant because the DOE was claiming it would also seek another defense waste disposal facility, but DOE has not sought another facility. If the previous promises made to the State of New Mexico by the Department of Energy are understood, regarding the mission of WIPP, the limited duration of its operation and the limited transportation of radioactive waste through the state are understood, the lesson to be learned is quite simple: **agreements made with the Department of Energy cannot be trusted by citizens in any state.**

The public can submit written comments to the U.S. Environmental Protection Agency, Planned Change Request for WIPP Replacement Panels 11 and 12, Docket EPA-HQ-OAR-2024-0309 by September 16, 2024 at https://www.regulations.gov/docket/EPA-HQ-OAR-2024-0309 or www.regulations.gov/commenton/EPA-HQ-OAR-2024-0309-0001

History relevant to WIPP: Don't forget that the EPA has often made bad regulations in order to placate the Department of Energy and independent technical reviews of DOE's repository modeling are needed

Some relevant history regarding the U.S. Environmental Protection Agency's tendency to contort human protection criteria toward the Department of Energy's desires comes from the history of regulations proposed for the Yucca Mountain repository.

The regulations for the proposed Yucca Mountain repository involve standards created by the U.S. Environmental Protection Agency as well as the NRC. The National Academy of Sciences did not support limiting the concern for repository performance to only 10,000 years. When a court ruled that the recommendation of the National Academy of Sciences had been stipulated as needing to be followed and the doses after 10,000 years needed to be considered for Yucca Mountain, the EPA modified its regulation to limit an individual's exposure from Yucca Mountain trickle out contamination from water that infiltrates the repository from 15 mrem/yr for the first 10,000 years to a two-tier regulatory scheme that allowed more contamination exposure to individuals after 10,000 years.

In the EPA's initial draft of the two-tier scheme, **the limit for exposure after 10,000 years was an obscene 350 mrem/yr,** [20] which the nuclear industry doesn't even like to talk about now.

After public backlash, the EPA backed it down from 350 mrem/yr to 100 mrem/yr after 10,000 years, see Table 2. Why didn't the EPA just apply the same 15 mrem/yr dose that the EPA considered safe for the entire duration that the waste was toxic? It appears that the Department of Energy's modeling which had accepted escalating radiation releases after 10,000 years, did not think that estimated doses could be kept below 15 mrem/yr after 10,000 years. It appears to me that the EPA was under the influence of the Department of Energy when its two-tier radiation standard was issued.

The 2007 Draft Yucca Mountain Environmental Impact Statement read as follows:

> "To obtain NRC authorization to construct the Yucca Mountain repository, DOE must demonstrate that the proposed repository meets the regulatory individual radiation protection standards set by EPA and NRC. Under the existing standards, estimated repository performance will be compared to a mean annual dose of 15 millirem for the first 10,000 years after closure. Under the proposed standards, estimated repository performance will be compared to a median annual dose of 350 millirem for the post-10,000-year period."

[20] U.S. Department of Energy, *Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, DOE/EIS-0250F-S1D, October 2007. https://www.energy.gov/sites/prod/files/EIS-0250-S1-DEIS-Summary-2007_0.pdf

The annual dose of 100 mrem/yr commencing to a child, embryo or fetus and continuing over a lifetime would assure a significantly higher rate of cancer and disease. The annual dose rate from the ingestion of radionuclides, of 350 mrem/yr would be a health catastrophe. That EPA's regulation allows the 95th percentile doses to be as high as the sky and for years on end shows that the EPA's regulation had little concern for life on the planet Earth. (See our August 2020 newsletter and other articles on the Environmental Defense Institute website to better understand the harm of radiation exposure.)

The Department of Energy's modeling of the trickle out of radionuclides from the disposal of spent nuclear fuel at Yucca Mountain made it problematic to achieve 15 mrem/yr to an individual living 18 km downgradient of Yucca Mountain. But as water seeps into the porous volcanic "tuff" of the mountain and the waste containers inevitability corrode, the radionuclides trickle out, moving with groundwater. The degree of "sorption" of radionuclides to the soil along the way has been modeled based on contrived laboratory tests and often over zealously is modeled to sorb to the soil rather than reach the person drinking water 18 km from the disposal site.

The water infiltration model was thought by one prominent geologist, Lynn W. Gelhar, to underpredict the groundwater flow and the estimated annual radiological dose, as he explained in Chapter 14 of the book *Uncertainty Underground*. [21] But something would happen to drastically lower the Department of Energy's trickle out radiation doses between 2007 and 2008 when the DOE submitted its license application for Yucca Mountain to the NRC. I had trouble understanding how the predicted doses dropped to less than a mrem/yr for post-10,000-year time frame. Both the earlier and later submittals had assumed perfect titanium drip shield performance, despite the implausibility of ever installing them in the repository. I finally found the answer in a letter on the State of Nevada's website for Yucca Mountain. [22]

An independent review of DOE's calculations had been contracted by the DOE but withheld from the State of Nevada. The review's conclusion was that the Department of Energy's modeling of water infiltration to the disposed of waste **did not provide a credible representation of water infiltration at Yucca Mountain**. In other words, because the periodic spikes in water infiltration had raised the estimated radiation dose, the water infiltration spikes were simply removed from the modeling in order to drive the estimated radiation exposures down. The contamination trickle-out problem that had previously estimated 95th percentile

[21] Edited by Allison M. Macfarlane and Rodney C. Ewing, *Uncertainty Underground – Yucca Mountain and the Nation's High-Level Nuclear Waste*, The MIT Press, 2006. ISBN 0-262-13462-4. Chapter 14 by Lynn W. Gelhar, *Containment Transport in the Saturated Zone at Yucca Mountain*. He concludes that the DOE calculations "could easily be three orders of magnitude larger than the DOE predicts (see figure 14.3). Figure 14.3 shows radiation dose versus time with the dose peaking after 10,000 years from closure. The DOE prediction was from 2001, DOE/RW-0539. Gelhar also points out the looseness of the EPA's standard "that probabilistic results be interpreted by applying the numerical standards to a "reasonable expectation" prescribed to be the mean is troubling." Figure 14.3 shows DOE's model yielded 95th percentile doses above 1000 mrem/yr after 100,000 years.

[22] Senate Hearing 109-523, Yucca Mountain Repository Project, May 16, 2006. https://www.govinfo.gov/content/pkg/CHRG-109shrg29473/html/CHRG-109shrg29473.htm

radiation doses above 1000 mrem/yr (yes, one thousand mrem/yr) and would struggle to meet the 100 mrem/yr median requirement by EPA regulations now had contrived the modeling to slash the estimated radiation dose to a person living 15 km (or 11 miles) downgradient to less than 1 mrem/yr.

The DOE's problem of meeting the regulatory standards for Yucca Mountain was easily solved by the use of technically unsupportable assumptions, which naturally the NRC had no problem with. The NRC would tell the media and the Government Accountability Office that there were no technical reasons to object to the repository at Yucca Mountain and that the Yucca Mountain repository would be "safe."

Table 2. History of EPA radiation standards for Yucca Mountain.

