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General Comment

See attached file(s) The file ISP-WCS-EIS is based on the files CIS-DEIS-Comments and Rail Accidents.

Attachments

ISP-WCS-EIS

CIS-DEIS-Comments

Rail Accidents

Comments on ISP/WCS DEIS
By
Marvin Resnikoff, Ph.D.[1]
Radioactive Waste Management
October2020

Our review of the DEIS for the proposed ISP/WCS facility is focused on the transportation impact of licensing the proposed Texas facility. The DEIS is based on NUREG-2125, which is based in turn on reports by Hanson and Volpe. We find the probability of serious accidents, particularly, accidents involving fires, are underestimated. Based on FRA data, the number of freight train accidents per freight train mile is **4.83E-06,** or 36 times the NRC/DOT estimate. Since the analysis by the NRC is based on NUREG-2125, which we extensively reviewed for the proposed CIS facility in New Mexico[2], we've attached the previous analysis and will not repeat it here

We are most concerned about fire accidents. Supporting documents to NUREG-2125 model a cask sitting on a pool of fire, a configuration that is not the most serious. NRC regulations require the cask to be at a 1 meter height above a fire pool which implies higher flame temperatures at the ends and sides of a cask. Higher flame temperatures at the cask ends can degrade the cask seals, as shown in studies by Sandia[3].

Cask Seals Degrade in Hydrocarbon fire

As the figure from NUREG/CR-6672[4] below shows, the monolithic steel rail cask reaches an internal temperature of 900 degrees centigrade at hour 11 of a theoretical fire. This is due to a hydrocarbon fire temperature of 1000 degrees centigrade for 11 hours. The model that is used by Sandia is a one dimensional model (radius R), so the model does not reflect the temperature at the ends of a cask nor the flame temperature for a cask 1 meter above a pool fire (which is the regulatory requirement). As Greiner shows, for a cask 1 meter above the fire pool, the temperature at the cask ends exceeds the temperature at which the seals degrade in a time that's closer to 2 hours, as discussed in the attached report. The fire temperature at the cask ends is higher than below or above the cask body. Greiner's results, which appear in a Sandia report, are based on modeling with the program CAFÉ that has been benchmarked for real fires. At the point when the seals degrade, the radioactive gases and volatiles may begin to be released from the cask that is under pressure.

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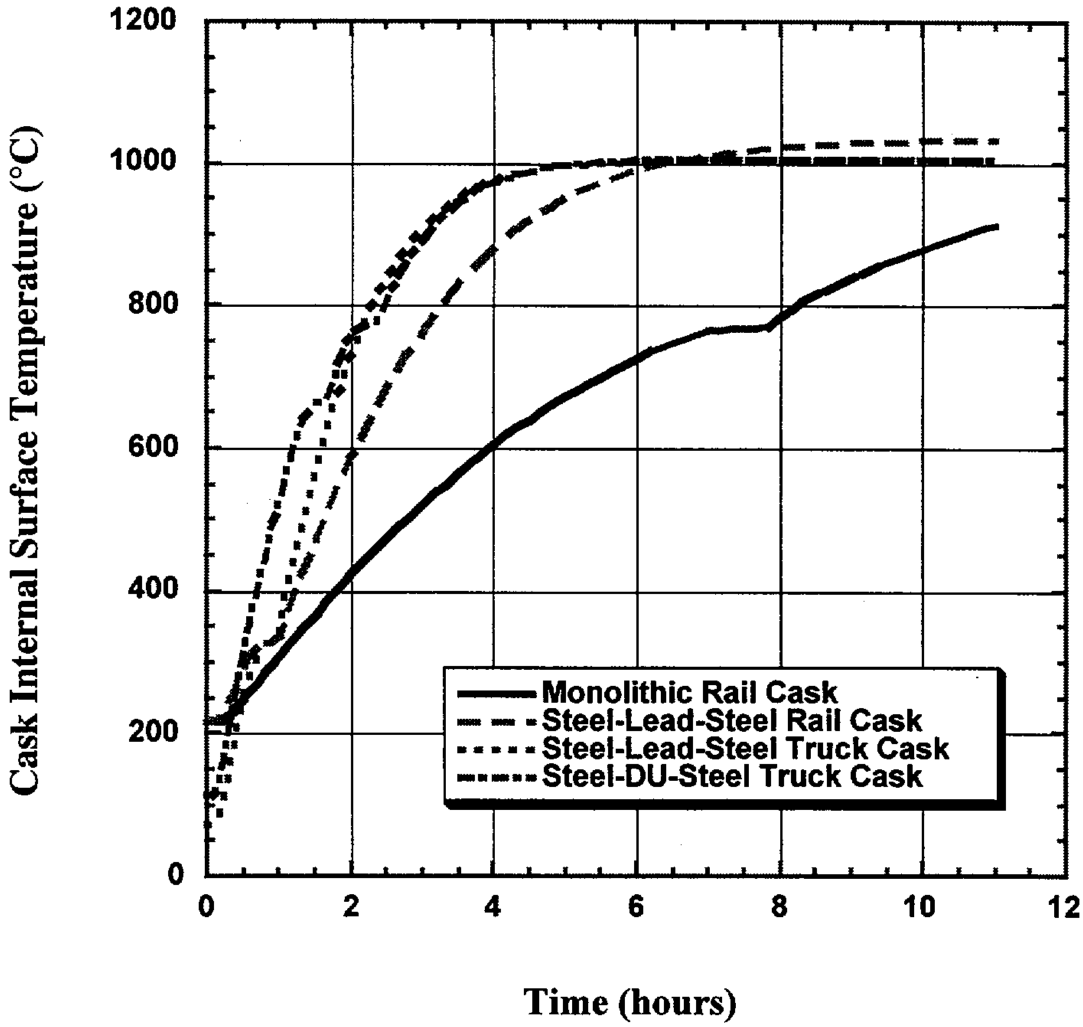
1 Marvin Resnikoff is a high energy theoretical physicist who has worked on nuclear transportation issues for the Sierra Club and many State governments for 45 years. His resume is attached.

