ASSESSING EXPOSURE TO THE PUBLIC FROM LOW LEVEL RADIOACTIVE WASTE (LLW) TRANSPORTATION TO THE NEVADA TEST SITE

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ABSTRACT

The United States (U.S.) Department of Energy (DOE) Nevada Test Site (NTS) is one of two regional sites where low-level radioactive waste (LLW) from approved DOE and U.S. DOD generators across the United States is disposed. In federal fiscal year (FY) 2002, over 57,000 cubic meters of waste was transported to and disposed at the NTS. DOE and U.S. Department of Transportation (DOT) regulations ensure that radiation exposure from truck shipments to members of the public is negligible. Nevertheless, particularly in rural communities along transportation routes in Utah and Nevada, there is perceived risk from members of the public about incremental exposure from LLW trucks, especially when “Main Street” and the LLW transportation route are the same.

To better quantify the exposure to gamma radiation, a stationary monitoring array of four pressurized ion chambers (PICs) have been set up in a pullout just before LLW trucks reach the entrance to the NTS. The PICs are positioned at a distance of one meter from the sides of the truck trailer and at a height appropriate for the design of the trucks that will be used in FY2003 to haul LLW to the NTS. The use of four PICs (two on each side of the truck) is to minimize and to correct for non-uniformity where radiation levels from waste packages vary from side to side, and from front to back in the truck trailer. The PIC array is being calibrated by collecting readings from each PIC exposed to a known $^{137}$Cs source that was positioned at different locations on a flatbed stationed in the PIC array, along with taking secondary readings from other known sources. Continuous data collection using the PICs, with and without a truck in the array, is being used to develop background readings. In addition, acoustic sensors are positioned on each side of the PIC array to record when a large object (presumably a truck) enters the array.

In FY2003, PIC surveys from as many incoming LLW trucks as possible will be made and survey data recorded automatically by dataloggers that will be periodically downloaded. Solar panels provide power for the batteries to run both the dataloggers and PICs. Truck drivers have been asked to park their truck within the PIC array for only the
time it takes to complete an information log before moving on to one of two Radioactive Waste Management Sites (RWMS) on the NTS. On the log, the truck drivers record their shipment identification number, the time of day, where the waste originated, and information on the route they used to reach the NTS. This data will facilitate comparison of PIC readings with waste manifests and other waste disposal operations data collected at the RWMSs. Gamma radiation measurements collected from the PICs will be analyzed using standard health physics and statistical methods for comparison to DOT standards, but with the added benefit of obtaining an improved understanding of the variability of readings that can occur in the near vicinity of a LLW truck. The data collected will be combined with measurements of street width and other information about transportation routes through towns to develop realistic dose scenarios for citizens in Nevada and Utah towns.

INTRODUCTION

Since 1980, over 651,000 cubic meters (m$^3$) or 23,000,000 cubic feet (ft$^3$) of low level radioactive waste (LLW) has been disposed at the Nevada Test Site (NTS) by shallow land burial of waste containers. Since 1988, the majority of this waste was generated at other U.S. Department of Energy (DOE) and U.S. Department of Defense (DoD) sites and facilities in the United States. Between now and fiscal year 2006, the volumes of LLW being shipped by truck to the NTS are projected to increase sharply with the accelerated closure of DOE Environmental Management (EM) Project sites (1).

There continues to be public concerns over the safety of LLW shipments to the NTS. They can be broadly divided into two categories: (1) the risk of accidents involving trucks traveling on public highways; and (2) whether residents along transportation routes are exposed to incremental doses from LLW shipments that pose a long-term health risk. DOE and U.S Department of Transportation (DOT) regulations ensure that radiation exposure from truck shipments to members of the public is negligible. Nevertheless, particularly in rural communities along transportation routes in Utah and Nevada (see Fig. 1), there is a perceived risk from members of the public about incremental exposure, particularly when “Main Street” and the routes being used by LLW trucks are one in the same.

To provide an objective assessment of risk from exposure from gamma radiation to members of the public, the Desert Research Institute (DRI) and the DOE, National Nuclear Security Administration Nevada Operations Office (NNSA/NV) has established a stationary and automated array of four Reuter-Stokes pressurized ion chambers (PICs) in a roadside pullout just before LLW trucks reach the entrance to the NTS. The PICs are positioned at a distance of 1 meters from the sides of the truck trailer and at a height of 1.52 m (5 ft) to simulate conditions that a member of the public might experience if a truck were to pass them while the person was on the side of the road, or if a truck were to come to a stop at a stoplight in one of the smaller towns along the transportation routes, but also so that the PICs are positioned above the bed of most LLW trailers. At 1.52 m (5 ft), the height of the PICs is also representative for the exposure of chest organs for a “Reference Man” using the Snyder-Fisher model of an adult human for dose studies (2).
Fig. 1. Most common truck transportation routes for shipping LLW to the NTS.
Also, by being above the bed, the potential radiation level observed is maximized. See Fig. 2 for a schematic of the PIC array. The purpose in automating the system is to provide as an objective and consistent means of measurement to calculate potential radiation exposure and dose from the trucks as possible. The goal is to collect data from as many as 1000 waste shipments to the NTS to see variation in measurements in trucks, and to test whether any anomalies in readings correlate with the type of truck containers or the waste being hauled.