Standards	History	Citation	Apply to	Key Provisions
Generic radiation protection standards	Original 1985 Vacated 1987 Revised 1993	40 CFR 191	WIPP, potential non-NWPA repositories, monitored retrievable storage facilities, private interim storage	1993 standards: exposure limits to any individual, 0 – 10,000 years: 15 mrem/yr *
Yucca-specific standards, draft	Initial two-tier draft, 2007	40 CFR 197	Yucca Mountain	2007 draft standards: exposure limits to "reasonably maximally exposed individual," 0-10,000 years: 15 mrem/yr; 10,000 – 1,000,000 years: 350 mrem/yr **
Yucca-specific standards	Original 2001 Vacated 2004 Revised 2008	40 CFR 197	Yucca Mountain	2008 standards: exposure limits to "reasonably maximally exposed individual," 0-10,000 years: 15 mrem/yr; 10,000 – 1,000,000 years: 100 mrem/yr **

Table notes: Some information in the table is based on Richard Burleson Stewart and Hane Bloom Stewart, *Fuel Cycle to Nowhere – U.S. Law and Policy on Nuclear Waste*, Vanderbilt University Press, 2011. But *Fuel Cycle to Nowhere* did not discuss the proposed 350 mrem/yr EPA individual dose limit.

*The exposure limits apply to all individuals outside the controlled area, defined as an area no more than 100 km^2 extending no more than 5 km from the site (40 CFR 191.12. Annual exposure to any individual is limited to 25 mrem (40 CFR 191.03.

** Typically, the EPA defines the controlled area around a toxic waste site as no more than 300 km^2 extending no more than 5 km from the site. For Yucca Mountain, the distance in the direction of groundwater flow was extended to 18 km. Human intrusion limits not included in the table.

The State of Nevada, however, had noted that in addition to the contrived modeling of the trickle out from Yucca Mountain, that other essential aspects of the license application for Yucca Mountain were technically unsupported and lacked design details or even the identification of applicable codes and standards. The Department of Energy has no technical basis to support the claims in its 2008 Yucca Mountain License Application about corrosion resistance of the metal waste packaging and drip shield and had not corrected the situation even after strong urging from the U.S. Nuclear Waste Technical Review Board. [23] [24]

The proposed Yucca Mountain disposal site has a tunnel but was never granted a license to construct. The technical flaws in the various proposed concepts for Yucca Mountain are even more problematic than the political problems. The State of Nevada was astutely aware that the analysis claims for container robustness against corrosion and the claimed limited water infiltration and trickle-out were not just unreliable, the claims were known to be scientifically unjustified. The final stated low radiation doses from the trickle-out of radionuclides relied on the installation of thousands of undesigned and impossible to install titanium drip shields.

A review of Sandia's modeling for Yucca Mountain that yielded estimates of low radiation doses from water contamination from the trickle out of radionuclides found that the Sandia models were technically indefensible. [25]

That independent review of DOE's calculations had been contracted by the DOE but withheld from the State of Nevada. The review's conclusion was that the Department of Energy's modeling, by Sandia, of water infiltration to the disposed of waste did not provide a credible representation of water infiltration at Yucca Mountain.

In other words, because the periodic spikes in water infiltration had raised the estimated radiation dose, the water infiltration spikes were simply removed from the modeling in order to drive the estimated radiation exposures down. The contamination trickle-out problem that had previously estimated 95th percentile radiation doses above 1000 mrem/yr (yes, one thousand mrem/yr) and would struggle to meet the 100 mrem/yr median requirement by EPA regulations now had contrived the modeling to slash the estimated radiation dose to a person living 15 km (or 11 miles) downgradient to less than 1 mrem/yr. [26]

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[23] State of Nevada to Chairman of the Nuclear Waste Technical Review Board, October 8, 2008. http://www.state.nv.us/nucwaste/news2008/pdf/nv08108nwtrb.pdf

[24] See the State of Nevada website, including the "Key Technical Issues" webpage at http://www.state.nv.us/nucwaste/technic.htm

[25] Senate Hearing 109-523, Yucca Mountain Repository Project, May 16, 2006. https://www.govinfo.gov/content/pkg/CHRG-109shrg29473/html/CHRG-109shrg29473.htm

[26] Letter from Council for the State of Nevada to Secretary of the U.S. Nuclear Regulatory Commission, State of Nevada's Supplement to its June 4, 2008 Petition Asking the NRC to Reject DOE's Yucca Mountain License Application as Unauthorized and Substantially Incomplete, July 21, 2008. The letter cites the review of DOE's

The Department of Energy's rapidly evolving waste emplacement concepts continued to evolve as every assumption about how the Yucca Mountain repository would contain the waste didn't hold up. Also, no utility has packaged its spent nuclear fuel into DOE's recommended "transport, aging and disposal" TAD canister.

Regarding criticality issues, the Department of Energy initially hand-waved away criticality concerns in the Yucca Mountain repository. After analyses were finally conducted especially for the use of higher enriched or "high burn-up" fuels, the agency began claiming that multiple criticalities in the waste repository wouldn't add that much harm to a disposal repository's already estimated harm. Criticality risks for commercial spent nuclear fuel peak in 25,000 years, despite government standards for criticality risk ending in 10,000 years.

The Environmental Protection Agency's approval of the West Lake Landfill in Missouri is also informative. The EPA and State of Missouri approved the disposal cover for the West Lake landfill in 2008, containing both have buried chemically laden and radioactive waste. The West Lake landfill in Missouri failed within a couple years of installation, and has had underground fires burning since December 2010 that no one knows how to extinguish. [27] [28] The EPA has told residents near to West Lake Landfill, to stay indoors and close the windows…

"Atomic Homefront," a documentary about the uranium processing waste dumped into the West Lake Landfill. The documentary includes footage of Environmental Protection Agency officials downplaying and denying the health problems associated with the radioactive waste.

Over the Environmental Protection Agency's history, the EPA has often made inadequate regulations and delayed making needed regulations. Even with adequate regulations, the EPA's enforcement has often been tardy or absent. So, when the EPA holds meetings and postures that its regulations are conservative and that the public should trust the EPA, like EPA did last August in New Mexico about changes to WIPP, the EPA has signaled its intent to rubber-stamp any Department of Energy proposal and abdicated its needed role in protecting the public and the environment.

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infiltration model performed at DOE's request by ORISE (Oak Ridge Institute for Science and Education). ORISE provided the results of this independent review to DOE on April 30, 2008. http://www.state.nv.us/nucwaste/news2008/pdf/nv080721nrc.pdf

[27] Robert Alvarez, Bulletin of the Atomic Scientists, "West Lake story: An underground fire, radioactive waste, and governmental failure," February 11, 2016. https://thebulletin.org/2016/02/west-lake-story-an-underground-fire-radioactive-waste-and-governmental-failure/

[28] Veronique Lacapra, St. Louis Public Radio, "Confused about Bridgeton, West Lake landfills? Here's what you should know," October 20, 2015. https://news.stlpublicradio.org/post/confused-about-bridgeton-west-lake-landfills-heres-what-you-should-know

High-Temperature Gas-Cooled Reactors radionuclide emissions during routine operations likely to remain unmonitored, but harmful

China has recently completed a test on its pebble bed gas-cooled high temperature reactor, showing that the helium circulation can adequately cool the fuel even without powering circulation of the helium.

In the U.S., X-energy is working to obtain a Nuclear Regulatory Commission license for its Xe-100 high-temperature gas-cooled reactors that are also pebble bed reactors. Each 80-megawatt-electric reactor can be included in a four-pack to make a 320 MWe power plant.

