

NIST Special Inspection of Possible Overexposure from Am-241

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Region I

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Am-241 Incident

NIST – Gaithersburg, Maryland Campus



Am-241 Incident Timeline

8/9/17 – NIST performs routine leak testing; cannot find Cf-252 source supposed to be in B143 storage area.

8/10/17 – NIST performs out-of-cycle physical inventory looking for Cf-252 source; all source 'owners' involved.

8/11-17 series of unusual leak test results, hand/foot monitor alarms in area including B143.

8/14/17 reported to NRC that a Cf-252 source was lost; source had been stored in Building 245, Room B143.

Am-241 Incident Timeline (cont'd)

8/16/17 reported to NRC that the Cf-252 source was found in Room B143.

8/17/18 while investigating leak test/contamination issues, identify problem in “cave” storage area for high activity sources, in B143.

8/18/17 RWP developed for entry to determine scope of problem in B143.

8/18/17 date of discovery.

Am-241 Incident Timeline (cont'd)

8/19/17 reported to NRC occurrence of unplanned contamination event in Room B143 due to broken vial of Am-241.

8/22/17 determines bioassay may be needed.

9/6/17 updates report to NRC that potential doses from uptake are in 10-100s of rem.

9/13/17 NRC site visit.

9/26/17 start of NRC full inspection.

Am-241 Incident Timeline (cont'd)

September 2017 – April 2018, NIST performs:

Extent of contamination surveys with assistance from DOE RAP team;

Bioassay of potentially exposed persons (more later) with assistance from REACTS;

Root cause investigation of both events;

Updates to NRC, including bioassay data; and

Weekly NRC/NIST calls to review information.

5/8/2018 NRC inspection exit.

Am-241 Incident: Source Overview



1.3 mCi Am-241

4.48 mL vial

1 molar hydrochloric acid

Am-241 Incident: Source Overview (cont'd)

5 mL flame-sealed borosilicate glass ampoule was used.

Stored sealed for 12 years.

Alpha decay of the Am-241 source produced sufficient hydrogen gas (H_2) during that time to result in an internal pressure of 25 atm.



Am-241 Incident: Source Rupture



Discovered August 18, 2017

Am-241 Incident: Annual Limit of Intake (ALI)

It is all about the ALI

Radioisotope	Inhalation ALI (uCi)
H-3	80,000
C-14	2,000
F-18	70,000
P-32	900
Am-241	0.006

1.3 millicuries of Am-241 is 2.2×10^5 ALIs

Am-241 Incident Discovered

Alpha contamination first discovered August 17, 2017.

Ruptured source discovered August 18, 2017.

Five (5) workers sent for in-vivo and urine bioassay results.

Work restricted in area starting August 19, 2017.

NRC notification made following positive urine result.

Am-241 Incident: Employee of Greatest Concern

Not big on disposable gloves.

Not a fan of extensive monitoring or frisking.

Lab coat often not worn properly.

Ate lunch every day at desk.



Am-241 Incident: Bioassay

Based on 1st in-vitro (urine) bioassay result

Intake date unknown

Ingestion could not be ruled out

CEDE = 120 rem (limit 5 rem)

CDE = 2200 rem to bone surfaces (limit 50 rem)

Am-241 Incident: Bioassay Measurements

Walter Reed Lung Scan (<MDA)

LLNL Whole Body Count (<MDA)

Results below MDA does not equal zero dose

34 rem whole body

615 rem bone surfaces

Am-241 Incident: Bioassay Measurements (cont'd)

Total 18 urine bioassay results.

One fecal bioassay result.

Four DATP treatments September 9-12, 2017

Later results were 2-3 order of magnitude lower than would have been expected from initial assumptions, and continued to drop more than expected.

Am-241 Incident: Intake Modeling

Intake modeling used to determine intake pathway, intake date, and intake quantity

Pathways = defines curve shape (multiple exponential functions)

All three are needed to determine doses:

Ingestion, inhalation, wound/absorption

Intake date = starting point

Intake quantity = amplitude

Am-241 Incident: Ingestion Intake Modeling

For Am-241 and other bone seekers, there is a very fast drop in activity in excreta and a plateau is expected within a week.

Most of the activity leaves the body early, primarily in feces.

A small fraction is transferred to the blood from the digestive tract, which in turn leave in the urine or plates on the bone surfaces.
(to a lesser extent on some other organs as well, like the liver)

After approximately one week, most of what remains is at the target organs. The only excreta observed is from small amounts resuspending into the blood and excreted primarily through urine.

Overwhelmingly, the long term retention is where the dose comes from.

Am-241 Incident: Inhalation Intake Modeling

Inhalation is similar to ingestion, but a plateau isn't achieved until 2-3 weeks following intake.

Intake route is slower than ingestion through lung surfaces, plus a small portion may return to the mouth and result in a later ingestion.

A larger percentage of the excreta will be through urine as opposed to the feces, because the digestive tract is less involved.

Am-241 Incident: “Wound” Intake Modeling

Wound modeling considered counter-intuitive to inspection team, initially.

NIST’s consultants considered it reasonable and likely.

