



# **Extremity Exposure Case Study Lessons Learned**

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# Event Summary

- During the month of January 2006, employees of a licensee conducted Neutron Activation Analysis (NAA) on samples received.
- On February 24, 2006, the licensee received a dosimetry report from the vendor for the month of January.
- During a review of the report, it was discovered that an employee (Worker A) received a whole body dose of 0.033 rem and an extremity dose of 75.8 rem.
- The licensee immediately noted the results, restricted Worker A from further exposure, and began a review of the situation.
- After careful consideration of various factors involved, the Facility Director and RSO determined that this was an anomalous reading and allowed Worker A to continue restricted activities.



## Event Summary (cont'd)

- At the end of February, personnel dosimeters were again gathered and sent to the vendor for processing.
- Those dosimetry results, received on March 15, 2006, indicated that Worker A, while conducting NAA using the pneumatic transfer system, had received a whole body dose of 0.006 rem and an extremity dose of 37.54 rem during February.
- The licensee notified the NRC of the event on March 15, 2006.
- The NRC inspector dispatched to the site arrived March 20, 2006, but due to the complicated nature of the event, a Special Inspection Team was assigned to review the event.
- The Special Inspection Team began their review on March 27, 2006.



# Background

- The licensee had been processing this type of NAA samples using the pneumatic transfer system at the facility for approximately one year.
- Another person, Worker C, had been the primary person who had handled the samples during 2005. A third person, Worker B, also performed the work of handling the samples on occasion.
- Worker A had been assisting as needed with this work for about six months.
- During 2005, neither Worker B nor Worker C had received extremity doses of the magnitude received by Worker A in January and February 2006. The highest extremity dose during 2005 was 1.58 rem received by Worker C.



# Background (cont'd)

Table 1

<u>Employee</u>	<u>Number of Samples</u>	<u>Period of Time</u>	<u>TLD Results, rem</u>
Worker C	226	October 2005	1.58
Worker C	240	November 2005	0.88
Worker B	88	December 2005	0.08
Worker B	195	January 10-27, 2006	0.18
Worker A	140	January 17-30, 2006	75.8
Worker A	141	February 6-22, 2006	37.54
Worker A	0	March 1-23, 2006	0.04



## Background (cont'd)

- During January and February 2006, Worker A also helped complete one radioactive material shipment, conducted various routine surveys, and performed routine calibrations of counting instruments.
- However, other licensee employees also helped with and/or completed the same or similar tasks during this same time period. With the exception of Worker B who had also processed samples in January, the only significant difference between Worker A and the others was that Worker A had been processing the NAA samples.
- During January and February, only Worker A had received a significant extremity dose.



# Observations

- In order to understand the event better, the inspector asked the licensee to process the same or similar samples again.
- The inspector observed as Worker D processed two samples using the pneumatic transfer system and measured the dose rates from the various components with an open-window ion chamber. The results were as follows in Table 2:

Table 2

<u>Items</u>	<u>Contact Reading</u>
Outer vial (with foam and inner vial)	2.6 Roentgen per hour (R/hr)
Foam cushioning material separately	470 mR/hr
Outer vial separately	26 mR/hr
Inner vial (with sample)	2.4 R/hr



