Update on M&C Exposure Pathway Modeling

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SC&A action items

- Reconsider NIOSH Building 10 subsurface one-to-one model (thorium issue)
- Reevaluate how burial ground data are used in modeling
- Explore if current ingestion model accounts for glove use

Subsurface indoor: Approach to internal dose

- Model:
  - Soil contains 6,888 pCi/g uranium (U) (95th percentile of pipe scale sampling)
  - Dust loading equal to 95th percentile Mound air sampling
  - 2 months per year
- Data:
  - 1995 Weston study to characterize drain lines
  - 20 sediment samples analyzed for isotopic uranium
  - Additional 1995 samples taken from priority 2 and 3 lines omitted

Subsurface indoor: Thorium

- No thorium (Th) or gross alpha measurements subsurface in Building 10
- NIOSH model assumes equivalent amounts by weight of natural U and Th-232
  - Documentation shows U operations far exceeded Th
  - No evidence suggests that equal weights of Th should be expected when U is present
  - Insufficient information to establish that it could not be that high
  - Cannot rule out a 1:1 mass ratio of U to Th; the approach is claimant favorable

Subsurface indoor: Concerns

- Representativeness of samples
  - Impossible to quantify potential pipe dilution over time
  - Coagulants may have concentrated some of the contamination into specific areas
  - Based on the available data:
    - May be possible to potentially bound the exposures such that workers are unlikely to receive a higher dose in the aggregate over the course of a year
    - Small fraction of pipes deemed contaminated
    - All materials below slab, both inside and outside pipes, assumed to be contaminated at 95th percentile activity
  - Examples of other residual period comparisons include Linde and Chapman Valve

Finding 1:

Building 10 subsurface external exposures not bounded

SC&A finds that NIOSH's proposed external dose rate assumptions are inconsistent with the contamination levels assumed for the subsurface of Building 10. SC&A's independent calculations suggest dose rates from the modeled pathway are expected to be substantially greater. NIOSH's 2017 SEC ER proposed using the 95th percentile dosimetry values (with adjustments for missed dose) of 200 mrem/year (16.7 mrem/month). SC&A believes it is more appropriate to assign elevated subsurface exposures inside Building 10 using the 95th percentile of the dosimetry with occupancy adjustments.

Subsurface indoor: Dust loading concerns

- October 15, 2020: NIOSH interviewed a subject matter expert (SME) about a Mound air sampling study for use as a surrogate modeling parameter
- May 20, 2021: Representatives of work group, NIOSH, and SC&A participated in reinterview of SME

Dust loadings: Surrogate data criteria

1. **Hierarchy of data:** No covered bioassays or air monitoring data exist to take precedence over Mound data.
2. **Exclusivity requirements:** The WG has deemed remediation air sampling data not applicable.
3. **Temporal considerations:** The Mound excavations occurred in 1996, while M&C excavations occurred from 1968 through 1996. The passage of time has not significantly altered backhoe operations, hand digging, or their ability to generate airborne dust.
4. **Plausibility:** The dust loading data have a range consistent with values expected from general excavation activities.
5. **Site and process similarities:** Outdoor and indoor dust loading during excavation activities apply to these same activities as those at M&C and might be considered generically applicable to outdoor and indoor excavation activities. However, for both indoor and outdoor excavation activities, there are likely many site-specific characteristics that can uniquely affect dust loadings, including the characteristics of the soil and the proximity of workers to the excavation activities. Very little can be done to accommodate these types of site-specific characteristics, except to use a degree of **professional judgement** on the applicability of data to place an upper bound on the dust loading factor.

Subsurface outdoor: Approach to internal dose

- Model:
  - Soil contains 117.86 pCi/g U (95th percentile soil samples)
  - Soil contains 87.5 pCi/g Th (95th percentile soil samples)
  - Dust loading equal to 95th percentile Mound air sampling
  - 2 months per year
- Data:
  - 2,391 soil samples collected prior to remediation in 1980s and 1990s
    - 1,629 samples were analyzed for gross alpha
    - 762 samples were collected for U and Th and analyzed using isotopic identification

Subsurface outdoor: Work group concerns

- "Debris buried in the burial site was not representative of radioactive materials (U and Th) handled throughout the AWE operational period (1952-67), but was a selective sample of those materials, largely from 1958-1961" (NIOSH, 2021a, p. 2).
  - Data do not represent entirety of operations
  - Do represent material present during residual period in the burial site
  - Ratios of U to Th not being used to establish Th concentrations indoor

Subsurface outdoor concerns: 1968 soil disturbance

Soil grading in 1968 following the construction of Building 12

- Dates of soil grading unknown but early in the residual period (began January 1, 1968)
- Any materials dispersed in 1968 throughout the site would be the same materials that workers were exposed to during the remainder of the residual period
- Disturbance happened early in the residual period; soil sampling from the burial area in the 1980s and 1990s could be considered representative of potential exposures encountered by maintenance workers

Subsurface outdoor concerns: 1980 soil disturbance

Installation of the compressed airline in August 1980

- According to a 1981 NRC inspection report (NRC, 1981, PDF p. 128), the area that was dug up was “slightly contaminated” and “a trained health physicist, surveyed the material dug up and placed any contaminated materials into 55 gallon drums. Eleven 55 gallon drums were sent to . . . Barnwell, South Carolina.”
- Remaining soils reburied (area later resurveyed and found to be below NRC release criteria).
- Burial area large compared to the small volume displaced by trench.
- Unlikely disturbance altered the distribution of materials in the burial grounds significantly enough to make later surveys not representative of the earlier exposure potential.