According to the ANS, X-energy has a joint development agreement with Dow to develop its first Xe-100 plant in Seadrift, Texas. X-energy is also seeking to develop up to 12 Xe-100 reactors near the Energy Northwest's Columbia nuclear power plant.

According to the Department of Energy, the Xe-100 reactor uses a uranium-based pebble fuel that could be available in the market as early as the late 2020s. The Xe-100 reactor core is made of graphite and filled with 15.5 percent enriched fuel pebbles, each about the size of a billiard ball. Each ball or pebble contains thousands of Tri-structural Isotropic (TRISO) uranium fuel particles.

The Department of Energy's website claims that the TRISO fuel particles are virtually indestructible. [29] However, there are various ways that radioactive particles can escape a gas-cooled reactor and reach the environment. Water ingress can create reactivity increases. Air ingress means radioactive particles can be released and there isn't a reactor containment. And graphite dust, laden with radioactive particles, can build up in the system. **The gaseous and radioactive particle release from the TRISO fuel may depend on the amount of time the fuel has been used in the reactor. At higher burnup times, more degradation of the TRISO fuel may occur that may allow more fission products to escape the fuel.** [30] [31]

[29] Department of Energy, Office of Nuclear Energy, webpage: X-energy is Developing a Pebble Bed Reactor That They Say Can't Melt Down, January 5, 2021. https://www.energy.gov/ne/articles/x-energy-developing-pebble-bed-reactor-they-say-cant-melt-down

[30] Matthias Englert, Friederike Frieb, and M.V. Ramana, "Accident Scenarios Involving Pebble Bed High Temperature Reactors, *Science and Global Security*, Vol. 25, No. 1, 42-55,2017. http://dx.doi.org/10.1080/08929882.2017.1275320 or https://www.semanticscholar.org/paper/Accident-Scenarios-Involving-Pebble-Bed-High-Englert-Frie%C3%9F/63348efe1bb352471a30bac362cb3d0ddc933221

[31] M. V. Ramana, *Nuclear is not the Solution – The Folly of Atomic Power in the Age of Climate Change*, Verso 2024. ISBN-13: 978-1-80429-000-2 Also, see https://www.theguardian.com/environment/article/2024/sep/04/mv-ramana-why-nuclear-power-not-solution-energy-needs

A 2012 NAS study acknowledged the airborne and liquid effluent radiological releases from commercial nuclear power plants, stating "At present, nuclear plants typically release between a few curies and several hundred curies per year in airborne effluents." [32]

To the nuclear industry, averaging the contamination levels throughout the year is adequate. And to the nuclear industry, emphasizing the average release from a nuclear plant is acceptable. But the variability matters, especially the maximum levels that the unborn, developing child in utero is exposed to.

Most of the airborne effluents are from radioactive iodines, krypton, xenon, argon fission and activation gases, and radioactive particulates such as cobalt-58, and cobalt-60, cesium-134 and cesium-137, chromium-51, manganese-54 and niobium-95, and tritium. But often the radionuclide releases from nuclear power plants simply are not monitored.

The U.S. NRC cancelled what would have been the first meaningful epidemiology study of health effects near US nuclear reactors, [33] despite the German epidemiology study of children living near nuclear plants have roughly double the incidence of cancer and leukemia and similar findings resulted from the study of clusters of childhood leukemia near nuclear sites including Sellafield, Dounreay and La Hague where an excess of 300-fold infant leukemia were found. [34] [35] [36]

Airborne radiological releases from nuclear power plants affect downwind residents but contaminated foods are distributed unevenly. Radioactive contamination that lands on pastures grazed by dairy cattle results in radioactively contaminated milk. Radioactive contamination also affects garden produce. Thus, the inhalation and ingestion of radionuclides varies according to location as well as diet.

The harm depends on gender and the age of exposure and it is known that women are more vulnerable than men, and children are more vulnerable than adults. [37] Radiological sampling of milk that was conducted in the U.S. allowed levels of radioactivity that we now know were

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[32] Committee on the Analysis of Cancer Risks in Populations near Nuclear Facilities, Nuclear and Radiation Studies Board Division of Earth and Life Studies, National Research Council of the National Academies, *Analysis of Cancer Risks in Populations Near Nuclear Facilities: Phase 1*, 2012. ISBN 978-0-309-25571-4

[33] NRC (Nuclear Regulatory Commission) 2010. NRC Asks National Academy of Sciences to Study Cancer Risk in Populations Living near Nuclear Power Facilities. NRC News No. 10-060, 7 April 2010. Washington, DC: NRC. The framework for the study was reported in "Analysis of Cancer Risks in Populations Near Nuclear Facilities; Phase I (2012). See cancer risk study at nap.edu.

[34] P Kaatsch et al., Int J Cancer, "Leukaemia in young children living in the vicinity of German nuclear power plants," 2008 Feb 15;122(4):721-6. http://www.ncbi.nlm.nih.gov/pubmed/18067131

[35] Spix C, Schmiedel S., Kaatsch P, Schulze-Rath R, Blettner M., Eur J Cancer, "Case-control study on childhood cancer in the vicinity of nuclear power plants in Germany 1980-2003." 2008 Jan;44(2):275-84.Epub 2007 Dec 21. http://www.ncbi.nlm.nih.gov/pubmed/18082395

[36] Chris Busby, "Infant Leukaemia in Europe after Chernobyl and its Significance for Radioprotection; a Meta-Analysis of Three Countries Including New Data from the UK," Chapter 8 of *ECRR Chernobyl: 20 Years On – Health Effects of the Chernobyl Accident*, Editors C.C. Busby and A. V. Yablokov, 2006.

[37] Environmental Defense Institute, August newsletter article "Nuclear energy promoters continue to ignore adverse impacts to children and the unborn child," August 2024 at http://www.environmental-defense-institute.org/publications/News.24.Aug.pdf

harmful. Diminishing radioactivity levels in the diet were accompanied by immediate and significant morbidity and mortality reductions among infants and young children, from 1965 to 1970.

Joseph J. Mangano and others published a study, "Infant Death and Childhood Cancer Reductions after Nuclear Plant Closings in the United States. The study found that following nuclear power plant closures, decreases in the radioactivity of milk has been noted and reductions in deaths among infants who had lived downwind and within 64 km of each nuclear plant were noted. Cancer incidence in children younger than 5 years of age were also noted to fall significantly after the shutdowns. [38]

Certain aspects of high-temperature gas-cooled reactors may be safer than other reactors, but the X-energy pebble bed HTGR is certainly far from inherently safe. And the non-accident radiological releases from each Xe-100 reactor may worsen as the fuel is used. The typical strategy is don't mention this vulnerability and don't monitor the radiological releases. Monitoring found that the Fort St. Vrain gas-cooled reactor had variable releases during its operation, but there was a careful effort to avoid admitting this. No one wants the local dairy farmers to known their milk is getting contaminated from the nuclear reactors within 50 miles or so.

There is no known way to reprocess TRISO spent nuclear fuel and similar spent nuclear fuel languishes at the Idaho National Laboratory and at the former Fort St. Vrain gas-cooled reactor in Colorado.