2 (RWMA, 2020)

3 (Greiner, 200), (Greiner, 2005), (Greiner, 2006).

4 (SAND, 2000)



Real Fires Can Easily Exceed NRC's Hypothetical Fires

In a critique of our comments in the New Mexico proceeding, Holtec states the Sierra Club doesn't address or dispute DOE's finding in the 2008 FSEIS that we used unrealistic parameters. The reality is DOE's critique appeared in the final environmental impact statement. The State of Nevada didn't have the opportunity to rebut this improper critique within the Department of Energy's FSEIS proceeding. Further, the NRC has not considered recent fire accident probabilities. We have also raised the issue of the increased probability of a rail fire accident based on recent FRA data. This issue has not been addressed by the NRC. The matter of fire probabilities is discussed in detail in our attached comments on the CIS DEIS. Further, real fire accidents have exceeded the 11 hour analysis carried out in NUREG/CR-6672 such as the 2013 fire accident in Lac-Megantic, Quebec[5] that burned for almost two days and destroyed half the town. There was therefore a genuine material dispute with the NRC that was not properly addressed by the NRC hearing panel. In any future proceeding regarding Yucca mountain or the

[5] (TrainsMag, 2018)

CIS facility we would use the Greiner results which have also been produced by Sandia laboratory to counter the NRC.

The DEIS also assumes an unrealistic 10-hour exposure time for emergency workers, implying the cask can be moved in this time period. NRC staff need to more closely examine real train derailments, particularly accidents involving fires, and the time to restore service. NUREG-2125 examines fires that burn up to 3 hours, while some real fires have burned for 2 days, as discussed in the attached report.

As the capacity of spent fuel casks has increased, the weight of the casks has increased as well. This additional weight will place a burden on the rail infrastructure. The HI-STAR cask, containing 37 PWR fuel assemblies, will require a 3-car, 12-axle carriage, which will cause a train to slow on curves.

NUREG-2125 considers only mid burnup fuel, 45 GWd/MTU, cooled for 9 years, and not high burnup fuel, with burnup between 60 to 70 GWd/MTU. High burnup fuel contains more fission products, particularly the semi-volatile Cs-137, which would account for high gamma doses to EMT's and the general public. The fraction of volatile Cs-137 in the gap between the cladding and fuel should be based on more recent DOE reports; supporting NRC documents for this gap cesium are not referenced, but, in our experience, are based on outdated 1978 reports. High burnup fuel also has thinner and more brittle cladding that may shatter in high impact accidents.

NRC staff needs to more carefully review the impact of transporting high burnup fuel to the proposed ISP/WCS facility. A spreadsheet containing our calculations is also attached.

References

(Greiner, 2000) Greiner, *et al,* NUMERICAL PREDICTION OF HEAT-FLUX TO MASSIVE CALORIMETERS ENGULFED IN REGULATORY FIRES WITH THE CASK ANALYSIS FIRE ENVIRONMENT (CAFE) MODE, SAND2000-1194C, July 2000.

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(TrainsMag, 2018) Trains Wreck, Vol. 2, Crashes that Changed Railroading, September 2018.

Comments on CIS DEIS
By
Marvin Resnikoff, Ph.D.[1]
Radioactive Waste Management Associates
September 2020

Summary

Our review of the CIS DEIS[2], including the supporting document NUREG-2125[3], and its supporting documents[4], show that the accident rate for rail freight and the fire accident rate for rail freight are underestimated. In a severe impact accident, according to NUREG-6672[5], the lid bolts may stretch, allowing gases and volatiles to escape. In a severe fire accident, which may involve more than one tank car, fires have burned for 48 hours, longer and hotter than considered in the DEIS and NUREG-2125. NUREG-2125 considers a 3-hour hydrocarbon fire by one tank car; NRC regulations[6] consider a ½ hour all-encompassing fire. Since the DEIS is based on NUREG-2125, which is incorrect, the NRC must correct the supporting documents and the CIS-DEIS itself.

Rail Freight Accident Rate/Probability

According to NUREG-2125, the average freight rail accident frequency is $1.32 * 10^{-7}$ per railcar mile based on DOT historic accident frequencies from 1991 to 2007. We have determined this accident frequency is an underestimate. From the DOT Federal Railroad Administration database, for the more recent period 2010 to 2018, the accident frequency is **3.4915E-06,** or 26 times greater than the NRC's number. If we assume almost all rail accidents are freight train accidents, the accident frequency, the number of freight train accidents per freight train mile is **4.83E-06,** or 36 times the NRC/DOT estimate. While the NRC estimates 8 accidents over a 20-year period to the proposed CIS, we estimate 168 rail accidents, assuming 3-car trains. This also assumes the rail infrastructure, including bridges, remains at the same safety level. A summary of these calculations appears in the attached spreadsheet[7], based on FRA spreadsheets of yearly accident data.

