Review of Overall NIOSH Response and SEC Issues under Consideration for M&C

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Chronology

- **March 3, 2022:** M&C Work Group tasked SC&A to focus on any remaining lines of inquiry or outstanding issues relevant to work group's review of SEC-00236 evaluation report
- **August 22, 2022:** SC&A issued supplemental review based on:
  - Record of work group discussions
  - Former worker input
  - Supporting NIOSH and SC&A reports, responses, white papers, and presentations
- **January 13, 2023:** NIOSH issued response paper to SC&A's supplemental review
- **April 25, 2023:** SC&A issued review of NIOSH response
- **May 12 and July 13, 2023:** M&C Work Group meetings
- **August 22, 2023:** NIOSH issued response to SC&A's April 2023 review

SC&A supplemental review: Findings and observations

- **Finding 1:** The back application of a high 1995 sediment survey result to bound inside subsurface activities is not adequately supported by information for M&C worker activities from the earlier residual period.
- **Finding 2:** The application of surrogate data from the Mound project to provide a dust-loading factor for M&C activities does not satisfy the Board's surrogate data policy.
- **Observation1:** The use of blended D&D characterization survey data from 1984 and 1992 to support a bounding dose for outside subsurface activities may not be necessarily bounding for work in nonuniform soil contamination, given the presence of hot spots that existed during the residual period at M&C.
- **Observation 2:** References to the M&C safety and health manual, NRC inspection results, operator training, and other programmatic considerations do not necessarily substantiate the conservatism of the 95th percentile soil contamination value being applied.

Intrusive nature of M&C maintenance work

- M&C maintenance activities were unique in terms of their level of intrusiveness (excavations, pipe cleaning, pipe cutting), work environments (confined spaces), and uncertain or unknown source terms (contaminated pipe sediments and scale, presence of coagulants, repurposed equipment).
- Like Linde Ceramics, M&C better fits "building renovation" scenario under NUREG/CR-5512 (NRC, 1992) than it does "building occupancy" scenario that typifies OTIB-0070 resuspension assumptions for other AWEs.
- NIOSH responds that "intrusiveness" should be judged "applying standard industrial hygiene or nuclear industry resuspension factors to a source term" and that the "source term at the Linde Ceramics Plant was considerably larger than M&C's" (NIOSH, 2023a).
- SC&A agrees M&C dose levels are relatively low compared with some SEC sites but are comparable to others (e.g., Pantex, Blockson, Sandia).

Concern with subsurface inside bounding concentration: Presence of coagulants

- A vegetable-based mineral oil that was used in Building 10 for drawing wire had the properties of a coagulant. Upon discharge to the drainage system, M&C workers found it would frequently “plug up the drains” (ORAUT, 2017).
- The discharged oil may have consolidated and concentrated drainpipe sediments, including existing AWE uranium and thorium.
- **Question:** During active Building 10 operations (through 1981), would regular releases of coagulants have led to more frequent and substantial blockages, involving elevated uranium and thorium as a function of the consolidation properties of the coagulant oil on sediments?

Presence of coagulants: NIOSH updated (August 2023) response

- As part of TBD updating, NIOSH will:
  - Identify locations of wire machines in Building 10 and overlay their locations above the drain lines to indicate distance from Priority 1 drain lines.
  - Mark up drain lines with flow paths to determine which lines were downstream of coagulant sources
- NIOSH will also consider that:
  - Weston could have noted and collected coagulant when they characterized drain lines
  - Airborne hazard associated with cleaning clogged pipes minimal because material was wet; coagulants functioned as glue, reducing resuspension and respirability of source term
  - No information found in literature supporting solvent properties of vegetable/mineral oils that made up coagulant
- NIOSH determined it can bound exposures associated with unclogging pipes while accounting for effects of nonradioactive coagulant to the drain line source term

Presence of coagulants: SC&A response

- Whether or not Weston would have identified and collected coagulant during characterization does not comport with coagulant mechanism: They are substances that serve to neutralize normally repulsive electrical charge of sediments in solution such that they can consolidate, forming floc.
- Coagulants are not “sticky” or function as “glue” (NIOSH, 2023b).
- Whether specific coagulant involved had “solvent” properties is speculative: Specific chemical and physical properties of coagulant, fixed contamination, and liquid within drain pipes are not known.
- **However, what is clear:** During M&C residual period, drain pipes contained both in-solution suspended sediments and fixed sediment contamination of varying degrees, for which regular introduction of oil-based coagulant was know by M&C workers to cause the blockage of drain pipes, requiring cleanout.
- SC&A concludes that presence of coagulant oils within the M&C drainage system may have led to increased concentrations of uranium- and thorium-contaminated sediments for which upper bound exposure estimates may not be feasible.

Concern with aerosolization of contaminated scale

- Accumulation of contaminated scale on inside of piping confirmed, with one survey of interior surface contamination exceeding 1,000,000 dpm/100 cm^2 for a 4-inch vitreous clay mainline drain being cut and removed.
- During M&C residual period, drain pipes were frequently cut, repaired, replaced, and cleaned out, using power tools such as saws, drills, grinders, and powered snakes, as well as cutting torches.
- As noted by DOE in its hazard assessment of Bridgeport Brass AWE, "the residual uranium could eventually be released . . . through intrusive work activities such as pipe cutting and removal," and that "it is possible that under certain conditions (such as cutting through a steel pipe with a cutting torch) surface activity attached to the steel could be released with the steel particles" (DOE, 1996).
- Such pipe cutting may have released fine aerosols that would have been concentrated by the confined space (trenches, pits) atmospheres where such work was performed.