An early gas-cooled reactor in the U.S., Peach Bottom Unit 1, has spent nuclear fuel stored at the Idaho National Laboratory's INTEC facility. Unwanted moisture ingress from the below grade spent nuclear fuel storage vaults has made it necessary to more the spent fuel to newer vaults that, hopefully, won't experience moisture ingress problems as soon. The Peach Bottom Unit 1 spent fuel transfers began in 2022 and are expected to continue through 2025. To date, 30 transfers, or 75 percent of the total[39], have been completed, according to the American Nuclear Society. [40] The cost of continued spent nuclear fuel management of the gas-cooled reactor spent nuclear fuel is being paid for by the U.S. taxpayer.

Do the electricity rate payers plan on the forever storage costs of the spent nuclear fuel from high-temperature, gas-cooled reactors?

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[38] Joseph J. Mangano, Jay M. Gould, Ernest J. Sternglass, Janette D. Sherman, Jerry Brown and William McDonnell, Radiation and Public Health Project, "Infant Death and Childhood Cancer Reductions after Nuclear Plant Closings in the United States," *Archives of Environmental Health*, Vol. 57 (No.1), January/February 2002.

[39] American Nuclear Society Nuclear Newswire, "Chinese pebble-bed reactor passes 'meltdown' test," July 24, 2024. https://www.ans.org/news/article-6241/china-pebblebed-reactor-passes-meltdown-test/ The article states that the reactor went into commercial operation December 2023.

[40] American Nuclear Society Nuclear Newswire, "INL spent fuel transfers are ahead of schedule," August 30, 2024. https://www.ans.org/news/article-6347/inl-spent-fuel-transfers-are-ahead-of-schedule/

NWTRB August 29 meeting reveals Idaho National Laboratory to miss major Idaho Settlement Agreement Milestone by, at least, many decades

As the Department of Energy has not proceeded with any actions to meet the Idaho Settlement Agreement's milestone to ship spent nuclear fuel out of the state by 2035, DOE has not been discussing just how many years late it would be.

Now DOE's Idaho Cleanup Project at the INL claims that a demonstration project in CPP-603 will load spent nuclear fuel in a configuration that will be "road ready," transportable and disposable.

According to an Idaho Cleanup Project presentation at the Nuclear Waste Technical Review Board Meeting held August 29, 2024, the packaging of Department of Energy EM-managed spent nuclear fuel is finally slated to be conducted at the Idaho National Laboratory's Idaho Nuclear Technology and Engineering Center (INTEC) CPP-603 facility. [41] However, packaging DOE-EM managed spent nuclear fuel at the INL could take decades, perhaps 60 years.

INTEC was formerly known as the chemical processing plant, and CPP-603 was build in stages between 1952 and 1974. The Irradiation Fuel Storage Facility of CPP-603 was built in 1974 for storing the Fort St. Vrain gas-cooled reactor spent nuclear fuel. Shipments of Fort St. Vrain fuel from Colorado ceased after only about one third of the SNF was shipped.

CPP-603 is not designed to receive welded-closed canisters, nor was its proposed replacement, the NRC-licensed, but never built Idaho Spent Fuel Facility.

For over two decades, the Department of Energy has been saying they would build a new facility for repackaging INL spent nuclear fuel and it was called the Idaho Spent Fuel Facility. Due to concerns over aging facilities, a design by Foster Wheeler was submitted to the U.S. Nuclear Regulatory Commission in 2001. [42] The Idaho Spent Fuel Facility was never built.

Now, in 2024, with no mention of the Idaho Spent Fuel Facility, DOE is posturing as though the decades-old CPP-603 is suitable. CPP-603 historically included spent nuclear fuel pools that were mismanaged and neglected. Safety problems at the dry spent fuel storage portion of CPP-603, for the public and for workers, need more examination.

The spent nuclear fuel is to be placed in DOE standard canisters. Then seven DOE standard canisters are to be placed into a single multi-purpose canister (MPC). The MPC can then be placed into a transportation package such as designs by Holtec International.

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[41] See Nuclear Waste Technical Review Board Summer meeting presentations for August 29, 2024 at https://www.nwtrb.gov/meetings/past-meetings/summer-2024-board-meeting---august-29--2024

[42] U.S. Nuclear Regulatory Commission, Policy Issue Notation Vote, Subject: Request for Authorization to Issue a License for the Idaho Spent Fuel Facility, Under 10 CFR Part 72, SECY-04-0199, October 26, 2004. See nrc.gov, ADAMS database ML042730592.pdf

The demonstration project would only package a single MPC. Various modifications to CPP-603 will be needed and although existing Type B shipping containers are to be used, the transportation method has not been developed for the needed onsite movement, as I understand it.

An SNF Staging Facility is to be built that would be a concrete pad or a vault system similar to the Three Mile Island Independent Spent Fuel Storage Installation. Further infrastructure such as a railroad spur will be needed before the spent nuclear fuel can be shipped to a repository.

At the INL, there are three entities that manage and store spent nuclear fuel: The Department of Energy, Office of Environmental Management, the DOE's Office of Nuclear Energy and the Naval Nuclear Propulsion Program. The Fort St. Vrain spent nuclear fuel is managed by DOE-EM.

The DOE-NE spent nuclear fuel is EBR-II SNF and other SNF at the Materials and Fuels Complex. The naval SNF is currently about 41 metric tons of SNF at the Naval Reactors Facility. The remaining SNF is DOE-EM managed.

The U.S. Nuclear Waste Technical Review Board published a report of the types and locations of spent nuclear fuel at the INL and other DOE facilities in 2017. [43] The DOE-managed (excluding naval SNF) was summarized in the August 2024 meeting presentation by the Idaho Cleanup Project and is provided in Table 3.

EBR-II driver fuel has been removed from the INTEC CPP-666 pool and some has been pyroprocessed for high-assay low-enriched uranium recovery that is releases considerable airborne radioactivity.

The Advanced Test Reactor at the INL continues to operate and generate more spent nuclear fuel. While there is more ATR fuel now, and less EBR-II driver fuel, the numbers given by the Idaho Cleanup Project presentation are similar to but I could not closely reconcile the amounts of SNF from the presentation to the 2017 NWTRB report.

Importantly, the Idaho Cleanup Project stated that Revision to DOE Order 435.1 allows DOE to manage approximately 53 MTHM as non-SNF. While remaining deliberately vague, it appears that DOE intends to treat and dump the sodium-bonded fuel. Part of the fuel may go to WIPP, part to low-level radioactive waste dumps like the one in Clive, Utah.

According the presentation by the Idaho Cleanup Project, Three Mile Island spent nuclear fuel debris is stored in an NRC-licensed NUHOMS-based ISFSI and will not require repackaging. The TMI-2 canisters are not sealed and leak radionuclides to the environment. The cladding is damaged or not present. It is nothing like the robust spent nuclear fuel "rod" DOE keeps talking about.

[43] U.S. Nuclear Waste Technical Review Board (NWTRB), Management and Disposal of U.S. Department of Energy Spent Nuclear Fuel. Arlington, December 2017.

Table 3. Idaho National Laboratory DOE-EM or DOE-NE managed spent nuclear fuel.