Accidents can include impact or fire, which are discussed in the next section. NUREG-2125 and NUREG/CR-6672 showed that a severe impact accident, between 90 and 120 mph, can lead to a lid opening in the transportation cask[8]. The estimated probability for the 7 impact accidents

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[1] Marvin Resnikoff is a high energy theoretical physicist who has worked on nuclear transportation issues for the Sierra Club and many State governments for 45 years. His resume is attached.
[2] (NRC, 2020)
[3] (NRC, 2014)
[4] (Volpe, 2006) and (Hanson, 2008)
[5] (SAND, 2000)
[6] 10 CFR 71.73
[7] (Resnikoff, 2020)
[8] (NRC, 2014), p. 123 and Table 5-10.

considered is, according to the NRC, 1 in a billion. The release is from a cask without an internal canister, such as the CASTOR cask; for the Holtec cask, with an internal canister, the DEIS assumes no release on impact. As shown above, the NRC accident probabilities are underestimates. Further, NUREG-2125 considers only mid burnup fuel, 45 GWd/MTU, cooled for 9 years, and not high burnup fuel, between 60 to 70 GWd/MTU, which contains more fission products, particularly the semi-volatile Cs-137, which would account for high gamma doses to the population and EMT's in a severe impact accident. Higher burnup can also cause a thinning of the cladding. The DEIS also assumes a 10-hour exposure time, which is entirely unrealistic for a severe accident in a populated area, such as Las Vegas. Radiation doses to EMT and the public are minimized by the NRC, by unrealistically assuming a cask can be moved within 10 hours. To see how unrealistic a 10-hour time period is, consider the following. An empty Holtec transfer cask, Holtec's HI-TRAN cask, fell off the highway in Andover, Vermont, on the way to the Vermont Yankee former reactor on June 25, 2020[9]. The local road was closed for 2 days while emergency equipment, including a crane (9 hours to assemble) and a heavy-duty tow truck were brought in. An accident involving radioactive materials could easily take much longer. NRC staff need to focus more realistically on the recovery time for a serious accident involving radioactivity, since this will reflect an NRC bias and whether the public can accept any other part of the DEIS.

Weight

In order to reduce the cost of dry storage, the nuclear industry has moved to larger casks with greater capacity. The first Holtec cask, the HI-STAR 60 (loaded weight 82 tons) held 12 PWR fuel assemblies. The HI-STAR 100 (loaded weight 140 tons) held 24 PWR fuel assemblies. The latest Holtec edition, the HI-STAR 190 XL (loaded weight 208 tons) contains 37 PWR fuel assemblies. As the capacity of Holtec casks increased, the weight of the casks increased as well. This additional weight will place a burden on the rail infrastructure. The general nationwide rail system has an axle limit of approximately 36 tons, or 143 tons for a 4-axle rail car, which is a problem since the HI-STAR 190 XL itself, without the carriage and cask restraints, weighs 208 tons. Other heavy casks, such as the Areva MP-197, face a similar predicament. While the loaded weight of the CASTOR V/21 cask (138 tons) plus carriage may exceed 143 tons, it is much lighter than the HI-STAR 190 XL. Larger CASTOR casks are also in use in Europe.

Rail cars that exceed 143 tons are in service on US rails, but must have more than 4 axles. GE diesel engines, such as the AC6000CW, weigh between 212 and 216 tons. The Navy M-290 transport cask weighs 260 tons, on a 3-car, 12-axle carriage. At 36 tons per axle, 12 axles can support 432 tons. DOE originally proposed an 8 axle car for the HI-STAR 190 XL, but design calculations showed wheel hunting, which produces side to side wobbling and potential derailment under high speed. The new car, being designed by Atlas, is similar to the 12-axle M-290 rail car. A 3-car, 12-axle carriage will cause the train to slow down on curves.

Rail Fires and Cask Damage

[B]Brattleboro Reformer, June 27, 2020.

While the rail accident rate, according to FRA, has declined in the years between 2010 and 2018, the same is not true for the fire accident rate, which has risen over the same years. Our review of the FRA data show 392 accidents involving fire of varying severity between the years 2010 through 2018, ranging between 16 and 79 fire accidents per year. Comparing the periods 2000 to 2009 considered in NUREG-2125, and the period 2010 to 2018, the fire accident rate has almost doubled. NRC staff should consider the most recent data. Graphs showing rail fires per freight train mile for the years 2000 – 2009, and years 2010 – 2018 appear as Fig. 1 and 2, respectively. The reason for this increase of fire accidents is not difficult to understand; more tanker cars are on the rail, mainly from North Dakota to refineries on both coasts.

Figure 1. Rail Fires, Yrs 2000 – 2009.