Trucks drivers began using the array the week of December 2, 2002. As of January 14, 2003, 35 percent of the drivers delivering LLW to the NTS had used the array. However, this percentage is expected to increase; drivers who have used the PIC array once have expressed no reservations about using it again on future deliveries. Only one DOE site shipping waste to the NTS has declined to participate in the study.

Fig. 2. Schematic of the PIC array set up for gamma radiation measurements. The PIC array is set up in a pullout on the Mercury highway off of U.S. Highway 95 just south of the entrance to the NTS.
BACKGROUND

The Role of the NTS as a Regional LLW Disposal Site

The NNSA/NV Environmental Management (EM) Program supports the DOE complex by maintaining essential capability to disposal of low-level radioactive waste (LLW) at the NTS from approved generators from across the DOE complex. This role was codified in the 1997 Waste Management Programmatic Environmental Impact Statement when the NTS was designated as one of two regional disposal sites for LLW. It is anticipated that the NTS will continue to be used by off-site generators until at least 2021 (1). Bechtel Nevada (BN) operates two disposal facilities at the NTS for shallow land disposal of LLW: the Area 5 RWMS, and the Area 3 RWMS.

Currently, 22 U.S. DOE and U.S. DoD off-site generators from across the United States are approved for disposal of LLW waste at the NTS. This is in addition to disposal of LLW generated by NNSA/NV’s own EM activities, although this has amounted to less than 1% of the LLW disposed in the last three years. In addition, another 16 generators may become certified to dispose of waste at the NTS. With the DOE EM Program accelerating cleanup at several key sites between now and FY2006, volumes of LLW to be disposal at the NTS are projected to increase substantially. FY2002 was the first year in which over 57,0000 m³ (2,000,000 ft³) of LLW from offsite generators was disposed at the NTS. Conservative projections for LLW disposal at NTS are for nearly 100,000 m³ (3,500,000 ft³) in FY2003 and FY2004. Among sites already approved for disposal of LLW waste at NTS that will be contributing to this increase are the Rocky Flats Environmental Technologies Site in Colorado, Mound and Fernald in Ohio, and the Oak Ridge Reservation in Tennessee. Most significant for this study, is the disposal of 100,000 m³ at the NTS from off-site generators, which represents approximately 2,500 LLW truck shipments per year.

Dose Limits for LLW Vehicle Shipments

The U.S. Department of Transportation (DOT), in addition to regulating packaging, labeling, handling, marking, and placarding of trucks and train cars used for LLW shipments, also sets standards for dose limits for “closed”, exclusive use vehicles such as trucks being used for delivering LLW to the NTS for disposal (3). Standards include 2 mrem/hour (hr) to the driver in the truck cab, 200 mrem/hr at contact with the truck trailer, and 10mrem/hr at 2 m (6.6 ft) distance. When trucks reach one of the two RWMS at the NTS to deliver LLW for disposal, BN operations personnel take surface swipes of the trailer and scans with hand-held instruments for comparison against these standards.

METHODS

Set-up and Calibration of the PIC Array

The objective of the calibration is to examine the response of the High Pressure Ion Chamber (PIC) array to a known source strength in the configuration to be used to study
the potential radiation exposure of a NTS bound load of LLW. Results of the calibration would also provide a correction factor that could be used, if necessary, to check the factory calibration of the PICs, and as a method to estimate the source strength, and exposure to potential individuals who happen to be in the vicinity of a shipment of LLW waste while being transported to the NTS for disposal. In addition, the calibration is helping determine the shielding characteristics of semi-trailers.

A flatbed semi-trailer or float and tractor were placed in the middle of the array of four Reuter-Stokes model RSS-131 High Pressure PICs. The PICs are positioned such that approximately one-third of the float extends beyond both the front and back PIC sets (See Fig. 3). Fifteen positions were marked on the float and the distance measured and recorded from these positions to each of the four PICs. A J.L. Shepherd & Associates 11.5 mCi Cs-137 source, ORNL capsule S.N. A-359 (about 1.26 centimeter (cm) in diameter by 1.0 cm {0.50 inches [in] and 0.39 in) was placed in a small plastic cup progressively in each of the 15 positions. The exposure rate was hand recorded and digitally recorded on a data logger. Data was collected at the surface (trial 1) of the float, and at 0.92 m (3 ft) and 1.84 m (6 ft) above the surface during trials 2 and 3.

Fig. 3. PIC array during calibration.
Upon completion of the 15 measurements at the surface level, a 0.91 m (3.26 ft) high cardboard box with a cup glued to the center of the box was placed at each of the same 15 positions and the above process repeated. This process was then repeated with two boxes of the same height stacked on top of each other.