Spent Nuclear Fuel Category	Primary SNF Types	Metric Tons Heavy Metal (MTHM)	Number of DOE Standard Canisters
1 – "Normal [for DOE-EM]"	Advanced Test Reactor, Fort St. Vrain, Shippingport, Peach Bottom, TRIGA	159.2 MT	1387
2 – "Sodium-bonded"	Fermi blanket material, EBR-II driver	54.9 * DOE plans to reclassified as Not Spent Nuclear Fuel ?	124
3 – "Epoxied"	Materials Test Reactor canal scrap	0.4	15
4 – "Rubble"	Pieces, scrap, and other damaged parts	4.2	66
5 – "Intact Commercial"	Big Rock, Turkey Point	44.1	124
6 – "Non-Intact Commercial"	Turkey Point and Surry disassembled fuels	23.9	42
7 – "Other"		0.7	6
Total		**287.4 MTHM**	**2002 DSC**

Source: Nuclear Waste Technical Review Board Summer meeting presentations for August 29, 2024 at https://www.nwtrb.gov/meetings/past-meetings/summer-2024-board-meeting---august-29--2024 See the presentation "Idaho National Laboratory SNF Management: Activities and Plan, Part 1, by Nicholas Balsmeier and Steven Wahnschaffe.

Table notes: DOE Standard Canisters (DSCs) come in either a 18-inch outer diameter or 24-inch outer diameter and lengths of 10 ft or 15 ft. Multi-purpose canisters (MPCs) are far larger, with a 68-inch outer diameter and a length of 15.8 ft. (See NWTRB presentations for August 29, 2024, "Flaw Tolerance of DOE SNF Storage Canisters" stored as a group of presentations for "Spent Nuclear Fuel Management Alternatives at the Savannah River Site."

The presentation also states that a geologic repository is not anticipated to be available for multiple decades and no shipments expected before 2055. There was no mention of sending the DOE-EM fuel to a consolidated interim storage site.

During the presentation, it was stated that after facilities and processes are developed, it will take roughly 60 years of packaging to make the DOE's spent nuclear fuel "road ready." When asked during the presentation whether or not "road ready" also meant

"disposal ready," the answer was given as "yes" but this appears premature. The text of the presentation states that the work of defining was "road ready" means work is "ongoing." [44]

In fact, what the INL is proposing would not be compliant with past Yucca Mountain repository plans. Spent nuclear fuel was to be placed in "transport, aging and disposal" overpack casks called TADs.

Yucca Mountain was never designed to accepted welded-closed multi-purpose canisters, or "MPCs."

Instead, bare fuel was to be loaded into TADs, but the electric utilities did not ever load SNF into TADs. For this reason, there is ongoing litigation between DOE and the electric utilities because **DOE says that spent nuclear fuel loaded into welded-closed MPCs is not considered by DOE to be an acceptable waste form for disposal.**

But INL is proposing loading SNF into welded-closed MPCs and claiming that they would be "disposal ready." That is, if there is ever a repository. But even shipping to a consolidated storage site would not happen for decades and it creates many other problems.

In presentations at the NWTRB meeting for the Savannah River Site's dizzying array of possible options in how to reduce the inventory of its spent fuel pool called L-Basin and whether or not to conduct many challenging SNF reprocessing campaigns with H-Canyon, the research needed for aluminum-clad fuels was discussed. [45] Aluminum-clad spent nuclear fuel at the INL from the Advanced Test Reactor is highly enriched in uranium-235 and was originally to be reprocessed at Savannah River Site's H-Canyon. Aluminum-clad spent nuclear fuel from the DOE's High Flux Isotope Reactor (HFIR) at Oak Ridge is stored at L-Basin. Dry storage of the aluminum-clad SNF is now being investigated. The key challenge is thought to be the chemically bound water in aluminum (oxy)hydroxides (AlOOH) or $AL(OH)_3$) with the potential for radiolysis producing H_2 gas. The presentation to the NWTRB states that "Results to date point to extended dry storage [of the aluminum clad SNF] being viable." But demonstration in the drying process and loading and handling in a canister have not been conducted.

Despite the challenges and belated research, next to nothing was said about the safety of long term storage and disposal of INL's aluminum clad ATR fuel or any spent nuclear fuel at INL.

The NWTRB meeting on August 29, 2024 would be a comedy – if it were not such a tragedy.

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[44] See Nuclear Waste Technical Review Board Summer meeting presentations for August 29, 2024 at https://www.nwtrb.gov/meetings/past-meetings/summer-2024-board-meeting---august-29--2024 See the presentation "Idaho National Laboratory SNF Management: Activities and Plan, Part 1, by Nicholas Balsmeier and Steven Wahnschaffe.

[45] See Nuclear Waste Technical Review Board Summer meeting presentations for August 29, 2024 at https://www.nwtrb.gov/meetings/past-meetings/summer-2024-board-meeting---august-29--2024 See the presentations "Spent Nuclear Fuel Management Alternatives at the Savannah River Site" and "ASNF Dry Storage Pilot.

NWTRB August 29 meeting highlights DOE's Paul Murray pursuit of favorable public opinion concerning the expanding nuclear waste problems

The Department of Energy's Paul Murray provided considerable cheerful and optimistic talk about spent nuclear fuel management at the Nuclear Waste Technical Review Board (NWTRB) meeting held August 29, 2024. [46]

The current efforts to site temporary consolidated interim storage by the Department of Energy is often referred to as "siting" for spent nuclear fuel and could be easily confused with the far more difficult work of siting a permanent disposal repository.

The recent ADVANCE Act of 2024 passed by Congress puts increased focus on DOE stating its tax payer liability for spent nuclear fuel. Murray emphasized the only the portion of the liability that, thanks to DOE, the taxpayers owe to commercial nuclear utilities.

Little information was provided about the full liability that taxpayers will be on the hook for to attempt to address storage, transportation and disposal of spent nuclear fuel. [47] [48]

DOE is required to pay to electric utilities for partial breach of contract for DOE not taking the commercial nuclear spent fuel and that money comes from the "Judgement Fund" that is paid by taxpayers.

The taxpayer liability Murray emphasized does not include the cost of DOE consolidated storage efforts or the cost of opening and operating the one or several permanent spent nuclear fuel repositories, the deep geologic repositories (DGRs), already needed. Following the suspension of the Yucca Mountain repository project in 2010, the Department of Energy has conducted several studies of several deep geologic disposal options. The DOE's geologic disposal research includes a variety of potential geologic media, including argillite, crystalline

[46] See Nuclear Waste Technical Review Board Summer meeting presentations for August 29, 2024 at https://www.nwtrb.gov/meetings/past-meetings/summer-2024-board-meeting---august-29--2024 See Paul Murray, Deputy Assistant Secretary, Spent Fuel & High Level Waste Disposition, U.S. Department of Energy, "Spent Nuclear Fuel and High Level Waste" presentation.

[47] Environmental Defense Institute, February newsletter article "Nuclear promoters continue to avoid realistic disclosure of the cost of spent nuclear fuel disposal or of reprocessing," "Still no repository identified for Department of Energy and Naval Spent Nuclear Fuel and High-Level Waste (or for Commercial Spent Nuclear Fuel)," "Department of Energy has no program for a permanent repository and it must be stressed that Consolidated Interim Storage Sites are not a solution for the growing nuclear waste problem," "Department of Energy advised to strengthen public trust and confidence back in 1998 and again in 2021, as DOE hires social scientists and gives money to its 'consortia' but continues to make no progress on any repository for the nation's spent nuclear fuel," and "Safety of spent nuclear fuel during long-term storage still unknown," March 2024 at http://www.environmental-defense-institute.org/publications/News.24.Mar.pdf

[48] Environmental Defense Institute, March newsletter article "Department of Energy's Push to Triple Nuclear Energy Ignores Cost and Difficulty of Managing and Disposing of Spent Nuclear Fuel," February 2024 at http://www.environmental-defense-institute.org/publications/News.24.Feb.pdf

and **salt**. [49] No decisions have been made and no repository has been sited. The study of volcanic tuff as a repository type hasn't completely ended, but is less openly discussed. The most recent Nuclear Waste Technical Review Board (NWTRB) report issued in 2024 highlights the Department of Energy's research over the last decade regarding spent nuclear fuel disposal. [50] [51]

The collection of ratepayer fees ceased a decade ago in 2014 because DOE has no repository program.