NIST inspection team reviewed NCRP Report No.156,
Development of a Biokinetic Model for Radionuclide Contaminated Wounds and Procedures for Their Assessment, Dosimetry and Treatment





Am-241 Incident: NCRP Report No. 156

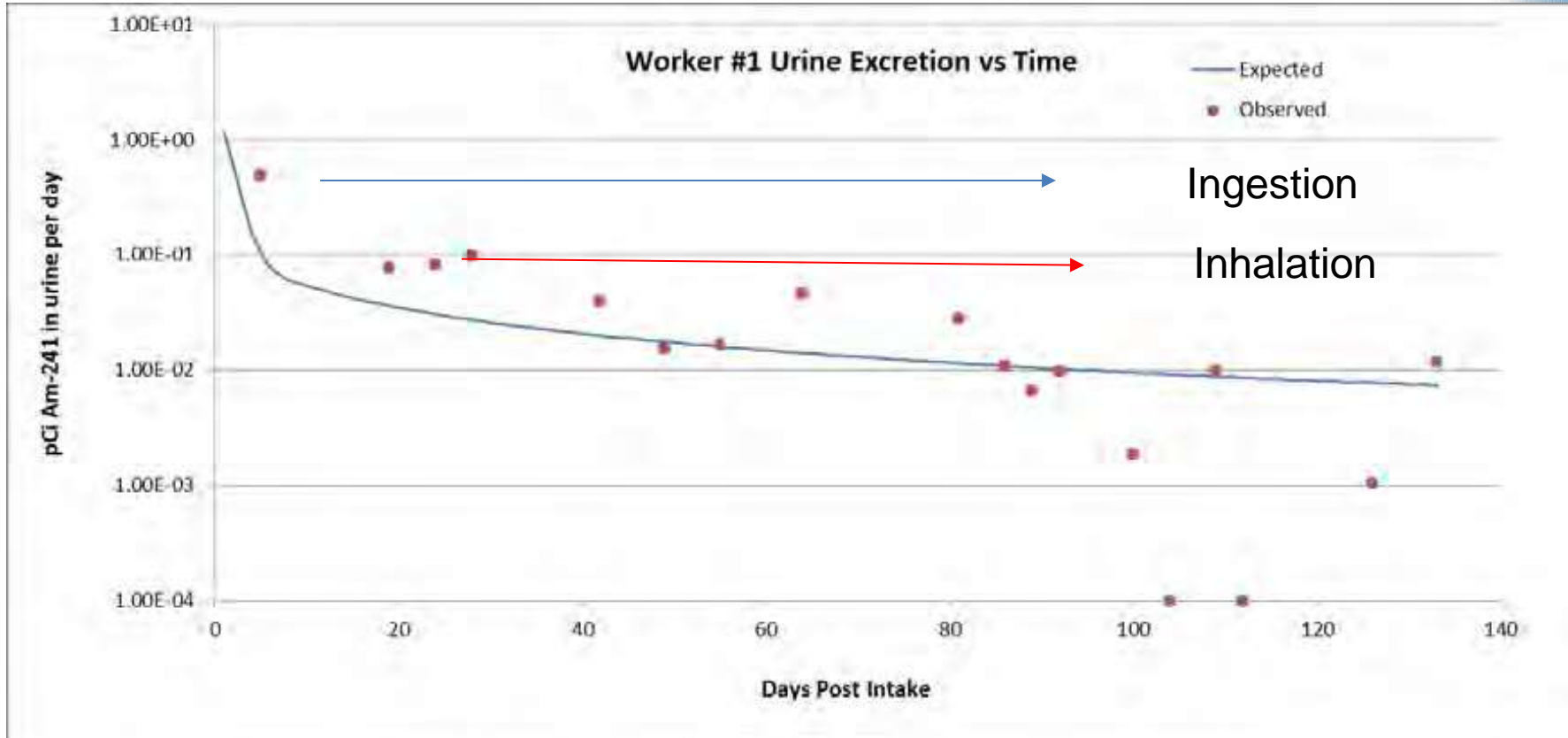
Allows for intakes through lacerated, abraded, and intact skin (absorption).

Inspection team determined that an absorption through intact skin, injection through small shards of glass, or intake through abraded skin were all possible.

Four retention models (Weak, Moderate, Strong, Avid) allow for different intake rates from a “reservoir” of activity.

Am-241 most commonly strongly-retained, which would account for a slower drop in urine bioassay results.

Am-241 Incident: Bioassay Graphics (Log Scale)



Am-241 Incident: Intake/Dose Conclusions

Strongly-retained wound

56 pCi of Am-241 on August 17, 2017

CEDE = 157 mrem

CDE = 3.68 rem (Bone Surfaces)

ICRP 30 dose coefficients

ICRP 26 tissue weighting factors

Am-241 Incident: Conclusions

In-Vitro vs. In-Vivo Bioassay for Alpha Emitters

Timeliness of Bioassay Sampling

Less than L_c doesn't necessarily mean no dose

Am-241 Incident: ALARA Regulation

10 CFR 20.1101(b) requires, in part, the licensee shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses that are as low as reasonably achievable (ALARA).

Questions

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