

Overview: AFCI Glovebox Incident

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The INL is a U.S. Department of Energy National Laboratory
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Background: One of the primary INL missions is to support development of advanced fuels with the goal of creating reactor fuels that produce less waste and are easier to store. The Advanced Fuel Cycle Initiative (AFCI) Glovebox in the Fuel Manufacturing Facility (FMF) is used for several fuel fabrication steps that involve transuranic elements, including americium. The AFCI glove box contains equipment used for fuel fabrication, including an arc melter – a small, laboratory-scale version of an electric arc furnace used to make new metal alloys for research – and an americium distillation apparatus.

This overview summarizes key findings related to the investigation into the releases of airborne radioactivity that occurred in the AFCI glovebox room in late August and early September 2014. The full report (AFCI Glovebox Radiological Release – Evaluation, Corrective Actions and Testing, INL/INL-15-36996) provides details of the identified issues, corrective actions taken as well as lessons learned.

On Sept. 24, 2014, transuranic material was discovered on air filters collected from the Advanced Fuel Cycle Glovebox Room the previous month. “Delayed” counting of air samples from radiological monitoring equipment is standard and conducted at least seven days after being collected. That allows naturally-occurring radon/thorium isotopes time to decay for more accurate readings.

Transuranic material found outside the glovebox indicates a problem with the equipment. The glovebox is constantly under negative pressure and any leakage would be from the outside in, not the inside out. As a result, it would require a leak path in combination with a pressure reversal to push the material outside the glovebox.

Immediately that day, Radiological Controls and Fuel Manufacturing Facility management (FMF contains the glovebox and is located within the Materials and Fuels Complex) responded by designating the enclosed room as an airborne radioactivity area (ARA). That designation required everyone entering the area to wear protective equipment and respirators.

Bioassay samples were collected from 15 workers to gauge worker exposure. Battelle Energy Alliance’s Office of Nuclear Assurance initiated an investigation, whose findings and the subsequent system testing documentation were peer-reviewed and finalized in December 2015. The technical report on the incident accompanies this summary.

No adverse health effects among workers are expected. Bio-assay results indicated nine workers had low levels of internal contamination, with americium as the primary isotope. The nine individuals who had uptakes received doses ranging from 2 millirem to 85 millirem. Under federal law, bioassay monitoring is not required for individuals expected to receive less than 100 millirem per year on the job.

For perspective, an individual can be exposed to 14 millirems by smoking a cigarette and 10 to 20 millirems getting a chest X-ray. Between medical and natural radiation, the average American receives about 620 millirem per year.

Bioassay samples were also obtained from six random personnel who entered the FMF facility during the Aug. 26-28, 2014 timeframe. No internal doses were found in any of them.

The INL Office of Nuclear Assurance investigation identified two primary causes for the Sept. 24, 2014 discovery:

- The AFCI Glovebox confinement was compromised. That provided a pathway for airborne contamination releases, “particularly when arc-melting activities with transuranics containing americium (Am)-241 were performed,” the report said.
- The continuous air monitors (CAMs) located in the AFCI enclosure did not correctly identify AM-241.

To further elaborate, we refer to section 7.3 (page 33) of the report detailing the investigation by the INL Office of Nuclear Assurance of this incident:

AFCI Glovebox Radiological Release – Evaluation, Testing and Corrective Actions

The AFCI glovebox is used to produce transmutation fuel samples (which include americium) through arc melting and to purify metallic americium through the americium distillation operation. Although the distillation process is a closed system the arc melting process is open to the glovebox atmosphere. Americium has a very high vapor pressure and as such during these operations, particularly arc melting, it is likely that some small amount of americium is volatilized and is spread into the glovebox atmosphere. The high vapor pressure of americium is unique among the actinide materials therefore the transport of the metallic sub-micron sized particles is not well known or documented. It is suspected that the small leak points in the glovebox confinement system allowed the americium metallic sub-micron sized particles to escape but did not allow other forms of contamination to escape under other operating conditions. It is also suspected that the sub-micron sized particles remained airborne and were pulled into the AFCI enclosure exhaust ventilation.

To fix the problem and prevent it from reoccurring, a thorough investigation was undertaken. FMF facility logs for Aug. 26-28, 2014 were reviewed, and no unexpected readings within the glovebox were identified. The report said that the cycling of the glovebox atmosphere to remove oxygen “could mask a slow leak into the glovebox.”

A series of exploratory tests were conducted over several months, during which the AFCI enclosure remained posted as an ARA, requiring workers to wear protective gear and respirators. Helium-leak testing, standard in the nuclear industry, revealed four leaks on July 28, 2015. Those leaks were repaired Aug. 11, 2015. A second leak check revealed two more leaks

on Aug. 17, 2015. Those were repaired. A follow-up helium leak test on Aug. 24, 2015 revealed no leaks. Additional testing and monitoring discovered no issues.

The ARA designation was removed, and the glovebox has been operating well under normal circumstances. Corrective actions to mitigate reoccurrence of the confinement breeches were implemented. These include more frequent helium-leak testing; replacing bellow pumps on the oxygen analyzer system every three years; and annual replacement of filters.

Extensive discussions were held with the continuous air monitor vendor and software upgrades were installed. The continuous air monitor alarm systems are now more sensitive and more reliable for detecting americium at the very lowest levels.

Conclusion: INL prioritizes worker safety. APCI glovebox containment is sound, and is continuously maintained and evaluated. The glovebox monitoring equipment is checked, verified and will consistently be able to identify americium. The best outcome is that none of the INL employees was injured or is expected to suffer any adverse health effects. INL's mission to help secure national security and advance clean energy research is possible only if INL employees know their safety is our No. 1 concern.

INL is also committed to being open and honest with the citizens we serve, those taxpayers who enable INL's important work. The attached technical summary contains detailed technical information which has been shared with other glovebox owners and operators so that any future incidents involving other gloveboxes can be identified and resolved promptly.