The ADVANCE Act conveniently ignores the spent nuclear fuel from new reactors that the DOE is promoting and DOE has no plan for even assessing those costs and tax payer liabilities.

The "High Burnup Demonstration Cask" is a single cask of high burnup commercial spent nuclear fuel, about 15 metric tons, [52] that DOE plans to open in 2029 to supply data. Murray said that the site where that research cask with spent nuclear fuel inside will be shipped has not been decided, but the research cask of SNF will need to move to a new home in 2027.

Murray indicated there will be plenty of strings attached to the research site selected opening the "High Burnup Demonstration" cask. The planned "International Center for Research for Storage of SNF and HLW" will be located wherever the high burnup cask is located. Department of Energy laboratories such as the Idaho National Laboratory are candidates.

Because the U.S. commercial reactors have continued to use higher and higher fuel burnup, the "High Burnup Demonstration Cask" is already more like the "medium burnup" research program and yet no research needs for the higher burnup fuel was mentioned.

Low burnup is considered to be 45 gigawatt-days per metric ton of uranium (GWD/MTU). Since the 1990s, almost all spent nuclear fuel removed from U.S. commercial nuclear reactors exceeds 45 GWD/MTU.

Murray emphasized that all spent nuclear fuel research results, such as the data from the "High Burnup Demonstration" research, will need to be reviewed **and will not be released to the public until approved by DOE <u>and DOE's general council</u>.** I'm still waiting for DOE's SNF research documents that it hadn't released for the August 2023 NWTRB meeting. So, as if

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[49] U.S. Nuclear Waste Technical Review Board, *Evaluation of the U.S. Department of Energy Research and Development Activities on the Disposition of Commercial Spent Nuclear Fuel in Dual-Purpose Canisters*, February 2024. https://www.nwtrb.gov/our-work/reports/evaluation-of-the-u.s.-department-of-energy-research-and-development-activities-on-the-disposition-of-commercial-spent-nuclear-fuel-in-dual-purpose-canisters-(february-2024)

[50] U.S. Nuclear Waste Technical Review Board, *Evaluation of the U.S. Department of Energy Research and Development Activities on the Disposition of Commercial Spent Nuclear Fuel in Dual-Purpose Canisters*, February 2024. https://www.nwtrb.gov/our-work/reports/evaluation-of-the-u.s.-department-of-energy-research-and-development-activities-on-the-disposition-of-commercial-spent-nuclear-fuel-in-dual-purpose-canisters-(february-2024)

[51] D. Sassani et al., *SFWST Disposal Research R&D 5 Year Plan – FY2021 Update*, SAND2021-12491R, Albuquerque, New Mexico, August 2021.

[52] Electric Power Research Institute (EPRI), *High Burnup Dry Storage Cask Research and Development Project Final Test Plan*, 2014.

the DOE did not already profoundly delay the release of unfavorable SNF research results, Murray seems to expect results from the spent fuel research that DOE will not want to disclose.

Results from fission gas sampling of the "high burnup demonstration" cask were, according to a EPRI report, were to be made public: "DOE will make the data available via a website accessible to the public." [53] Such results are needed for assessing the radiological consequences of spent fuel canister breach, which the industry is in no hurry to determine. [54]

Overall, Murray displays a profound distaste for any suggestion that any problems might be found during the research of spent nuclear fuel, and in fact, he is discouraging any questioning of spent fuel integrity or research to verify spent fuel integrity, because, it seems, he would rather just keep blind faith that the fuel will be fine during long term storage despite lacking an adequate technical basis for assuming this. This attitude has extended to some of the more vocal members of the NWTRB board, who, more than once during the meeting, berated presenters who were doing spent nuclear fuel research simply because it might imply that there *could* be a vulnerability during storage of the SNF. A dangerous mindset, indeed, and one that does not serve the public interest.

DOE's Paul Murray went so far as to say that DOE should not question any decision or analysis made by the U.S. Nuclear Regulatory Commission. Basically, he is suggesting that everyone just repeat to yourself the mantra "spent nuclear fuel is durable" and don't be concerned about actual data or the use of scientific approaches to verify fuel performance.

Does Murray even know that the NRC failed to meet its own requirements for spent fuel storage? The NRC required that spent nuclear be removable from the canisters, should a canister be misloaded. And NRC seemed surprised to learn that the SNF could not be removed if misloaded, because the fuel was too thermally hot. Does Murray even understand that the NRC approved the unsafe storage of SNF right on the Pacific coast for San Onofre spent nuclear fuel and it is likely to be inundated with sea water? [55] Does Murray understand the NRC licenses SNF storage for short licensing periods and doesn't seem to care what happens if the next relicensing isn't possible?

The Department of Energy is planning a "Package Performance Demonstration" in order to build public trust and confidence in the safety of SNF transportation casks. Murray stated that the "Package Performance Demonstration" program **does not and will not include comprehensive testing or verification of the adequacy of the many cask types.**

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[53] Electric Power Research Institute (EPRI), *High Burnup Dry Storage Cask Research and Development Project Final Test Plan*, 2014.

[54] U.S. Department of Energy, Spent Fuel and Waste Science and Technology, *Gap Analysis to Guide DOE R&D in Supporting Extended Storage and Transportation of Spent Nuclear Fuel: An FY2019 Assessment*, SAND2019-15479R, December 23, 2019. https://www.osti.gov/servlets/purl/1592862

[55] Samuel Lawrence Foundation, Full Transcript: Radioactive Waste: Growing Threats, Emerging Solutions, Symposium at UC San Diego, July 24, 2024. https://www.samuellawrencefoundation.org/radioactivewastesymposium

The effort, Murray explains, **is really just for public trust building** and not for assuring the adequacy of the transportation casks and their contents. The reality is that the "Package Performance Demonstration" program should be renamed the "Package Performance and Propaganda Demonstration."

DOE realized that it needed more people focused on engaging with the tribes so that consolidated interim storage could be located on tribal lands. Murray stated that additional "consortia" are being paid money to engage with Native American tribes.

DOE's Paul Murray is the poster child for a spokesman who knows, with confidence, that he will never be held accountable for his dangerous words and his non-existent spent nuclear fuel program to nowhere.

The recent book by summarizes the commercial nuclear waste problem: "Radioactive waste must be contained and managed for a duration longer than the age of civilization," and "In the U.S., there is currently no plan for long-term storage of waste generated by civilian nuclear power generation." [56] The August 29 NWTRB meeting reminds us that there is also currently no plan for long-term storage of waste generated by research or military reactors either.

The Department of Energy has acknowledged that there is not an adequate technical basis for long term storage of spent nuclear fuel or for transporting spent nuclear fuel after long term storage. The DOE's Paul Murray is dismantling SNF research by stating no one should question the U.S. NRC's often-wrong, short-sighted and unsafe licensing decisions and he is doing more to dismantle needed SNF research than to promote it. He has unabashedly decided to focus on propaganda and creating the illusion of a solution. But even he must know this is only so that the public won't know the truth and demand real progress and a stop to the madness of making more spent nuclear fuel.