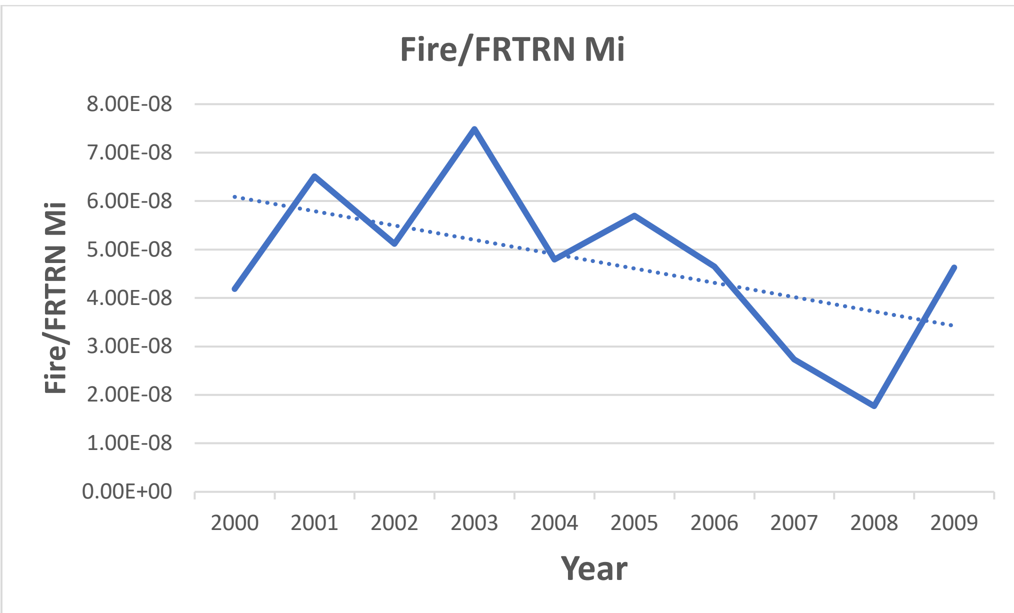
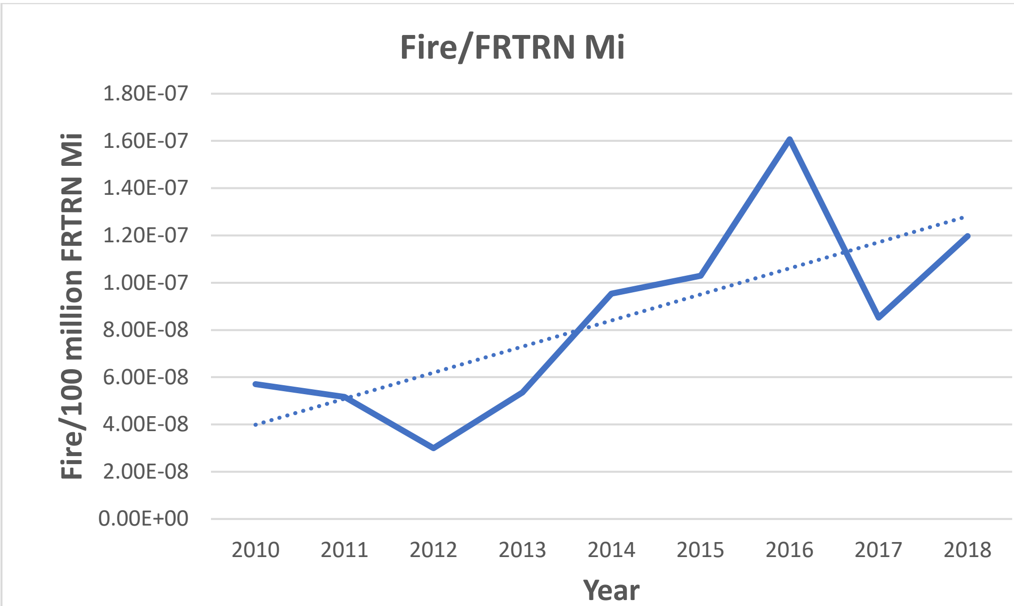


Figure 2. Rail Fires, Yrs 2010 – 2018.



The bottom line is more fires have been occurring per accident than is acknowledged by NUREG-2125.

Based on FRA data, as seen in the attached spreadsheet, fire accidents occur in about 2% of rail accidents. The fire accident probability calculated by Volpe[10], and used in NUREG-2125, is orders of magnitude smaller, and does not reflect reality. NRC staff need to more seriously examine recent rail fires and potential damage to cask seals, particularly the work at Sandia by Greiner[11].

The NRC does not correctly analyze the more serious consequences of a rail fire. NUREG-2125 states one CAFÉ nonregulatory fire was run—simulating the cask being on the ground and at the center of the pool[12]. NUREG-2125 states this is the most severe case; it is not, and it is not even the regulatory configuration. According to 10 CFR 71.73, a cask must be 1 meter above a hydrocarbon pool fire. As shown by Greiner[13], in a hydrocarbon fire with a horizontal cask at 1 meter above the pool fire, the flame temperatures at the extremities (the ends and the sides of the cask) are the hottest; the bottom and the top of the horizontal cask are at lower temperatures. Greiner ran the CAFÉ model for a 3-hour fire. The cask seal degraded at 2.25 hours, if the impact limiters were missing, which might occur in an impact accident, followed by a fire. If the impact limiters were present, serving as insulation, the seals would degrade a short time after the 3-hour fire was extinguished. However, rail fires can easily exceed 1/2 hour or 3 hours. Generally, trains hauling tanker cars can have 50 or more tanker cars in a train consist. One of

[10] (Volpe, 2006)
[11] (Greiner, 2000)
[12] (NUREG-2014), Fig. D-27.
[13] (Greiner, 2000)

the most serious train fire accidents occurred in Lac Megantic, Quebec, in July 2013, where a 74-car, tanker car train from North Dakota, derailed and burned for almost 48 hours and destroyed half the town, killing 47 residents[14]. It took hundreds of firefighters from Maine, Quebec and Ontario to extinguish the fire.

