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Title: WASTE ISOLATION PILOT PLANT (WIPP): THE NATIONS' SOLUTION TO NUCLEAR WASTE STORAGE AND DISPOSAL ISSUES

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WASTE ISOLATION PILOT PLANT (WIPP): THE NATIONS' SOLUTION TO NUCLEAR WASTE STORAGE AND DISPOSAL ISSUES

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ABSTRACT

In the southeastern portion of my home state of New Mexico lies the Chihuahauan desert, where a transuranic (TRU), underground disposal site known as the Waste Isolation Pilot Plant (WIPP) occupies 16 square miles. Full operation status began in March 1999, the year I graduated from Los Alamos High School, in Los Alamos, NM, the birthplace of the atomic bomb and one of the nation's main TRU waste generator sites. During the time of its development and until recently, I did not have a full grasp on the role Los Alamos was playing in regards to WIPP. WIPP is used to store and dispose of TRU waste that has been generated since the 1940s because of nuclear weapons research and testing operations that have occurred in Los Alamos, NM and at other sites throughout the United States (U.S.). TRU waste consists of items that are contaminated with artificial, man-made radioactive elements that have atomic numbers greater than uranium, or are trans-uranic, on the periodic table of elements and it has longevity characteristics that may be hazardous to human health and the environment. Therefore, WIPP has underground rooms that have been carved out of 2,000 square foot thick salt formations approximately 2,150 feet underground so that the TRU waste can be isolated and disposed of. WIPP has operated safely and successfully until this year, when two unrelated events occurred in February 2014. With these events, the safety precautions and measures that have been operating at WIPP for the last 15 years are being revised and improved to ensure that other such events do not occur again.

INTRODUCTION

In southeastern New Mexico lies the Chihuahauan desert where a transuranic (TRU) underground disposal site occupies 16 square miles. The Waste Isolation Pilot Plant (WIPP) is located approximately 26 miles east of Carlsbad, NM and is the nation's only nuclear waste, underground geological repository. WIPP has been operating for the past 15 years as the nation's radiological health and safety control implemented to protect the public and the environment from TRU waste hazards. The plant is used to permanently stockpile and dispose of TRU waste that has been generated as a byproduct of the Cold War and World War II nuclear production efforts that began in the 1940s due to nuclear weapons research and testing operations that have occurred at Department of Energy (DOE) sites such as Los Alamos National Laboratory (LANL) located in Los Alamos, NM, the birthplace of the atomic bomb, and other DOE defense production sites across the nation.

TRU waste consists of items that are contaminated with man-made, or artificial, radioactive elements that have atomic numbers greater than uranium, or are trans-uranic, on the periodic table of elements, such as plutonium (^{239}Pu).[1] Their radioactive and longevity characteristics may be hazardous to human health and the environment if not isolated. Plutonium is an artificial radioactive element used in nuclear reactors and nuclear weapons that, through fission reactions, can generate large amounts of energy.[2] Plutonium has 15 different isotopes that have half-lives ranging from 20 minutes to 76 million years.[2]

When an atom's nucleus is split during nuclear fission, radiation can be emitted in three different forms through subsequent radioactive transformations of the fission products, or radionuclides, until a stable end product is reached; the forms of radiation that are emitted are: alpha and beta particles and gamma rays.[3, 4] Alpha particles move slow and have short travel ranges in air due to their large mass (ie. from a few centimeters to an inch in air) therefore, the effects can be shielded from by skin or a sheet of paper; however, the biggest concern is that they can be radioactive for very long periods of time and are dangerous if inhaled or ingested.[3, 4] Beta particles, as opposed to alpha particles, can travel further in air (ie. up to a few feet or meters) and can pass through a piece of paper, only to be shielded by either aluminum foil or glass; like alpha particles, they pose a concern if they are inhaled or ingested.[3, 4] Of the three, however, gamma ray radiation is of the highest concern because it is penetrating and can only be shielded with lead, concrete, steel, or water in order to absorb its energy.[3, 4] The radiation particles that are emitted from the radioactive waste material disposed of at WIPP are predominantly alpha particles because this is the main radiation form emitted from plutonium and other TRU elements.[2, 3]

