

## USTUR

### ***Two Especially Critical Whole-body Donation Cases***

Case 0407 (Rocky Flats – 1965 Plutonium Fire): USTUR's oldest Registrant passed away in California – at age 90+ years – from heart failure. This gentleman worked at Rocky Flats as a Technical Inspector from 1958 through 1975. In 1962, he was involved in two relatively minor plutonium contamination incidents. In 1965, he was one of the most highly contaminated workers in an extensive plutonium fire incident, and was treated initially by intravenous Ca-DTPA chelation therapy. However, this therapy was of only limited effectiveness. Studies of the plutonium fire aerosol showed that this material was highly refractory, and thus retained in the lungs and not responsive to intravenous chelation treatment. The gentleman was re-assigned to non-plutonium work, and received no further intakes. In 1990, he was treated for prostate cancer (by surgical removal of the prostate and testes).

USTUR holds complete bioassay, health physics and medical records in this case. Fecal samples collected on the day following the Pu-fire exposure contained 33,100 dpm (0.55 kBq) of Pu  $\alpha$ -activity. The contemporary site estimate of this worker's lung burden was 4.6 times the then-maximum permissible amount, i.e., 184 nCi (6.8 kBq). This corresponds to about 17 times the current DOE (10 CFR 835, November 28, 2006) annual limit on intake of 400 Bq for Class 'Y' (insoluble) Pu.

Comprehensive external measurements of the 59.5 keV  $^{241}\text{Am}$   $\gamma$ -emissions from the chest, liver, forehead, knees, and ankles were carried out at PNNL's In Vivo Radiobioassay Research Facility (IVRRF) in downtown Richland. This procedure was observed in person by three of USTUR's graduate research students from Idaho State University's (ISU) Health Physics Program (Pocatello, ID), by special ISU request.



Nino Chelidze, M.S., Maia Avtandilashvili, M.S., and Erika Shelton, B.S. (ISU graduate research students) with Stacey McCord (USTUR project associate), John Berecca (PNNL – at screen) and Tim Lynch (PNNL/IVRRF Manager) looking at the  $^{241}\text{Am}$  spectrum accumulating from the chest (lungs) of Case 0407.



Four thin planar germanium detectors positioned over the chest to measure  $^{241}\text{Am}$  activity in the lungs of Case 0407.

A special study of the (43-y) lung and lymph node retention of the refractory Pu particles is planned in this case, including tissue histology and autoradiography. This, together with other USTUR cases (partial-body donations) from the 1965 Rocky Flats fire incident, will be the topic of Maia Avtandilashvili's Ph.D. dissertation research. A special quantitative study of the efficiency of counting  $^{241}\text{Am}$   $\gamma$ -emissions from the lungs and skeletal extremities, including the "cross-fire" between organs, is also being made in this case. Ultrasonic measurements of the chest wall thickness (CWT) will be calibrated directly by measuring the physical thickness of the chest wall (removed at autopsy) under the marked detector positions (see photos below).



Template used to mark the position of detectors on the chest, and locations of ultrasonic CWT probe.



Ultrasonic probe measuring the chest wall thickness (3 'spot' measurements per line).

Case 0846 (U.S. Radium Corp. – 1964-7 Chronic  $^{241}\text{AmO}_2$  Inhalation): The Registries' 34<sup>th</sup> whole-body donor passed away in Pennsylvania – at age 72 – again from heart failure. This gentleman, a technician, had been taken to the University of Pittsburgh whole-body counter upon the recommendation of an Atomic Energy Commission (AEC) inspector, who had noted in company bioassay records that “low-level alpha activity” had been indicated in urinalyses. The technician was a glovebox operator who had prepared an estimated 50 pressed gold foils, each containing 200 mg of americium oxide powder – over a 2- to 3-y period – in a process that involved ‘open’ transfer of unsealed materials between glove boxes with only rudimentary respiratory protection. The initial estimate of the  $^{241}\text{AmO}_2$  body burden was about 1  $\mu\text{Ci}$  (37 kBq). The employer then sent the patient to Argonne National Laboratory (ANL), Radiological Physics Division for assessment of the absolute quantity of americium in his body. The ANL measurements indicated a total body burden of 1.8  $\mu\text{Ci}$  (67 kBq), i.e., 36 times the then-recommended maximum permissible body burden (MPBB) of 50 nCi for americium. Such a deposition was projected to possibly deliver tens of thousands of rem to bone surfaces during the remaining lifetime of the patient; and was the highest body content of a radionuclide of the plutonium-americium radiotoxicity family known at that time to have been deposited in a person in the United States (Brodsky and Wald, 2004). Chelation therapy with intravenous Ca-DTPA was started in 1967, and continued through 1974. The patient was followed up extensively by both the ANL and University of Pittsburgh investigators, during and after therapy.