Without a more serious review of the probability and consequences of real rail fire accidents, NUREG-2125 reads like a fairy tale.

Severe Rail Accident Radioactive Releases

NUREG-2125 bases the release of gases and volatiles in spent fuel on a report by Hanson[15]. However, Hanson consider a release due to impact, not a fire. Nevertheless, Hanson does indicate how much cesium is in the gap between the cladding and the fuel itself in section 4.3, page 4.12. But Hanson does not have reference for the fraction 3×10^{-5} for cesium within the gap. In fact the value $3 * 10^{-5}$ is an old number, based on studies by Lorenz in 1978 and has little relevance to high burnup fuel, 60 – 70 GWd/MTU. The average burnup for the fuel considered by Hanson is on the order of 30 - 40 GWd/MTU.

Cesium Release in Fire Accidents

In NUREG-2125, fraction of cesium released to the internal cask environment (the rod to cask release fraction), is $3 * 10^{-5}$ (Table E-16). This release fraction pertains to an impact accident and does not pertain to a fire accident. NUREG-2125, based on Hanson, does not have a release due to a fire. The source of the parameter values in table E-16 is listed as Hanson, section 4.3, page 4 .12. But Hanson does not have that value for volatiles $3 * 10^{-5}$ in that section or in any section of the Hanson report. So where NUREG-2125 obtains the number $3 * 10^{-5}$ for volatiles is not documented. In fact, it is an old number, based on experiments by Lorenz in 1978.

Hanson does examine fission gas releases (FGR), mainly inert gases Xe and Kr, as a function of burnup. For medium burn up fuel, the FGR ranges from 0.25% to 18%, a very large spread. But when one looks at burnups on the order of 65 to 70 MWd/MTU, the FGR gas release is on the order 3% to 4.4% and the inventory of Cs is also greater. Obviously the higher the burn up, the more fission gas is generated in nuclear fuel and also the amount of cesium produced. Hanson does investigate the measured release fraction of fission gases for higher burnup fuel, on the order of 3 to 4%. But this release is not a function of fire. It is based on impact making a release from the fuel and from the cask itself.

In table 1.3 of PNNL-17275, the FGR from fuels is listed. The average burn up for the fuel is what we would call medium burn up fuel, on the order of 30 to 45 MWd/MTU. And the FGR varies from .25% to 11%. But Hanson does consider high burnup fuel in table 1.3. Hanson does analyze the amount of cesium percentage in the gap between fuel and cladding (Table 1.4), from 0.2% to 10%. But it does not list the gap cesium in high burnup fuel, a curious omission.

[14] (TrainsMag, 2018)
[15] (Hanson, 2006)

This gap cesium would be released in a serious accident. On page 1.12 of Hanson, the section titled Fission-Gas Release, volatile radionuclide release is listed. It states that the main contributor to FGR are the fission products xenon and Krypton since they are gases highly mobile and do not react with other elements. But for Cs, the report goes on to state that the fraction of cesium elements may be volatile at the temperatures of interest for fuel handling transport. Table 1.4 list the gap and grain boundary inventories measured by leaching for some of the fuels in table 1.3. But the fuels listed are medium burner and only minimal quantities it states with the exception of iodine are located outside of the fuel matrix. In the type of accident that NUREG-2125 considers, namely, impact, Hanson states the volatile element release is going to be similar to fine particles of fuel with the exception of iodine “and sometimes cesium” which are similar to the FGR. The respirable fraction is similar to that for gas. However, NUREG-2125 and Hanson in particular are measuring particulates and not gases in their experimental setups.

Fire analysis for truck and rail casks are contained in chapter 4. In addition impact limiters are modelled as undamaged. NUREG-2125 says it makes little difference whether the impact limiters are included or not, but we strongly disagree . According to Greiner, the presence of impact limiters makes a major difference on the heat that cask ends will experience. We discuss next Greiner results which show seal damage due to a fire, but none of the results in NUREG-2125 for fires up to three hour duration result in the release of radioactive material. None of the fire accidents consider seal damage; this directly contradicts the experimental results by Greiner both in terms of the Nevada supported papers and also the Sandia papers by Greiner.

Impact Limiter and Seal Damage[16]

NUREG-2125 states that cask seals would not be damaged in a regulatory fire, or even a fire of 3 hours duration. Experimental data by Greiner[17] shows this is incorrect. Greiner employed the CAFÉ (Container Analysis Fire Environment) computer code to simulate the response of a truck package designed to transport one PWR fuel assembly in a 7.2-m-diameter pool fires. Simulations were performed with the package centered over the fire, and offset axially from that location by 1 and 2.5 m. In all simulations the package body was 1 m above the fuel pool as required by NRC regulations, 10 CFR Part 71.73. Simulations were also carried out with the absence of an impact-limiter version. When the center of the no impact limiter cask is within 2.5 m of the pool center, fires shorter than 0.7 hour can cause the seal to reach the degradation temperature. “By contrast, the intact package protects the seal in fires that last roughly 2 hours.” Taking into account the internal cask pressure and fuel cladding damage, Greiner did not estimate the amount of volatiles released and the potential health effects.

In more detail[18], Table 10 shows results of a 3-hour fire. The seal reaches its temperature of concern at t = 2.25 hour. It reaches its maximum temperature of $T_{S,Max}$ = 496 ºC at t = 3.15 hour, 0.15 hour after the fire is extinguished.

