*Alpha Contamination Assessment for D&D
Activities: Monitoring Inside Glove Boxes and
Vessels*

RECEIVED

FEB 28 1996

OSTI

Los Alamos
NATIONAL LABORATORY

*Los Alamos National Laboratory is operated by the University of California
for the United States Department of Energy under contract W-7405-ENG-36.*

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Edited by Paul W. Henriksen, Group CIC-1

An Affirmative Action/Equal Opportunity Employer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither The Regents of the University of California, the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by The Regents of the University of California, the United States Government, or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of The Regents of the University of California, the United States Government, or any agency thereof. The Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; therefore, the Laboratory as an institution does not endorse the viewpoint of a publication or guarantee its technical correctness.

*Alpha Contamination Assessment for D&D Activities:
Monitoring Inside Glove Boxes and Vessels*

*Mohini W. Rawool-Sullivan
Richard D. Bolton
John G. Conaway
Duncan W. MacArthur*

Los Alamos
NATIONAL LABORATORY

MASTER

Los Alamos, New Mexico 87545
DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED *M*

ALPHA CONTAMINATION ASSESSMENT FOR D&D ACTIVITIES: MONITORING INSIDE GLOVE BOXES AND VESSELS

by

Mohini W. Rawool-Sullivan, Richard D. Bolton, John G. Conaway, and Duncan W. MacArthur

ABSTRACT

We have developed a new approach to glove box monitoring that involves drawing air out of one glove port through a detection grid that collects ions created in the air inside the glove box by ionizing radiation, especially alpha radiation. The charge deposited on the detection grid by the ions is measured with a sensitive electrometer. The air can be circulated back to the glove box through the other glove port, preventing contamination from leaving the glove box and detector system. Initial experiments using a mock-up constructed of sheet metal indicate that this technology provides the measurement technique needed to perform a defensible, non-invasive measurement of alpha contamination inside glove boxes destined for waste disposal. This can result in an enormous cost savings if a given glove box can be shown to fall into the category of Low-Level Waste rather than Trans-Uranic Waste. Considering that hundreds of glove boxes contaminated with plutonium will be taken out of service at various nuclear facilities over the next few years, the potential cost savings associated with disposal as LLW rather than TRU waste are substantial.

MONITORING INSIDE GLOVE BOXES AND PROCESS EQUIPMENT

Decommissioned glove boxes used for procedures involving nuclear materials must be surveyed for radioactive contamination to satisfy nuclear safety safeguards and waste disposal requirements. Safeguards requirements can be satisfied if the uranium or transuranic element content of the glove box is measured and reported to the nearest gram. DOE Order 5633.3 specifies a measurement uncertainty goal of $\pm 25\%$. In addition, waste disposal regulations define glove boxes with greater than 100 nCi/g of transuranic (TRU) contaminants as TRU waste and glove boxes with less than that amount as low-level waste (LLW).

At Los Alamos, decommissioned glove boxes are frequently cleaned in situ, without being disconnected from the exhaust ventilation system, in preparation for removal, crating, and shipment. Cleaning removes most paint and deposits and is often successful in reducing TRU contaminants to below 100 nCi/g. However, Draft Revision B of DOE Order 5820 requires that any measurement made to establish that a glove box is LLW rather than TRU waste must be made with 95% confidence. Because of the large uncertainty associated with conventional measurement techniques, many glove boxes that meet the definition of LLW may have to be disposed of as TRU waste.

If in situ measurements indicate contamination levels after cleaning are still above 100 nCi/g, further cleaning can be performed. If credible measurements can be performed in situ, glove boxes can usually be cleaned efficiently to LLW levels. Once the glove box is removed from the ventilation system, further cleaning is not possible for safety and economic reason. Glove boxes removed from the ventilation system and determined to be contaminated above LLW levels have been disposed of as TRU waste.

The current cost of disposing of a glove box as LLW is about \$5,000 per glove box at Los Alamos, compared to about \$400,000 per glove box for TRU disposal. Considering that hundreds of glove boxes contaminated with plutonium will be taken out of service at various nuclear facilities over the next few years, the potential cost savings associated with disposal as LLW rather than TRU waste are substantial. Clearly, a nondestructive, in situ method for characterizing the glove boxes would greatly reduce the cost of disposing of glove boxes.