If stockpiled at above ground locations, TRU waste poses an exposure risk for the environment and the public. Therefore, WIPP has underground rooms that are embedded in 2,000 square foot thick salt formations approximately 2,150 feet underground.[1] Items such as clothing, rags, debris, tools, soil, etc. that are contaminated with TRU radioactive elements, such as plutonium, are placed into large drums/casks that are shipped to WIPP for underground stockpiling and disposal.[1] WIPP is primarily regulated by the Environmental Protection Agency (EPA) and the New Mexico Environmental Department (NMED), however, several other institutions contribute to its success and monitor its progress. These institutions include, but are not limited to, the U.S. Department of Energy (DOE), Sandia National Laboratory (SNL) located in Albuquerque, NM, and LANL, which is a TRU waste generator site, as well as other TRU waste generator sites across the nation.[1]

HISTORY

The U.S.' nuclear defense program began in the 1940s with World War II and the advent of the Cold War. This created TRU waste as a byproduct, which in order to protect the environment and human health, needed to be handled and stored properly due to its radioactive nature and longevity potential hazards. Geological formations such as deep salt beds were suggested as being an ideal location for disposal for many reasons, including stability, since the 1950s by the National Academy of Sciences.[1] In 1974, a remote desert area near Carlsbad, NM, that had a 2,000 foot thick salt bed which was created 250 million years ago by the ancient Permian Sea during evaporation cycles, was chosen by the U.S. Atomic Energy Commission (AEC), later known as the U.S. DOE, to be tested as a possible location.[5, 6] The area near Carlsbad, NM was chosen as the future WIPP site due to these deep, geologic salt beds that could be utilized because of many positive aspects that include the following: salt beds do not have free flowing water; fractures are sealed and openings are closed naturally by salt rock; it can be easily mined; the location is remote enough from large, public areas; and it is water resistant and geologically stable.[7] Thus, the location has ideal conditions for isolating radioactive wastes.[5]

Congress approved the site and plans for WIPP in 1979 and site construction began in the 1980s.[5, 7] After billions of dollars and numerous political actions, regulations, impositions, and testing, WIPP was approved and ready to receive its first shipment in 1999.[6] On March 26, 1999, WIPP received its first TRU waste shipment from LANL.[6] During this first year, other shipments were received from the Idaho National Environmental and Engineering Laboratory (INEEL) and the Rocky Flats Environmental Techonology Site, followed in 2000 by the Hanford site, the Savanah River Site (SRS) in 2001, the Argonne National Laboratory-East in 2003, and the Nevada Test Site (NTS), the Lawrence Livermore National Laboratory (LLNL), and the Argonne National Laboratory-West in 2004.[6] Thus far, 22 DOE generator sites have utilized WIPP as a disposal for legacy TRU waste.[7] Since 1999, WIPP has operated successfully without any incidents and has set a high standard of excellence and safety in handling and disposing of long-lived radioactive waste up until two recent events that occurred in February 2014.

CATEGORIES OF TRU WASTE

The WIPP Land Withdrawal Act transferred the land jurisdiction to DOE and was signed into law in 1992 by President George Bush.[6] This act stipulated that the anticipated volume of waste to be disposed of at WIPP would be 175,570 cubic meters, of which 96% would be categorized as contact-handled (CH) TRU waste, and only 4%, or 7,080 cubic meters, would be remote-handled (RH) TRU waste.[1, 7, 8] This categorization is based on the radiation dose measurements that are taken on the surface of the container.[7] CH TRU waste has a radiation dose rate that does not exceed 200 millirem per hour (mrem/hour).[1, 7] Under controlled conditions, it is considered to be able to be safely handled by workers without shielding other than the container that the waste is in itself.[1]

RH TRU waste must be transported in lead-shielded casks because the radiation dose rate can be up to 1,000 rem per hour and has the potential to emit the more penetrating form of radiation, gamma rays.[1, 7, 9] Up until October 2006, WIPP was not receiving any RH TRU waste and was only receiving CH TRU waste.[8] However, in 2004, the EPA approved DOE's proposal plans for WIPP to receive RH TRU waste and NMED finally approved it as well in 2006 after WIPP had shown safe handling and receipt of over 5,000 CH TRU waste shipments.[8] On January 23, 2007, the first RH TRU waste shipment was received at WIPP.[6]