Subsurface outdoor concerns: Occupancy

"NIOSH will assume an occupancy rate of two months per year for subsurface work (2000 hours per year x 2/12 {fraction of year} = 333.33 hours per year). If the subsurface work area (e.g., inside or outside) cannot be determined, the most claimant-favorable work location will be assigned" (NIOSH, 2021b, p. 14).

Observation 1: SC&A reviewed the claimant interviews and does not believe that there is sufficient evidence to limit any individual's subsurface exposures to a single subsurface scenario. The interviews indicate that, irrespective of an individual's job title, they may have been asked to complete any task on site. SC&A believes that means an individual could have participated in both indoor and outdoor subsurface scenarios within a year.

Roof and overhead: Approach to internal dose

- Model:
  - 95th percentile removable contamination level of 8.99 dpm/100 cm^2
  - resuspension factor (RF) of 10^{-5} per meter
  - a breathing rate of 1.2 m^3/hr
  - 1 month per year
- Data:
  - 285 grid average alpha surveys
  - Surveys were completed by Texas Instruments (TI) in 1982 in support of license termination
  - Completed before the positive temperature coefficient powder explosion (believed to have occurred in the late 1980s or early 1990s)
  - Subsequent cleanup activities would not likely impact results

Roof and overhead: Roof weathering concerns

- Only 40 of 285 measurements used were from the roof
  - Measurements were taken radially around exhaust pipes (no prior cleaning)
  - TI noted that exhaust from fuel monitoring area showed essentially background radioactivity in the air being discharged
  - Assuming 10 percent removable contamination: direct survey of 2.6 dpm/100 cm^2 and a 95th percentile of 29.0 dpm/100 cm^2 (roughly double the amount modeled by NIOSH for the aggregate roof and overhead model)
  - Weather effect: Reasonable to assume source term depletion occurred over ~14 years of the residual period
  - Suggests roof not bounded by combined model but doses still <1 mrem in 1982
- 1982 NRC: “Fixed and removable contamination levels measured during the inspection are comparable to those in the licensee’s close-out survey” (NRC, 1982, PDF p. 25)

Welding: Approach to internal dose

- Model:
  - Source term: 89.94 dpm/100 cm^2 (95th percentile measured contamination)
  - Resuspension factor: 10^{-3}/m
  - Exposure time: 48 hours/year
- Data:
  - identical to the 1982 data used in the roof and overhead but assumes 100% removable contamination

Welding: Work group and SC&A concerns

- SC&A raised a concern (finding 2) in its 2019 and 2020 reviews of welding and thorium activities that a resuspension factor of 10^{-3}/m may not be adequate to represent the dust generated by grinding and wire brushing to prepare a surface for welding
- Echoed by the WG during September 2, 2020, WG meeting
- To date, this issue has not been resolved
- Likely a “TBD issue” rather than an SEC issue

HVAC maintenance

- Model:
  - Source term: 1.23 x 10^{-4} dpm/µg
  - 10^{-5} resuspension factor
  - Specific airborne contamination: 100,000 µg/m^3 dust loading in vent
  - 1 hr/year (standard breathing rate of 1.2 m^3/hr)
- Data:
  - 7,765 gross-alpha swipe data collected near the end of Atomic Weapons Employer (AWE) operations in 1966 and 1968
  - Represents removable contamination found at the site at the end of operations
  - End of the AWE operations period:
    - Non-HFIR areas were cleaned and released for use
    - Cleaning would be expected to reduce the contamination during the residual period

Remaining (non-maintenance)

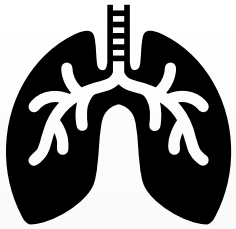
- Represents remaining work in generally accessible parts of the site
- Model:
  - Source term: 12.3 dpm/100 cm^2
  - Source term depletion per ORAUT-OTIB-0070
  - Balance of year (1,451 hours)
- Data:
  - 7,765 gross-alpha swipe data collected at the end of AWE operations in 1966 and 1968 (identical to HVAC model data)

Summary of modeled internal dose pathways

Model	Year of measurements used in model	Uranium internal dose (mrem) *	Thorium internal dose (mrem) *
Subsurface inside	1995	17	29
Subsurface outside	1980s and 1990s	<1	2
Roof and overhead	1982	<1	<1
Welding	1982	6	17
HVAC	1966 and 1968	<1	<1
Remaining	1966 and 1968	<1	1

* Modeled internal doses shown are committed effective doses provided for comparison. Under the EEOICPA, annual organ doses are assigned.

OCAS-TIB-009 ingestion modes



- Mode 1: Inhaled materials caught in mouth, throat, and lungs are removed by normal lung function to gastrointestinal tract

- Mode 2: Material in air settles onto food and drink and is later ingested

- Mode 3: Material is transferred from contaminated surfaces to hands and is subsequently ingested

Does TIB-009 model account for ungloved hands?

- Yes, Mode 3 includes inadvertent hand-to-mouth ingestion
  - Applies to the transfer of material from contaminated surfaces to the hands
  - Covers ingestion from using contaminated hands to
    - eat,
    - drink, and
    - smoke

References

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