Long Range Alpha Detector (LRAD) technology developed at Los Alamos National Laboratory (LANL) is capable of measuring the low levels of plutonium constituting LLW. In laboratory tests in a 1 m x 1 m x 0.67 m simulated glove box made of sheet metal and safety glass, we have been able to measure contamination as low as 0.0008 nCi/g.

Conventional technologies

Conventional methods for determining contamination levels in glove boxes are based on measuring gamma or alpha emissions from ^{235}U or TRU isotopes. The sodium iodide detectors used are relatively inexpensive, rugged, and are reasonably easy to decontaminate. This method provides good detection sensitivity but requires a nominal deposit-to-detector distance to be assumed. This assumption is violated when the contaminant distribution is non-uniform, which is normally the case, leading to a large potential measurement error. Another gamma-ray

measurement involves positioning the detector outside the glove box and measuring gamma emissions of the entire glove box or large sections of the box. This method is less prone to error introduced by the non-uniform distribution of contaminants but detection efficiency is low and background interference is a major problem. In practice, these approaches are only feasible once the glove box is removed from the work area to a low-background area. If the glove box is then found to be inadequately cleaned to meet LLW limits, as is often the case, the glove box is disposed of as TRU waste.

Alpha particle measurements using both solid-state detectors and gas proportional detectors have been used to assess glove box contamination. Because the alpha particles have limited range, a few centimeters in air, measurements must be performed on the entire interior of the glove box. It is difficult to position alpha detectors in hard-to-reach areas yet these areas are likely to have the highest contamination levels because they are the most difficult to clean. Thus, conventional alpha counting methods are subject to substantial error in practice. LRAD technology^{1,2} provides the measurement breakthrough needed to provide a defensible measurement of alpha contamination inside glove boxes destined for waste disposal.

Laboratory test setup

To investigate the problems involved in glove box monitoring, we used a first-generation glove box monitor and constructed a mockup of a glove box using commercial shelving brackets and sheet metal; the dimensions were 1 m x 1 m x 0.67 m. One of the 1-m box surfaces had two 8.9-cm (i.d.) holes cut into it to represent glove ports. On one of these glove ports we mounted an LRAD airflow monitor similar to those used in investigating pipe contamination. The detector was cylindrical, 15 cm long by 8.9 cm in diameter, and was backed up by fans that pulled air out of the glove box through the detector. The fans were attached to a variable power source. The detector had a single detection grid kept at +300 V. On the second glove port we attached an electrostatic filter to prevent ions in room air from entering the glove box.

In the final version of the detector, we envision that the air stream drawn out of one glove port through the detector will be returned to the glove box through the adjacent glove port, thus preventing contamination from leaving the glove box and detector system. A conceptual drawing of this arrangement is shown in Fig. 1.

Response of glove box monitor to various air-flows

For this test we used a nominal 125,000 dpm (56 nCi) ^{238}Pu source. The net weight of the test glove box was 70 kg, which meant that we were looking at a contamination level below 0.001 nCi/g. To qualify as low-level waste, a glove box must register alpha activity of 100 nCi/g or less. To simulate contamination at this level would require a 1.6×10^8 dpm (1200 nCi) source in our test glove box.

Figure 1: Drawing of final glove box monitor.

On each of the six interior surfaces of the glove box we chose five positions to place the radioactive source, as shown in Fig. 2. The "front" surface refers to the side of the box with the glove ports, as shown in Fig. 1. "Right" and "left" are from the point of view of a person standing in front of the glove box as if it were in use.

Figure 2: Location of the source positions when looking at the surface from inside the box.

The fan shown in Fig. 1 was attached to a Variac. In these experiments we were not equipped to determine air velocity, so air velocity is represented here qualitatively by the Variac settings. We made measurements at three different Variac settings, 30, 50, and 80. The response from each of the five source positions on the left surface is shown in Fig. 3.

Figure 3: Response of the glove box monitor to the source (0.001 nCi/g) at the five locations on the left surface, as shown in Fig. 2.

From Fig. 3 one can see that for a contamination level of 0.001 nCi/g we measured detectable current well above background at all source positions and the response for a given position varied as a function of air speed. At a Variac setting of 50, the overall response seems to have evened out compared to a setting of 30, i.e., the difference between the largest response obtained and the smallest response was less for a setting of 50 than for 30. At the higher setting of 80, the response was generally below or equivalent to the response obtained at 50. It appears likely that air flow at a setting of 80 was turbulent. Data obtained using sources on each of the other five surfaces of the box were similar.