Undocumented subtraction of elevated background can underestimate external radiation dose, according to energy worker compensation studies by NIOSH

The issue of background radiation at DOE sites has been relevant to the Energy Employee Occupational Illness Compensation (EEOIC) program. [57] Workers at a DOE site who might not be monitored for radiation can be getting elevated levels of radiation, above typical ambient levels. For workers who are monitored by Thermolumenescent dosimeters (TLDs), there are also TLDs placed at the facility to monitor background levels at various locations. The facility's background dose is subtracted from a radiation worker's TLD, lowering the worker's recorded dose.

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[56] Doug Brugge and Aaron Datesman, *Dirty Secrets of Nuclear Power in an Era of Climate Change*, Springer, 2024. ISBN 978-3-031-59594-3, https://doi.org/10.1007/978-3-031-59595-0

[57] 42 USC 7384, The Act--Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA), as Amended and see the website for the Center for Disease Control, National Institute of Occupational Safety and Health, Division of Compensation Analysis and Support at http://www.cdc.gov/niosh/ocas/ and U.S. Department of Labor, Office of Workers' Compensation Programs, EEIOCPA Program Statistics, http://www.dol.gov/owcp/energy/regs/compliance/weeklystats.htm

At various DOE sites, the amount that the background radiation levels have varied from facility to facility and have varied over time. A 2006 report for the EEOIC program by the Oak Ridge Associated Universities described the issue of potentially elevated ambient levels of external radiation at various DOE sites. [58]

The elevated level of background at DOE facilities often was simply subtracted from a worker's recorded dose. **But the elevated level of background at DOE facilities since the 1950s has varied from zero to a whopping 946 mrem per year.**

At the Idaho National Laboratory, ambient background dose was estimated as 223 mrem in 1974, but was usually less than 160 mrem per year. After 1984, INL background doses were typically elevated by 27 mrem per year above natural background. This is the dose a worker, such as a secretary or accountant, would get at a desk without ever doing work under a radiation work permit.

It is noteworthy that many DOE sites did not document the elevated background dose, which was due to reactor operations, spent nuclear fuel storage, spent fuel reprocessing, etc.

It is also noteworthy that the U.S. Navy does not disclose the background levels that have been subtracted from their workers doses. The U.S. Navy claims that its annual radiation doses to its personnel are very low but the Navy only provides only average doses and not doses for specific jobs. The U.S. Navy claims to have personnel radiation doses that are far lower than a person would get at its neighboring Idaho National Laboratory DOE facilities. Note that most workers at the Naval Reactors Facilities (NRF) on the Idaho site are not considered naval personnel, nor are these employees eligible for the Energy Employee Occupational Illness Compensation program.

Many former INL workers may suspect that they have been exposed to radiation or chemicals and following illness may have applied to the Energy Employee Occupational Illness Compensation Program Act (EEOICPA) only to be denied. The National Institute of Occupational Safety and Health (NIOSH) that administers the energy employee illness program, the EEOICPA, emphasizes that it uses claimant favorable modeling to determine whether working at INL likely caused the illness. But they have denied two-thirds of the claims by INL workers. Fortunately, there are now several radiation exposure cohorts that provide compensation for INL and ANL-W employees for certain years of employment without requiring radiation dose reconstruction to determine eligibility. [59]

[58] Robert C. Winslow, Oak Ridge Associated Universities, ORAU TEAM Dose Reconstruction Project for NIOSH, *Occupational Onsite Ambient Dose Reconstruction for DOE Sites*, ORAUT-PROC-0060, June 2006.

[59] See the Idaho National Laboratory status at http://www.cdc.gov/niosh/ocas/ineel.html and see the portion of INL formerly ANL-W at http://www.cdc.gov/niosh/ocas/anlw.html

Last month, I reviewed the shocking finding that naval personnel have 9.2 times the U.S. cancer incidence, despite the Navy's claimed low average radiation doses and meticulous radiation dose monitoring. [60] [61] [62]

As of the end of 2021, the U.S. Navy operated 70 nuclear-powered submarines, 11 nuclear-powered aircraft carriers, and three moored training ships. There are also six shipyards to maintain, overhaul, or refuel these nuclear propulsion plants, and two tenders and six naval bases. The U.S. Navy expounds on its meticulous radiation monitoring and attention to avoiding radiation doses that exceed federal standards.

While I don't think that the treatment of subtracting the elevated background dose from the worker's external radiation dose completely explains the extraordinarily high cancer incidence of naval personnel, I think it is worth discussing. It certainly undercuts the reported doses to its workers at NRF, but few of those workers are considered naval personnel.

I remember being told that my background dose at the Idaho National Laboratory was probably about 100 millirem and was not included in my radiation dose records. The DOE assured workers that doses below 100 millirem were negligible. INL has long reported worker doses as zero dose — when the elevated background radiation doses were significant and, prior to 1984, sometimes exceeded 100 mrem per year.

To obtain the workers stated external radiation dose, the elevated background dose is subtracted from the dose the worker receives, with the idea that only the dose above the facility's background needs to be counted as coming from employment and radiation work.

I recall other issues at the Idaho National Laboratory. The TLDs sat in the guardhouse when not being worn by an employee, unless the TLD was taken home. There were irradiated fuel shipments frequently driving past the guardhouse. Those radiation exposures were being subtracted from the TLDs at the end of the month, which would be appropriate when the worker was not exposed to the shipments. But what about workers exposed to those shipments, who also had those doses subtracted? And for the workers that took their TLD home, far too much background was being subtracted from their doses. You can start to see the inaccuracies piling up.

The external radiation background levels vary from facility to facility and also within a facility, within perhaps a quarter of a mile, the background doses can vary considerably,

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[60] Environmental Defense Institute, August newsletter article "Navy's own data for over 65,000 individuals reveal that Naval personnel have cancer rates exceeding nine times the national average and Navy continues the gaslighting," August 2024 at http://www.environmental-defense-institute.org/publications/News.24.Aug.pdf

[61] Chris Busby, *Counterpunch*, "Cancer in US Navy Nuclear Powered Ships," March 6, 2020. https://www.counterpunch.org/2020/03/06/cancer-in-us-navy-nuclear-powered-ships/

[62] Dose Assessment and Recording Working Group (DARWG) with support from the Defense Threat Reduction Agency (DTRA), Submitted by the Office of the Assistant Secretary of Defense for Health Affairs, Final Report to the Congressional Defense Committees in Response to the Joint Explanatory Statement Accompanying the Department of Defense Appropriations Act, 2014, page 90, "Radiation Exposure," June 2014. https://www.health.mil/Reference-Center/Reports/2014/06/19/Radiation-Exposure-Report

depending of the location of nuclear reactors, and spent nuclear fuel in storage pools, stationary dry storage, or in shipments.

At the INL test reactor area where I worked, the stack from a hot cell had a filter in the stack, above the roof of the hot cell but the multi-story office building was near the stack. The filter in the hot cell's stack had quickly filled with radioactive particulate when a flimsy container broke inside the hot cell. The radionuclides caught in the filter were causing "shine" through a second story office windows, dosing workers sitting at their desks. It took a few months for the reasons for the unusually high external doses to be discovered. This was only about two decades ago.