PACKAGING AND TRANSPORTATION

All shipping casks used to transport TRU waste to WIPP are certified by the U.S. Nuclear Regulatory Commission (NRC) and meet both the NRC and the U.S. Department of Transportation (DOT) public safety radiation limits.[9] In addition, these type B NRC certified casks strictly adhere to design, manufacture, maintenance, and operation NRC requirements. They have undergone extensive testing assessments that include drop, fire, puncture, and pressure tests because they must be able to handle any transportation conditions or scenarios that could occur such as possible debris or accident impacts, variable temperature ranges, and external pressures.[9]

For packaging and shipping of CH TRU waste, TRU-PACT IIs, TRU-PACT IIIs, and HALF-PACT casks are used.[8, 9] A shipping trailer can hold up to any combination of three of these types of casks.[8] With an 8 foot diameter and a height of 10 feet, TRU-PACT II stainless steel casks were rigorously tested to be leak resistant at SNL.[9] To help with the leak resistance characteristic, the cask has inner and outer containment vessels that can hold any of the following packaging combinations: six 100 gallon drums, eight 85 gallon drums, fourteen 55 gallon drums, 2 standard waste boxes, or one 10 drum overpack.[9]

The TRU-PACT II cask is a heavy, tall cask and may need to be substituted by a HALF-PACT cask in order to meet the 80,000 lb weight limit set by the U.S. DOT for the shipment, truck, and trailer. Therefore, HALF-PACTs were designed by DOE to be shorter and lighter. They can hold any of the following packaging combinations: three 100 gallon drums, four 85 gallon drums, or seven 55 gallon drums.[9]

A TRU-PACT III cask was designed by DOE specifically to fit Standard Large Box 2 (SLB2) CH TRU waste containers because they could not fit in either the TRU-PACT II or the

HALF-PACT cask. This rectangular cask has inner and outer stainless steel plates as well as polyurethane foam to protect against fire and puncture.[9] A custom-designed trailer is used to transport this cask because it has the potential to slightly exceed the 80,000 lb limit and must have an overweight shipping permit to be transported to WIPP. [9]

Two types of steel casks, that are further fit with impact limiter caps at each end which act as shock absorbers in case of an accident, are certified to ship RH TRU waste due to their safety and ability to remain leak tight.[8] These casks are the RH-72B and the CNS 10-160B, the former of which is used most often.[8] Standing 12 feet in height, the RH-72B cylindrical cask has a 3.5 foot diameter, is lined with lead, and has inner and outer containment vessels.[9] Three 55 gallon drums or one cylindrical canister of RH TRU waste can be packaged into an RH-72B cask while ten 55 gallon drums can be packaged into a CNS 10-160B cask. A trailer can only hold one of these RH casks per trip because of the weight of the lead shielding.[8]

Diesel tractors and custom-designed trailers are used to transport the TRU waste casks to their final destination at WIPP.[9] Transportation routes to WIPP for both CH and RH TRU wastes are the same and have been agreed upon by the different states and tribal nations through which these waste shipments pass through.[8] Per DOT regulations, the interstate highway system is to be used at all time unless a state has designated a specialized route for transportation, some of which have been made to ease public concern. For example, Los Alamos, NM is located in north central New Mexico and for transportation containers to get to WIPP from LANL, shipments needed to be transported through the city of Santa Fe, NM. However, the city of Santa Fe and its residents were not pleased that radioactive shipments would be traveling through the middle of the city and demanded the construction of NM-599, which is a relief route that bypasses the city of Santa Fe.

Numerous, stringent control measures have been implemented for the safety and security of the public when these shipments are transported. Some control measures include: tracking of all shipments by satellite from a secure, 24 hour control center and the requirement that all shipments undergo the most rigorous inspection of the shipping industry, a Commercial Level VI inspection, before leaving a generator site.[8, 9] WIPP shipment truck drivers must pass rigorous safety and emergency response training and meet strict requirements for qualification to transport TRU waste.[9] They are required to stop every 150 miles or every three hours to do an inspection and must work in pairs to ensure the safety of the shipment.[8, 9] Emergency first responders located near WIPP routes have also been trained on how to handle an emergency situation involving WIPP shipments.[8] The employee and public radiation exposure risk that can occur during the transportation of TRU waste to WIPP is very small and, according to the United States DOE Carlsbad Field Office, if an individual were to walk within 30 feet of a TRUPACT-II container, the exposure dose has been calculated to be less than ten millionth of the dose that an average person receives from natural background radiation sources annually.[2]