We tried directing the air flow in the glove box because we were convinced that the large variation in response as a function of source position described above could be reduced with some refinement of our approach. A pipe 5 cm in diameter and about 1 m in length was used to direct air inside the glove box. The end of this pipe was left open outside of the glove box while the inside end had an empty soft drink can attached to it with its solid bottom end pointing toward the back wall of the glove box, thus forming an enclosed volume. Along the length of the can, a hole was cut out to form an air nozzle 1 cm wide and 6.2 cm long. The air pipe could be moved in and out and nozzle alignment marks were made such that the nozzle could be aligned from 0° to 360° around the length of the air pipe.

The source was located on the top surface at position #2, which is the general direction when the Coke can is in the back position with its nozzle pointed at 45°. In our earlier tests (without directed airflow) at this position, the maximum response measured was 863 (± 61) fA above background. With directed airflow, this response was improved to 2567 (± 17) fA above background. Measurements made with the source at position #4 on the right wall found similar results. It appears that directed airflow will help equalize instrument response for sources in various locations.

Source response in a glove box with a glass window

All of the experiments described above were made using an all-metal box as a mockup for the glove box. Because most glove boxes have a safety glass window and nonconducting materials such as safety glass can sometimes affect LRAD measurements, we added a safety-glass window to our mockup glove box and carried out a series of tests to determine if this affected the results. We did not see any loss of signal that could be attributed to the presence of the glass window.

Effects of Lexan™ on detector response

To investigate the effects of Lexan on the response, we replaced the safety-glass window with a sheet of Lexan. A source was placed on the bottom surface in the five locations shown in Fig. 3. The responses were lower in all cases than in earlier experiments. In particular, there was no response at all whenever the source was placed near the Lexan wall. This is because Lexan acts as a sink for ions, giving an overall lower response and no response whatsoever when ions are generated near the Lexan wall. Similar observations were made when tests were conducted with sources on the other glove box surfaces.

To see what would happen if we increased the strength of the source, we used refills of a StaticMaster™, each of which has a nominal 500- μ Ci activity from ^{210}Po . In our glove box mock-up, this activity is equivalent to a contamination level of 7 nCi/g. When we put a StaticMaster refill at location #3 next to the Lexan wall on the bottom surface we did not obtain any response using a 125,000-dpm source.

The instrument response to the 500 μ Ci ^{210}Po source is shown in Fig. 4 as a function of time. It took about two hours after the source was placed in the box for the response to level off at 5000 fA. This long rise time was due to the charging of the Lexan wall, which finally became saturated with ions. The response returned to the background level of about 160 fA when the source was removed.

Although we failed to detect contamination at the previous 0.001 nCi/g level when one wall of the glove box was made of Lexan, we detected contamination at a level of 7 nCi/g, which is still well below the government guideline of 100 nCi/g.

Figure 4: Response of the glove box monitor to the 500- μ Ci source plotted against time in minutes. The source was placed at location #3 on the bottom surface.

Conclusions

Our preliminary tests indicate that ion-transport technology, once fully developed, will provide a defensible way of measuring contamination within glove boxes and other enclosed volumes. Federal government guidelines require that we be able to measure contamination at the level of 100 nCi/g. Our test results show that we can actually measure much lower levels of contamination. Glove box monitors based on ion-transport technology can operate *in situ* and are nondestructive. They can give results in real time, which will enable the user to get immediate feedback on how well the decontamination of a glove box is proceeding. With these monitors it will also be possible to locate hot spots by making measurements as various surfaces inside the glove box are covered.

References

- {1} J. G. Conaway, M. W. Rawool-Sullivan, and D. W. MacArthur, "Alpha Contamination Assessment for D&D Activities, Part 1: Technology Overview," Los Alamos National Laboratory report LA13062-MS (February 1996).
- {2} D. W. MacArthur, K. S. Allander, J. A. Bounds, K. B. Butterfield, J. L. MacAtee, "Long-Range Alpha Detector," *Health Physics* **63**, 324-330 (September 1992).

This report has been reproduced from the
best available copy.

It is available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62,
Oak Ridge, TN 37831.
Prices are available from
(615) 576-8401.

It is available to the public from the
National Technical Information Service,
US Department of Commerce,
5285 Port Royal Rd.,
Springfield, VA 22161.

Los Alamos
NATIONAL LABORATORY

Los Alamos, New Mexico 87545