# Observations (cont'd)

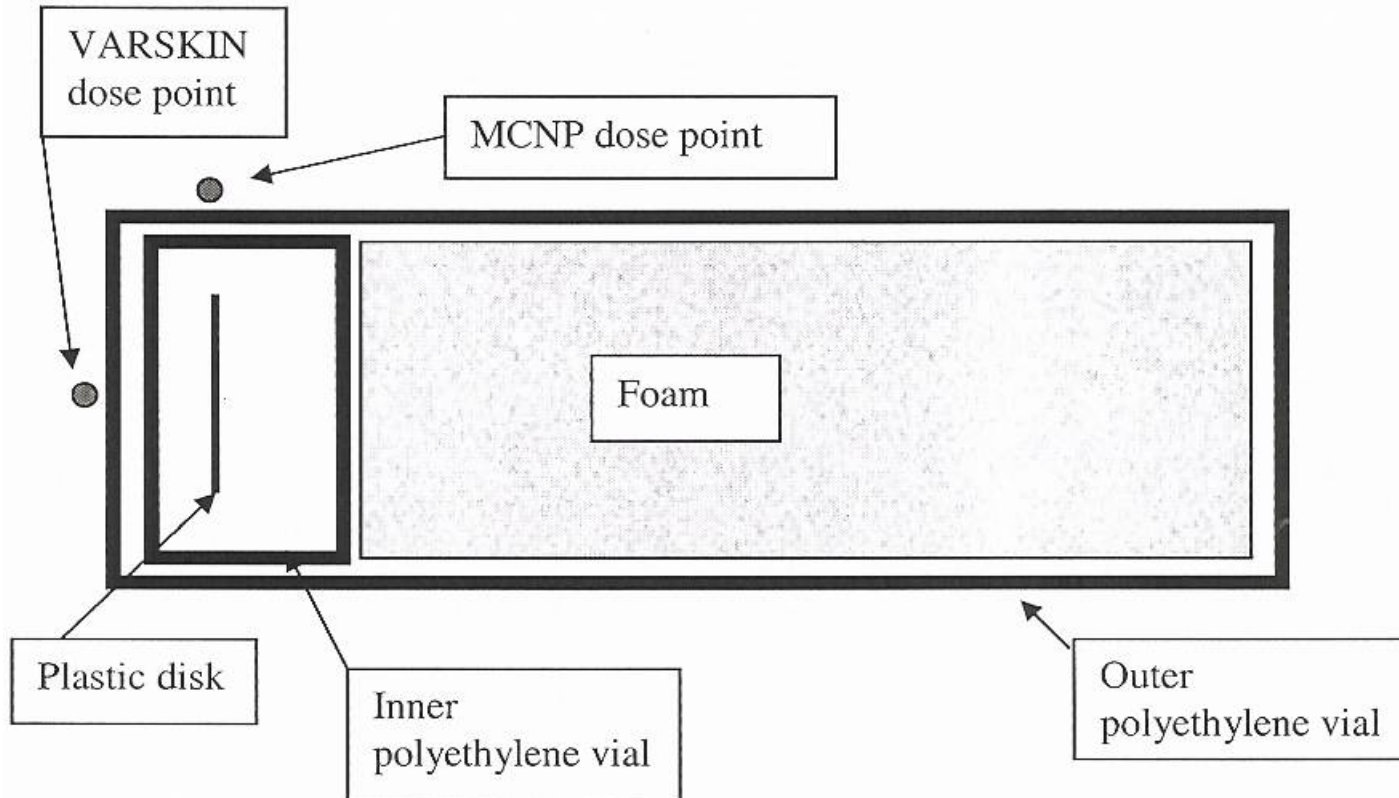


Figure 1. Schematic of source configuration



## Observations (cont'd)

- In an attempt to quantify the dose rates from the vials, several samples identical to those handled by Worker A were irradiated in the reactor for the same length of time.
- After each sample vial was irradiated, samples were placed on a bench and a set of TLD chips were held against the vial for approximately one minute. Six chips were used in each test, distributed along the vial to obtain an axial dose distribution.
- In addition, a finger ring dosimeter was placed against the vial wall opposite the activated sample.
- TLD chips were stored overnight (standard procedure) and read by the licensee the following morning while the finger ring dosimeters were sent to the dosimetry processor for emergency processing.



# Observations (cont'd)

- The licensee operates a TLD chip reader system calibrated using radiation measuring detectors traceable to the National Institute of Standards and Technology (NIST). The dose rates obtained from these experimental measurements are shown here in Table 3.

Table 3

Location of Chip	Dose Rate - mrad/min	Location of Chip	Dose Rate - mrad/min
1	38.2	7	42.6
2	81.4	8	104.3
3	419.9	9	681.0
4	1115.4	10	622.0
5	180.4	11	187.4
6	23.2	12	18.2



# Observations (cont'd)

- The readings were all corrected for background. Chips #1 and #7 were close to the top of the vial, Chips #2 and #8 were about halfway along the length of the vial, chips #3, #4, #9, and #10 were opposite the irradiated sample, and chips #5, #6, #11, and #12 were below the bottom of the vial.

Table 4

Chip/Finger Ring Reading	Resulting Dose Rate – mrad/min	Total Dose After 35 minutes - rads
Ave. reading of the 4 chips located opposite the sample	710	24.8
Highest chip reading	1115.4	39.0
First finger ring	460	16.1
Second finger ring	390	13.7



## Observations (cont'd)

- Using a second approach, both the licensee and the NRC calculated the doses that would result from handling the irradiated samples.
- The licensee used a computer code to calculate doses resulting from beta radiation, and another to calculate the doses from photons.
- However, neither code is capable of representing the exposure geometry in this case with sufficient accuracy, and both the licensee and NRC also used the Monte Carlo transport code MCNP to supplement the beta radiation calculations.
- FYI - The dimensions used for the vials were 7.5 cm length and 1.7 cm outer diameter for the larger outer vial, and 1.0 cm length and 1.2 cm outer diameter for the inner vial. Each vial had a wall thickness of 0.1 cm, and the vials were made of polyethylene.



# Measurement and Calculation Summary

- The calculations were based on sample activities obtained by reviewing the records of the isotopic gamma analyses and also by irradiating several samples during the inspection under the same conditions used by Worker A.
- Results of the measurements and calculations performed by NRC and the licensee are shown in Table 5. All the doses shown are based on estimating the dose rate per minute and multiplying by an exposure duration of 35 minutes to obtain the dose for the month.



# Measurement and Calculation Summary (cont'd)

Table 5

Type of Dose Estimate	Dose During the Month, rad
Mean of TLDs chip readings	24.8
Maximum TLD chip reading	39.0
Minimum TLD chip reading	14.7
Finger ring reading	16.1
Finger ring reading	13.7
MCNP calculation with gloves (NRC)	21.0
MCNP calculation with gloves (licensee)	5.0
MCNP calculation w/o gloves (licensee)	12.3
VARSKIN calculation (NRC)	22.0
VARSKIN calculation (licensee)	17.5



# Conclusion

- The NRC concluded that the licensee did not:
  - (1) make adequate surveys to fully establish the radiological hazards that were present following the initial trial runs of vials,
  - (2) acceptably train and monitor workers regarding the handling of sample vials with their hands/fingers,
  - (3) conduct surveys of the sample vials of irradiated material following the first indication of a possible overexposure, and
  - (4) formally arrange for rapid feedback from the dosimetry provider in circumstance where there were indications of high exposure.



## Conclusion (cont'd)

- The licensee immediately notified the NRC upon receipt of the second report containing an unusually high reading for the same worker.
- Although this type of response by the licensee would generally be acceptable, the NRC must be notified of any conditions that conform to the notification and reporting requirements in Part 20, even in the face of great uncertainty regarding the validity of the data, as was the case in this event.
- The licensee did not notify the NRC after receiving the first high dosimetry report even though the dose reported was substantially above the limit. Although the dose was not likely to have been received in 24 hours, the conservative action would have been to report the event.