PIC readings recorded between truck drivers using the facility are being used to develop a database of background readings for the site. Based on background data collected in January 2003, background at the site ranges between 9 and 12 microR/hr, with an average of approximately 12.

**Calibration Results**

Although LLW trucks have already begun using the PIC array, analysis of the calibration and its implications for eventual data analysis are still in progress. The data from each trial and for each PIC has been compared against the theoretical response calculated for the Cs-137 source.

Evaluation of the calibration data and the array design indicated that regulated voltage to the PICs was approximately 14.5 percent too low because of how the PICs were grounded. However, after adjustment, all four PICs responded appropriately to a known 8 microCi Cs-137 source used to indicate response of the same Reuter-Stokes model of PICs used at off-site monitoring stations around the NTS. Further calibration verification using the same traceable J.L. Shepherd & Associates 11.5 mCi Cs-137 source is scheduled to develop a correction factor for the PIC data collected prior to the voltage adjustment.

**Instructions to Waste Generators**

To obtain as large a population of radiological readings from trucks, the NNSA/NV EM Program, in a letter to all approved offsite LLW waste generators, requested that all truck drivers participate in the study (3), assuming safe conditions for use of the site. For example, the pullout being used is long enough that several trucks can safely be pulled off the highway at one time to go through the PIC array. However, the driver should bypass the array if the only way that he or she may go through it would be to stop their truck on Road 100 leading to the entrance gate at the NTS. The instructions included instructions for the drivers on the location of the array, how to park the truck in it, as well as photographs of the site (4).

At the PIC array, the drivers are asked to record several key pieces of information in a logbook about their waste shipment. The most significant number is the Waste Identification Number that will allow PIC readings from the truck to be compared to information on the waste manifest sheets collected at the RWMS. This will facilitate comparison of truck readings to waste type and generator, and the type of truck. The driver is also asked to record the date and time of day as a secondary means of interpreting data stored by the data loggers. Lights are provided at the PIC array so that it may be used 24 hours per day. Lastly, the drivers are asked to record the direction from which they came to arrive at the NTS. This information, supplemented by information on
the waste manifest sheets, can be used to analyze populations of trucks that traveled on particular routes and towns on their way to the NTS. A map of the most common routes used to transport LLW to the NTS is shown in Fig. 1.

One unanticipated but beneficial result of calibration of the array was the discovery that the PICs readings stabilize within 10 seconds of the truck entering the PIC array. It was previously expected that the drivers would need to be instructed to leave the truck in the array for a minimum period to obtain measurements. Instead, in the short amount of time the driver needs to record information in the logbook on the waste shipment, suitable measurements of the truck will have been made, greatly simplifying the process for the drivers.

DATA ANALYSIS

A search of the literature and questioning of various organizations who have been engaged in analysis of transportation risk exposure of LLW have not produced any data records where actual measurements in a consistent geometry were made on the roadside near trucks loaded with LLW. Large volumes of data have been collected for compliance with DOT regulations at the point of origin of waste shipments and at disposal sites such as the Area 3 and 5 RWMSs at the NTS, but these measurements are taken at the prescribed distances, and points of compliance such as “contact with waste container” and “contact with truck van surface” as required by DOT. This may be the first study that will examine a large number of truck shipments, containing various configurations of source term distribution in the trailer, which will be analyzed in a fixed roadside geometry over a long period of time.

Among the data analyses and products that will be developed from the PIC array measures will include the following:

- Determining if PIC readings are statistically above background.
- Assessing the uniformity of the exposure field of the LLW load, i.e., do PICs readings vary significantly for the same waste shipment?
- Calculating what the potential exposure, if any, would be to members of the public, given various time and distance scenarios.
- Developing a summary report comparing actual measured exposures, in stated time and distance scenarios versus the DOT standards.

One outcome of the first calibration is a hypothesis that the bed of the trailer may provide more shielding than previously anticipated. Additional measurements specific to investigate this question will be taken during the calibration verification. In addition observational data will also be gathered on the float bed height and its composition from trucks at the NTS RWMSs. This data will help to better understand the frequency to which this shielding could affect potential dose.
Other environmental measurement programs at the NTS will aid in the analysis. Most notably, the Desert Rock Meteorological Station, located approximately 1.5 kilometers (1 mile) west of the PIC array, provides continuous meteorological data including temperature, wind, humidity, and barometric pressure. Changes in meteorological conditions could be responsible for variations in background readings for the site and potentially measurements from the trucks. If desired, PIC measurements can be assessed against continuous time records from the Desert Rock Station. The Special Operations Research Division of the Air Resource Lab of the National Oceanic Atmospheric Administration operates the Desert Rock Station.

ACKNOWLEDGEMENTS

DRI appreciates and wishes to acknowledge the assistance of Bechtel Nevada Waste Operations for support in calibration of the PIC array, and in making waste manifests available to DRI for analysis of the data. The Division of Waste Management, U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office is providing funding for the study.

REFERENCES