This gentleman first registered with the USTUR in 1995 – as a potential whole-body donor. He was introduced by Dr. Dick Toohey, who had been a lead investigator on the ANL study. The primary medical and health physics records in this case had remained in the custody of the University of Pittsburgh. On being notified by the gentleman's spouse at the time of his death, USTUR sought the collaboration of Drs. Neil Wald, Allen Brodsky and Jerry Rosen (original University of Pittsburgh investigators) and Dr. Dick Toohey (currently of ORAU) to obtain original case records and their special insights and experiences. All willingly volunteered their help.

The Registrant arrived in Richland and, at the suggestion of DOE/HS-13 personnel, USTUR had contacted Dr. Gordon Livingston (Technical Director, Cytogenetic Biodosimetry Laboratory, Oak Ridge Associated Universities (REAC/TS), and Dr. Livingston had agreed to attempt cytogenetic analyses of post-mortem blood in this case. Accordingly, USTUR took two heparinized cardiac puncture blood samples, and shipped these overnight to REAC/TS (Oak Ridge, TN). This procedure had not previously succeeded with post-mortem blood, and unfortunately, the Case 0846 samples did not yield viable lymphocyte cultures either (at 67-h post-mortem). However, for appropriate future cases, both USTUR and REAC/TS are very interested in carrying out cytogenetic biodosimetry studies; using sterile, *in-vivo* blood samples, as allowed in USTUR's current WSU/IRB-approved study protocol.

On the day of receipt of this whole-body donation, a full set of external  $^{241}\text{Am}$   $\gamma$ -emission measurements were made at PNNL's IVRRF laboratory – including chest counts (with ultrasonic CWT measurements), liver counts, and skeletal extremity counts over the forehead, top of the head, wrists, knees and ankles. The figure shows the  $^{241}\text{Am}$  spectrum obtained from a 60-minute count over the chest. Similar spectra (including quantitative determination of the 14-, 17.5-, and 26-keV  $^{241}\text{Am}$  photons) were obtained for all other counting positions.