[16] (Greiner, 2005)
[17] *Ibid.*
[18] *Ibid.*

Conclusion

Our review of the DEIS for the proposed CIS facility focused on the transportation impact of licensing the proposed New Mexico facility. The DEIS is based on NUREG-2125, which is based in turn on reports by Hanson and Volpe. We find the probability of serious accidents, particularly, accidents involving fires, are underestimated. Over a 20-year period, we estimate 168 rail accidents to the proposed CIS, assuming 3-car trains. Based on FRA data, the number of freight train accidents per freight train mile is **4.83E-06,** or 36 times the NRC/DOT estimate.

We are most concerned about fire accidents. Supporting documents model a cask sitting on a pool of fire, a configuration that is not the most serious. NRC regulations require the cask to be at a 1 meter height above a fire pool which implies higher flame temperatures at the ends and sides of a cask. Higher flame temperatures at the cask ends can degrade the cask seals, as shown in studies by Sandia.

The DEIS also assumes an unrealistic 10-hour exposure time, implying the cask can be moved in this time period. NRC staff need to more closely examine train derailments, and the time to restore service.

As the capacity of Holtec casks have increased, the weight of the casks has increased as well. This additional weight will place a burden on the rail infrastructure. The HI-STAR cask, containing 37 PWR fuel assemblies, will require a 3-car, 12-axle carriage, which will cause a train to slow on curves.

NUREG-2125 considers only mid burnup fuel, 45 GWd/MTU, cooled for 9 years, and not high burnup fuel, between 60 to 70 GWd/MTU, which contains more fission products, particularly the semi-volatile Cs-137, which would account for high gamma doses to EMT's and the general public. The fraction of volatile Cs-137 in the gap between the cladding and fuel should be based on more recent DOE reports; supporting NRC documents for this gap cesium are not referenced, but, in our experience, are based on outdated 1978 reports. High burnup fuel also has thinner and more brittle cladding that may shatter in high impact accidents.

NRC staff needs to more carefully review the impact of transporting high burnup fuel to the proposed CIS facility. A spreadsheet containing our calculations is attached.

References

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M.RESNIKOFF, PH.D. RESUME

EDUCATION

Ph.D., Physics - 1965, University of Michigan
M.S., Physics - 1962, University of Michigan
B.A., Physics/Math - 1959, University of Michigan

SUMMARY OF PROFESSIONAL EXPERIENCE

Marvin Resnikoff is Senior Associate at Radioactive Waste Management Associates and is an international consultant on radioactive waste management issues. He is Principal Manager at Associates for dose reconstruction and risk assessment studies of radioactive waste facilities and transportation of radioactive materials. A nuclear physicist and a graduate of the University of Michigan, Dr. Resnikoff has worked on radioactive issues since his first project at West Valley, New York in 1974.

Throughout his career, he has assisted public interest groups and state and local governments across the US, Canada, Germany and England on radioactive waste storage and transportation issues. He has authored or co-authored four books on radioactive waste issues including *Living Without Landfills*, regarding low-level waste landfills, and *The Next Nuclear Gamble,* regarding transportation of radioactive waste.

PROJECTS

Radiological Implications of Fracking. Dr. Resnikoff examined the radiological implications of fracking in papers on indoor radon concentrations and drill rock disposal in landfills from the Marcellus shale formation. For Delaware Riverkeepers (PA), FreshWater Accountability Project (OH) and Residents for the Protection of Lowman and Chemung (NY) he wrote reports that examined the implication of disposal of drill cuttings and drill fluids on landfills and the environment. In 2011 he was an invited speaker at the national conference of the Water and Environment Federation. He examined several fracking sites in Pennsylvania.

Dose Reconstruction. He has conducted dose reconstruction studies of oil pipe cleaners in Mississippi and Louisiana, residents of Canon City, Colorado near a former uranium mill, residents of West Chicago, Illinois near a former thorium processing plant, and residents and former workers at a thorium processing facility in Maywood, New Jersey. He has also served as an expert witness for plaintiffs in Karnes County, Texas, Milan, New Mexico and Uravan, Colorado, who were exposed to radioactivity from uranium mining and milling activities. He has worked on personal injury cases involving former workers and residents at the ITCO and other oil pipe cleaning yards in Louisiana and Texas. He also evaluated radiation exposures and risks in worker compensation cases involving former workers at Maywood Chemical Works thorium processing plant.

He also served as an expert witness in a case involving the Port St. Lucie reactors and brain cancer developed by two children and in a case involving clean-up of an abandoned radioactive materials processing facility in Webster, Texas. He investigated phosphogypsum plants in Florida, Texas and Alberta, Canada and served as an expert witness in a personal injury case involving a Texas phosphogypsum worker. He served as an expert witness in a case involving plutonium workers at INEEL, and federal border guards in Brownsville, TX. He is also a member of the Health Physics Society. In June 2000, he was appointed to a Blue Ribbon Panel on Alternatives to Incineration by DOE Secretary Bill Richardson.

Decommissioning. In February 1976, assisted by four engineering students at State University of New York at Buffalo, Dr. Resnikoff authored a paper that, according to Science, changed the direction of power reactor decommissioning in the United States. His paper showed that power reactors could not be entombed for long enough periods to allow the radioactivity to decay to safe enough levels for unrestricted release. The presence of long-lived radionuclides meant that large volumes of decommissioning waste would still have to go to low-level or high-level waste disposal facilities. He assisted public interest groups and served as an expert witness before the NRC on decommissioning the Yankee-Rowe, Diablo Canyon, Big Rock Point and CT Yankee reactors.