AT WIPP

Once at WIPP, CH TRU and RH TRU waste is transported to the underground disposal rooms. CH TRU waste casks are stacked in rows on the floor in the underground rooms.[8] When RH TRU waste shipments arrive at WIPP, the contents of an RH-72B or a 10-160B cask must be transferred to a facility cask which is transported underground and moved onto horizontal emplacement equipment by a forklift.[8] The container then gets pushed out of the facility cask by the horizontal emplacement equipment into a borehole that has been drilled specifically to place the RH TRU waste containers and a concrete shield plug is placed over the borehole.[8]

THE RECENT RADIOLOGICAL RELEASE EVENT AT WIPP (FEBRUARY 14, 2014)

In 15 years of operations, WIPP had not had any hazardous events occur until two events recently occurred in February 2014. The first event, where a salt haul truck caught fire underground at WIPP occurred on February 5, 2014, but this event will not be discussed in this paper.[10] The second event involved a radiological release at WIPP and is unrelated to the February 5, 2014 fire event.[10] As one of the many control measures in place at WIPP, Continuous Air Monitors (CAMs) are strategically located in both underground and above ground areas to monitor radiological particulate concentrations. CAMs draw in alpha, beta, and gamma ray particulates and a detector inside the CAM monitors the particulates that are deposited on the filter paper, alarming if radioactivity is detected at a certain level.[11] An underground CAM picked up airborne radioactivity in the vicinity of active waste disposal operations and alarmed during the nightshift on February 14, 2014.[10] A total of 13 employees were on site, potentially exposed during the event, and have been analyzed for internal contamination of possible inhalation or ingestion: eleven employees were on site above ground at the time of the alarm and, a few hours later, two additional employees reported on site.[10]

Immediately when the CAM alarmed, one of the many controls that are in place in case of such of an event was activated; the WIPP ventilation exhaust was redirected to filtration mode through high efficiency particulate air (HEPA) filters when two dampers in the exhaust duct immediately closed upon alarming, allowing filtering of radioactive particles to be removed from the air.[10] However, on February 15, 2014, extremely low levels of airborne radioactivity were detected above ground at WIPP when 140 employees were already on site; these employees were kept inside while air sampling was taken and testing services were offered to them as a precaution.[10] The exhaust duct dampers that automatically closed when the CAM alarmed are believed to not have fully sealed, allowing a small radiological release to occur above ground.[10] An immediate corrective action that included placing high-density expanding foam insulation on the dampers to seal them was implemented.[10] In addition, air monitors have been lowered through shafts to monitor airborne radioactivity and have not detected further activity.[10]

Numerous other actions have taken place in response to the event to ensure that WIPP employees, the public, and the environment are protected. Environmental monitoring for radioactivity in the air, water, and soil above ground have shown levels are not of concern and are at background levels.[11] Three different bioassays were conducted on the 13 employees as well as additional employees that requested sampling: whole body counts, urine analysis, and fecal analysis.[11] Eighty six whole body counts, measuring internal lung radioactivity exposure levels, were conducted yielding all negative results.[11] Urine and fecal analyses were used to measure the amount of radioactivity excreted from the body as another form of assay to detect internal exposures; 140 urine and 31 fecal samples were analyzed with 1 urine and 20 fecal samples yielding low positive results.[11] Upon subsequent analysis, all of these were below detectable limits.[11]

The CAM alarm has not reoccurred since February 14, 2014.[12] The cause of the event has been identified as a hot reaction that occurred in a LANL cask/drum that caused a release.[16] Currently, a full review and investigation is being conducted by the DOE, LANL, NMED, and other organizations/institutions to prevent this event from occurring again as well as to implement further safety precautions that may help in preventing loose radioactive particle inhalation and ingestion.[12] Additional CAMs have been placed strategically above ground and underground to ensure an even higher level of protection.[11] Per the EPA, their data review has indicated that there is no public health concern from the radiation releases that occurred from this event, all EPA procedures were followed by DOE, and WIPP is in compliance with all EPA regulations.[13]