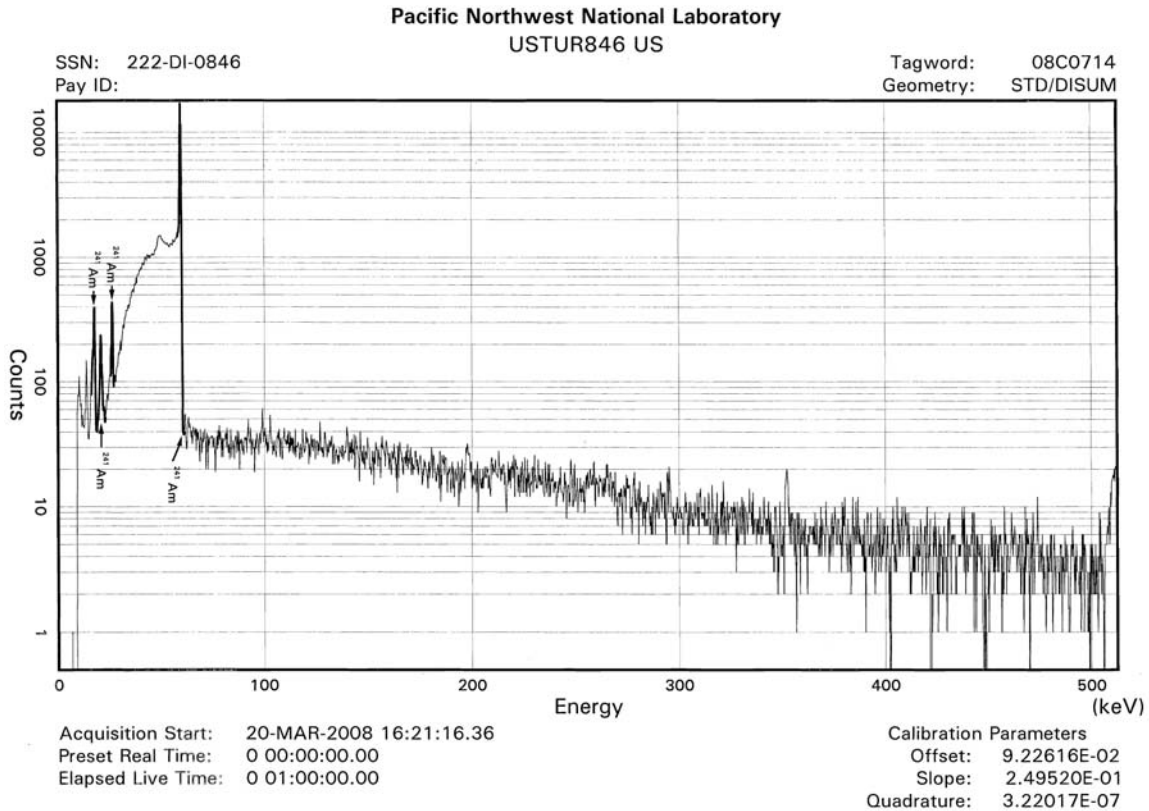


Figure 1. Summed  $^{241}\text{Am}$  photon energy spectrum (60-minute count) from four thin planar germanium detectors placed over the chest of USTUR Case 0846.

Autopsy of this case was carried out next day. In this special case, each of the five separate lobes of the lungs was dissected (by the medical examiner) into its individual segments. All visible tracheobronchial lymph nodes were dissected from each segment. All lung tissue samples and lymph nodes were weighed and fixed in 10% neutral buffered formalin, for future histopathology and autoradiographic study. The larynx, trachea and both left and right bronchial trees (down to about the third airway generation) were also dissected out, and fixed, for autoradiographic study of  $^{241}\text{Am}$  retention in the airway epithelium and walls. Samples of all other major soft tissues were also fixed for histological study. The  $^{241}\text{Am}$  activity in all tissue samples, individual bones, and whole organs, will be counted externally, with quality assurance measurements by  $\alpha$ -spectrometric radiochemistry (and SF-ICPMS). Evidence of pancreatic cancer (apparently non-metastasized) was found at the autopsy, but we await a full autopsy report. Except for the heart, all other soft tissue organs (including the lungs and liver) appeared healthy by visual inspection.

Following the autopsy, the whole body (less the lungs, liver, and other internal organs) was recounted at PNNL's IVRRF laboratory. The chest plate (removed at autopsy) was replaced for these measurements, enabling the "cross-fire" from the rib cage and vertebrae into the lung-counting field to be determined directly.



Two thin planar germanium detectors positioned to count  $^{241}\text{Am}$  activity in the liver of Case 0846 (post-mortem).

Clearly, this case will provide USTUR, DOE, and our national and international collaborators with a unique opportunity to determine the full-lifetime biokinetics of  $^{241}\text{AmO}_2$  inhaled in a form that could well be used malevolently by a 'radiological' terrorist – including the effects of chelation treatment, and the lifetime effects (or lack thereof) of chronic, high  $\alpha$ -dose (accurately determined) on human body organs. Progress updates (on this and other cases) will be posted regularly on USTUR's web site ([www.ustur.wsu.edu](http://www.ustur.wsu.edu)).

#### Reference

Brodsky A and Wald N. Experiences with Early Emergency Response and Rules of Thumb. Chapter 20 in *Public Protection from Nuclear, Chemical, and Biological Terrorism*. Proceedings of the Health Physics Society 2004 Summer School. Madison, WI: Medical Physics Publishing; Pp.335-371; 2004.