In addition, internal radiation doses from airborne releases from nuclear facilities add to the worker's radiation dose but this would only be addressed by bioassay and is not addressed by TLD monitoring.

There is a problem with the reporting of internal radiation dose, as well. Adequate monitoring of inhaled and ingested radionuclides is also lacking, and compounding the lack of internal dose monitoring is the problem of underestimated health harm from internal radionuclides. Many independent experts estimate that internal radiation health harm is perhaps 100 times higher than official models predict. That means that a 1-rem dose from internal radiation would be more like a 100-rem dose.

Regarding annual radiation doses, the Navy has long claimed that it keeps average radiation doses far below the permissible 5 rem annual dose. In a 1994 report, the Navy claimed average doses were 200 millirem per year and that total lifetime doses from radiation associated with Naval nuclear propulsion plants averages only about one rem person. [63] More recently in 2022, the Navy states that no personnel have exceeded 2 rem in any year in the last 41 years. The Navy also states that most of the dose is from external radiation and the since 1962 no civilian or military personnel received more than 500 millirem annually from internal radiation exposure from naval nuclear propulsion plants. The average occupational exposure since 1954 from external and internal radiation combined is less than 110 millirem per year, according to the Navy.

Regarding lifetime average radiation doses, according to the 2022 report by the Navy, the total lifetime average exposure during this 68-year period is less than 1 rem per person. [64] With the Navy's stated external radiation doses being so low, the treatment of subtracting the elevated background dose at the facility becomes particularly important and shows how worker doses can easily be significantly higher than stated on official external dose records, particularly when those external doses are stated to be low, around 100 mrem/yr or less.

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[63] Naval Nuclear Propulsion Program, *Occupational Radiation Exposure from U.S. Naval Nuclear Plants and Their Support Facilities*, NT-94-2, March 1994. "The average occupational exposure of each person monitored is less than one-fifth of a rem per year, The total lifetime exposure from radiation associated with Naval nuclear propulsion plants to date for all personnel monitored since 1954 has averaged about one rem per person."

[64] Naval Nuclear Propulsion Program, Department of the Navy, *Occupational Radiation Exposure from U.S. Naval Nuclear Plants and Their Support Facilities*, Report NT-22-2, May 2022.

The Navy's radiation doses are obtained after subtracting the unpublished elevated ambient doses from worker doses.

Let's consider the TLD processing to determine the worker's external radiation dose. Since the 1970s, external radiation dose has been monitored using Thermolumenescent dosimeters (TLDs), rather than film badges that were used since the 1940s. The TLDs are typically worn on the upper torso. The TLDs are worn at the facility and typically placed in a rack at the facility when the worker goes home for the day. At the end of the month, the TLDs are evaluated using computer-based processes and no other record of the dose remains. The calibration of the equipment used to read the TLDs is one area of problems in estimating the dose a worker received.

In a review of the external radiation monitoring program at Pantex, the Defense Nuclear Facilities Safety Board (DNFSB) described problems in the Department of Energy's program to monitor worker radiation doses. [65] Problems at Pantex regarding worker radiation external dose included significant personnel turnover, aging dose monitoring and processing equipment, unavailability of replacement parts, and inadequate response to signs of weakness in the program.

A Pantex, thermolumenescent dosimeters (TLDs) are used to monitor radiation worker external doses. The TLDs are read in special TLD readers that had been in operation since 1980. Problems with the TLD readers began in 2019. In June 2020, all four TLD readers at Pantex were inoperable and replacement parts were no longer available. Another DOE site, NNSA, that used similar equipment agreed to use their TLD readers to process the Pantex TLDs to record worker doses.

The doses read by the other site were noted as being higher than expected for Pantex. The reason for the higher doses was that the TLD reader systems were set up and maintained differently. **The software algorithm and calibration techniques were specific to each facility. A review of the dosimeter processing equipment found that many actions necessary to complete a dose calculation from the TLDs were not documented adequately.** [66]

Among the issues was the need to document the background dose subtraction methods and the TLD take-home policy. There were differences in the background radiation levels of Pantex and the NNSS area at the Nevade National Security Site where the TLDs were processed after the Pantex TLD readers were no longer functional. Variations in background doses can lead to significant changes in the final dose.

[65] Defense Nuclear Facilities Safety Board letter to Department of Energy Secretary Jennifer M. Granholm, (Regarding Pantex's external dosimetry problems), May 10, 2022. See www.dnfsb.gov

[66] C.E. Hopponen and D. K. Stone, Lawrence Livermore National Laboratory, *Review of Pantex Radiation Safety Department 2020 Backup Dosimetry Processing Methodology*, LLNL-TR-823739, June 14, 2021.

Basically, the background dose for the facility is subtracted from a worker's TLD dose. A higher background dose will cause more dose to be subtracted from the worker's TLD dose. The nuclear facility does not report the amount of background dose that is being subtracted.

Furthermore, the DOE Standard 1095-2018, *Department of Energy Laboratory Accreditation Program for Personnel Dosimetry*, is not necessarily required by DOE contractors and even if applied, the performance testing of dosimeters is conducted in a laboratory setting. Importantly, the **DOELAP accreditation does not evaluate the adequacy of a dosimetry program to accurately measure occupational dose in actual work environments encountered at DOE sites.**

In the Pantex case, they were able to argue that no worker exceeded the administrative whole body dose level of 750 mrem per year that Pantex was using. The Department of Energy allows 5,000 mrem per year doses to radiation workers.

Thee uncertainty and the accuracy of the reported external radiation doses for radiation workers throughout the Department of Energy sites really isn't known. The U.S. Navy and the nuclear industry suffer from the same issues in the **underreporting of external radiation doses**. External radiation doses at a land-based nuclear facility may easily be 30 to over 100 mrem/yr above the officially recorded external radiation dose.

Internal radiation doses are also likely to be unmonitored, unreported and underreported. Many independent experts find that radiation health harm may be perhaps 100 times higher for internal radiation. That would cause, for example, a 10 mrem/yr internal dose to yield health harm more like 1000 mrem/yr The elevated tritium, carbon-14, uranium decay progeny and other radionuclides inhaled by workers are often not monitored at nuclear facilities.

Most radiation worker health studies are cancer mortality (death) studies and are limited to the study of death certificates and do not provide the number of cancers incurred that were not the cause of death.

The discovery that naval personnel have 9.2 times the U.S. cancer incidence, [67] despite the Navy's claimed low average radiation doses and meticulous radiation dose monitoring does not mean that the exceptional health harm from what are stated to be very low radiation doses is limited to naval personnel.

Former Department of Energy contractor employees, both those eligible for compensation and those such as the workers at the Naval Reactors Facilities at the Idaho National Laboratory who are excluded from compensation programs, would likely also suffer far higher cancer incidence than currently predicted by accepted radiation cancer risk models.

[67] Chris Busby, *Counterpunch*, "Cancer in US Navy Nuclear Powered Ships," March 6, 2020. https://www.counterpunch.org/2020/03/06/cancer-in-us-navy-nuclear-powered-ships/

Radiation workers at commercial nuclear power plants and at radioactive waste disposal facilities would likely also have the higher cancer incidence rates and these workers are not eligible for compensation programs for their elevated rates of cancer or shortened life spans.

Articles by Tami Thatcher for September 2024.

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