BIOASSAY RESULTS FROM THE FEBRUARY 14, 2014 RELEASE EVENT

To help employees and the public gain an understanding of the bioassay results of the positive sample results that were measured from site employees from the radiological release recent event that occurred on February 14, 2014, the WIPP site has posted a bioassay result chart on the following online location: http://www.wipp.energy.gov/wipprecovery/fact_sheets.html.[14] The thirteen employees that were onsite during the event release received internal contamination.[12] These tests indicated that radioactive emitting alpha particles were inhaled.[12] All employees that were onsite during the event release were evaluated for internal contamination as well as some that were onsite on February 15, 2014 that requested evaluations. As reviewed above, alpha particles can be shielded from by clothing, skin, and paper but, when inhaled or ingested, these particles pose the greatest danger; beta and gamma particles are not related to this event.[12] The chart demonstrates that the federal limit for radiation contamination is 5,000 mrem and the treatment recommended limit is 2,000 mrem.[14] The radiation exposure policy for WIPP is that if an internal contamination dose is suspected of being above 2,000 mrems, then a radiation control manager may recommend for the employee to seek treatment thru an occupational medicine physician.[14] The minimum reporting limit is 10 mrem and positive results from site employees were below that, ranging from 0.50 to 7.92 mrem as of May 22, 2014.[14]

In addition, to put these event exposures into perspective, a typical average annual exposure chart from the American Nuclear Society is provided that demonstrates radiation exposures that occur from other background sources.[14] As discussed in the radiological health and safety textbook, all creatures are continuously exposed to external radiation that can occur through natural occurring radionuclides as well as cosmic rays and other sources.[4] Location altitude and other sources such as x-rays and CAT scans can contribute to the total amount of background radiation that an individual is exposed to on a yearly basis; for example, a higher altitude location will expose an individual to a higher dose of radiation because the cosmic radiation dose increases with altitude.[3, 4] In this chart, it shows that the average U.S. radiation dose exposure from all sources is 620 mrem, air exposure is 228 mrem, cosmic radiation exposures in Carlsbad, NM from the sun is 41 mrem, food and water exposure is 40 mrem, smoking ½ pack of cigarettes a day causes an exposure of 18 mrem, a single CT scan of the chest causes an exposure of 700 mrem, a single chest x-ray causes an exposure of 10 mrem.[14] Therefore, even though the event exposures are being taken very seriously, the site employees' positive results are so low that the risk of health effects from this event do not pose any health concerns.[14] Further biological sampling has been done as well and these results are negative for contamination, indicating that exposure levels that the employees' experienced were very low.[12]

OFFSITE SAMPLING FOR THE FEBRUARY 14, 2014 RELEASE EVENT

Sampling was conducted offsite as well in order to determine exposure risks for the public and the environment. One location that is 0.6 miles from the site boundary showed radioactive levels that were slightly above background levels, however, this is the only above background result, thus, sampling indicates that there was no offsite exposure risk.[12] Naturally-occurring radiation is always present in the environment and background levels are defined by this fact.[12] All investigations have determined that this release event was a one-time event and all sampling conducted offsite has shown that above background levels are returning to normal.[12]

CONCLUSION

To be good environmental stewards, the U.S. has constructed WIPP, the nation's only nuclear waste, underground geological repository for TRU mixed waste storage and disposal. Efforts started in the 1950's to find a place for the nation's TRU waste above ground stockpile came to fruition in 1999 when WIPP began receiving shipments to stockpile underground. WIPP has successfully received 11,000 shipments and 80,000 cubic meters of waste over the past 15 years from 22 DOE TRU waste generator sites, filling approximately 53% of its capacity, and has prided itself on the safety and efficiency status that they have maintained during these years.[15, 16]

Unfortunately, two incidents occurred in February 2014 that have left a blemish on this successful record. While an investigation is being conducted of the radiological release event, no further shipments will be received at WIPP until the investigation is completed and recovery efforts are implemented.[16] However, the event is being used as a "lessons learned" to improve the safety and efficiency of WIPP operations in order to gain the public's trust back on the ability of WIPP to provide protection to the environment and the public.[16] Numerous engineering, administrative, and personal protection controls are being thoroughly evaluated and investigated for radiological exposure protection of which distance, time, and shielding are the most valuable methods.

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