He conducted studies on the remediation and closure of the leaking Maxey Flats, Kentucky radioactive landfill for Maxey Flats Concerned Citizens, Inc. and of the leaking uranium basin on the NMI/Starmet site in Concord, Massachusetts under grants from the Environmental Protection Agency. He co-authored a study on the cost of remediating the former West Valley, New York reprocessing plant site. He also conducted studies of the Wayne and Maywood, New Jersey thorium Superfund sites and proposed low-level radioactive waste facilities at Martinsville

(Illinois), Boyd County (Nebraska), Wake County (North Carolina), Ward Valley (California) and Hudspeth County (Texas). He also served as an expert witness for CRPE, a public interest groups, regarding the proposed expansion of the Buttonwillow, California NORM landfill and for Earthjustice re. the licensing of an irradiation facility near the Honolulu airport in Hawaii. In August 2010, he was an invited panelist at President Obama's Blue Ribbon Commission on Nuclear Safety. In October 2011, he was an invited panelist at the annual conference of the Water Environment Federation on the subject of radioactivity in Marcellus shale wastes.

Transportation of Irradiated Nuclear Fuel. In addition to dose reconstruction and decommissioning cases, Dr. Resnikoff also works on the risk of transporting radioactive material. Under a contract with the State of Utah, Dr. Resnikoff was a technical consultant to DEQ on the proposed dry cask storage facility for high-level waste at Skull Valley, Utah. He assisted the State on licensing proceedings before the Nuclear Regulatory Commission. He has also prepared studies on transportation risks and consequences for the State of Nevada and the Nevada counties: Clark, White Pine, Lander and Churchill. In addition, at hearings before state commissions and in federal court, he investigated proposed dry storage facilities at the Point Beach (WI), Prairie Island (MN), Palisades (MI), Maine Yankee, Connecticut Yankee and Vermont Yankee reactors.

He is presently working for the State of Nevada on Yucca Mountain repository issues before the Nuclear Regulatory Commission (NRC). He is also serving as an expert witness for Earthjustice on a proposed NRC license for a food irradiator at the Honolulu, Hawaii airport. In 2013, he was an invited panelist before the Nuclear Waste Technical Review Board, Implication of High Burnup nuclear Fuel on decommissioning and transportation.

Nuclear Waste Management. Dr. Resnikoff is an international expert in nuclear waste management, and has testified often before State Legislatures and the U.S. Congress. In Canada, he conducted studies on behalf of the Coalition of Environmental Groups and Northwatch for hearings before the Ontario Environmental Assessment Board on issues involving radioactive waste in the nuclear fuel cycle and Elliot Lake tailings and the Interchurch Uranium Coalition in Environmental Impact Statement hearings before a Federal panel regarding the environmental impact of uranium mining in Northern Saskatchewan. He also worked on behalf of the Morningside Heights Consortium regarding radium-contaminated soil in Malvern and on behalf of Northwatch regarding decommissioning the Elliot Lake tailings area before a FEARO panel. He conducted a study for Concerned Citizens of Manitoba regarding transportation of irradiated fuel to a Canadian high-level waste repository. He authored a report for Greenpeace on the environmental assessment of a proposed intermediate level waste repository under Lake Huron, and for the Provincial Womens Council of Ontario on radioactive waste management costs in a proceeding before the Ontario Energy Board. As part of an international team of experts for the State of Lower Saxony, the Gorleben International Review, he reviewed the plans of the nuclear industry to locate a reprocessing and waste disposal operation at Gorleben, West Germany. He presented evidence at the Sizewell B Inquiry on behalf of the Town and Country Planning Association (England) on transporting nuclear fuel through London.

He has extensively investigated the safety of the West Valley, New York and Barnwell, South Carolina nuclear fuel reprocessing facilities. His paper on reprocessing economics (Environment, July/August, 1975) was the first to show the marginal economics of recycling plutonium. He completed a more detailed study on the same subject for the Environmental Protection Agency, "Cost/Benefits of U/Pu Recycle," in 1983. His paper on decommissioning nuclear reactors (Environment, December, 1976) was the first to show that reactors would remain radioactive for several hundred thousand years. In March 2004, Dr. Resnikoff was project director and co-author of a study of groundwater contamination at DOE facilities, Danger Lurks Below.

Dr. Resnikoff has prepared reports on incineration of radioactive materials, transportation of irradiated fuel and plutonium, reprocessing, and management of low-level radioactive waste. He has served as an expert witness in state and federal court cases and agency proceedings. He has served as a consultant to the State of Kansas on low-level waste management, to the Town of Wayne, New Jersey, in reviewing the cleanup of a local thorium waste dump, to WARD on disposal of radium wastes in Vernon, New Jersey, to the Southwest Research and Information Center and New Mexico Attorney General on shipments of plutonium-contaminated waste to the WIPP facility in New Mexico and the State of Utah on nuclear fuel transport. He has served as a consultant to the New York Attorney General on air shipments of plutonium through New York's Kennedy Airport, and transport of irradiated fuel through New York City, and to the Illinois Attorney General on the expansion of the spent fuel pools at the Morris Operation and the Zion reactor, to the Idaho Attorney General on the transportation of irradiated submarine fuel to the INEL facility in Idaho and to the Alaska Attorney General on shipments of plutonium through Alaska. He was an invited speaker at the 1976 Canadian meeting of the American Nuclear Society to discuss the risk of transporting plutonium by air. In July and August 1989, he was an invited guest of Japanese public interest groups, Fishermen's Cooperatives and the Japanese Congress Against A- and H- Bombs (Gensuikin).

Research Director of the Radioactive Waste Campaign. Dr. Resnikoff was formerly Research Director of the Radioactive Waste Campaign, a public interest organization conducting research and public education on the radioactive waste issue. His duties with the Campaign included directing the research program on low-level commercial and military waste and irradiated nuclear fuel transportation, writing articles, fact sheets and reports, formulating policy and networking with numerous environmental and public interest organizations and the media. He is author of the Campaign's book on "low-level" waste, Living Without Landfills, and co-author of the Campaign's book, Deadly Defense, A Citizen Guide to Military Landfills.

Project Director at the Council on Economic Priorities. Between 1981 and 1983, Dr. Resnikoff was a Project Director at the Council on Economic Priorities, a New York-based non-profit research organization, where he authored the 390-page study, The Next Nuclear Gamble, Transportation and Storage of Nuclear Waste. The CEP study details the hazard of transporting irradiated nuclear fuel and outlines safer options.

1974 - 1981. Between 1974 and 1981, he was a lecturer at Rachel Carson College, an undergraduate environmental studies division of the State University of New York at Buffalo, where he taught energy and environmental courses. The years 1975-1977 he also worked for the New York Public Interest Group (NYPIRG).

1965 - 1973. In 1973, Dr. Resnikoff was a Fulbright lecturer in particle physics at the Universidad de Chile in Santiago, Chile. From 1967 to 1973, he was an Assistant Professor of Physics at the State University of New York at Buffalo. He has written numerous papers in particle physics, under grants from the National Science Foundation. He is a 1965 graduate of the University of Michigan with a Doctor of Philosophy in Theoretical Physics, specializing in group theory and particle physics.

Dr. Resnikoff is a member of the Health Physics Society. Dr. Resnikoff also has published many articles and books as well as being invited to speak at many prestigious conferences.

Year	Total Mi	Total Acc	Acc/Mi	Total Fire	Fire/Mi	Total Expl	Total FRTRN Mi	Fire/FRTRN Mi	Year	Fire/100 million FRTRN MI	Year	rail car ac/rail car k
2010	7.05E+08	2655	3.77E-06	29	4.11456E-08	2	5.08E+08	5.71E-08	2010	5.71	1991	2.08E-
2011	7.18E+08	2780	3.87385E-06	27	3.76237E-08	2	5.23E+08	5.16E-08	2011	5.16	1992	1.91E-
2012	7.32E+08	2437	3.33115E-06	16	2.18705E-08	0	5.34E+08	3.00E-08	2012	3.00	1993	1.68E-
2013	7.48E+08	2543	3.39766E-06	29	3.87464E-08	0	5.42E+08	5.35E-08	2013	5.35	1994	1.64E-
2014	7.66E+08	2523	3.29453E-06	53	6.92073E-08	0	5.56E+08	9.53E-08	2014	9.53	1995	1.53E-
2015	7.38E+08	2617	3.54389E-06	55	7.44799E-08	0	5.34E+08	1.03E-07	2015	10.30	1996	1.39E-
2016	6.9E+08	2308	3.34654E-06	79	1.14548E-07	0	4.92E+08	1.61E-07	2016	16.07	1997	1.32E-
2017	7.06E+08	2387	3.38224E-06	43	6.09285E-08	0	5.05E+08	8.52E-08	2017	8.52	1998	1.19E-
2018	7.1E+08	2477	3.48666E-06	61	8.58644E-08	0	5.10E+08	1.20E-07	2018	11.97	1999	1.12E-
average	**7.24E+08**	**2.53E+03**	**3.4915E-06**	**acc/frtrn mi =**	**4.83E-06**		**5.23E+08**	**8.40E-08**		**8.40**		
Year				392	1.38E+00			**Fire/FRTRN Mi**	**Year**	**Fire/100 million FRTRN MI**	2000	1.12E-
2000				23			5.49E+08	4.19E-08	2000	4.19	2001	1.18E-
2001				35			5.38E+08	6.51E-08	2001	6.51	2002	1.12E-
2002				28			5.47E+08	5.12E-08	2002	5.12	2003	1.12E-
2003				42			5.61E+08	7.49E-08	2003	7.49	2004	1.02E-07
2004				28			5.84E+08	4.80E-08	2004	4.80	2005	1.00E-07
2005				34			5.97E+08	5.70E-08	2005	5.70	2006	1.04E-07
2006				29			6.24E+08	4.65E-08	2006	4.65	2007	9.60E-08
2007				16			5.86E+08	2.73E-08	2007	2.73		
2008				10			5.65E+08	1.77E-08	2008	1.77	**avg =**	**1.32E-0**
2009				22			4.76E+08	4.63E-08	2009	4.63		
								4.76E-08		26.7	Volpe	
				267								

ACC/MI = 3.4915E-06 acc/km = 2.16863E-06

Fire/MI = 6.04905E-08 Fire/FTM = 8.40E-08 (Fire/Mi)/(Fire/FRTRN Mi) 1.39E+00

Fire/Acc = 0.017325084

F/A 2010 = 0.010922787

F/A 2018= 0.024626564