Aerosolization of contaminated scale: NIOSH updated response

- NIOSH considers snap cutting or sawing more routine than torch cutting of steel pipes.
- NIOSH did not select cutting of drain lines as a bounding scenario for M&C, in contrast to the Bridgeport Brass hazard assessment concern with cutting of steel drain lines.
- NIOSH reviewed the exposure assessment in DOE's model and found that the ratio of assigned doses to source term level for Bridgeport Brass compares favorably to M&C.
- NIOSH notes that the 1,000,000 dpm/100 cm^2 was not for "scale" but for interior pipe surface contamination, and that it was for a vitreous clay pipe, not cast iron. NIOSH notes that scale and rust are associated with cast iron pipes.
- Regarding whether contaminated scale deposits are an isolated or systemic source term, NIOSH "relies on available source-term data because of the comprehensiveness exercised by Weston and Texas Instruments" (NIOSH, 2023b). Illustrative interior pipe "scale" survey data provided.
- NIOSH performed a dose assessment based on the source term calculation model in the Bridgeport Brass hazard assessment, using the 1,000,000 dpm/cm^2 survey measurement.

Aerosolization of contaminated scale: SC&A response

- M&C workers used wide array of powered tools to cut and clean out pipes. These mechanized tools would have volatilized and suspended fine particles and fumes. Torch-cutting example from Bridgeport Brass AWE was highlighted by SC&A in its supplemental review to substantiate exposure pathway involved with cutting pipes with in-pipe surface contamination (scale).
- Comparative use of Bridgeport Brass pipe and surface contamination parameters for modeling M&C exposure is problematic: M&C had different or uncertain conditions, processes, source terms, and surface contamination thickness.
- NIOSH's conclusion on scale only being associated with cast iron pipes is not corroborated: 1,000,000 dpm/100 cm^2 in-pipe surface contamination was found in vitreous clay mainline pipe.
- NIOSH appears to lack sufficient and representative survey data for in-pipe contaminant scale (or interior pipe surface contamination) to provide an adequate basis for an upper bound source term.

Aerosolization of contaminated scale: NIOSH survey data and SC&A response

- **NIOSH:** Caged Area (Areas 1 and 4) – typically less than 3,000 dpm/100 cm²

  SC&A: Survey data from "near-surface recirculation piping," not drain pipes (Weston 1996)
- **NIOSH:** Locations 4 and 5, supporting assay laboratories – concentration of 500 pCi/g total U

  SC&A: Specific to only one Building 10 activity
- **NIOSH:** Areas 3 and 4 – total uranium concentration of 1,864 pCi/g

  SC&A: Represents total loose pipe sediment and debris, not just scale
- **NIOSH:** Reliance on "beta scintillator data" to represent scale activity

  SC&A: Beta scintillator used to identify, not quantify, scale activity; Weston emphasized limitations of any direct measurements given pipe surface irregularities, geometry, presence of blockages and liquids
- **NIOSH:** Reliance on Weston methodology for "hypothetical dose and exposure rate" (Weston 1997)

  SC&A: May not be sufficiently accurate for bounding source term for scale

Aerosolization of contaminated scale, NIOSH exposure model calculation

- NIOSH used source term concentration calculation method provided in Bridgeport Brass AWE hazard assessment
  - Applied 1,000,000 dpm/100 cm² survey value to model dose associated with cutting through a contaminated pipe
- NIOSH found that adding calculated dose to other subsurface data increases worker dose from 71 to 96 mrem CED
- NIOSH concludes not an SEC issue

Aerosolization of contaminated scale, NIOSH exposure model calculation: SC&A response

- SC&A finds:
  - NIOSH has not demonstrated that the as-high-as-1,000,000 dpm/100 cm² value is bounding in-pipe surface contamination or scale value at M&C during residual period
  - Additional survey data are few in number, some are not applicable, and overall, not representative of drain pipes at M&C
  - Bridgeport Brass source term values are based on actual U-238 surface activity measurements; those model parameters do not necessarily extend to M&C (particularly "T," thickness of interior pipe surface activity, which can involve significant uncertainty and is unknown for M&C)
  - Increasing 95th percentile by factor of 2 goes beyond mere conservatism to extreme means to compensate for uncertainty of application
- SC&A concludes not enough M&C-specific information and survey data to support use of Bridgeport Brass model

Concern with subsurface inside bounding concentrations: Confined space effects

- Presence and effect of extensive confined space work at M&C not reflected in exposure modeling. Leads to increased resuspension of contaminant particulates and concentration of aerosols.
- Prevalence of confined space work at M&C differentiates it from other AWEs.
- Mound project data used for M&C dust loading factor do not account for confined space effects and are therefore not an acceptable surrogate under Board guidelines.

Confined space effects: NIOSH updated response

- M&C workers not actually in trench installing Beckett line for full 6 months
- Drain line work typically done in trenches located 2–3 feet below facility grade with building ventilation, not considered confined space in standard industrial practice
- Priority 1 drain lines only made up small area of Building 10; workers recollected confined space work in other areas not associated with radiological source term
- “NIOSH is committed to reviewing recent suggestions to upgrade its dust loading models, including enhancement factors and confined spaces, and will consider incorporating methods suggested by SC&A in their supplemental review” (NIOSH, 2023b).

Confined space effects: SC&A response

- Beckett line work was highlighted to demonstrate not all M&C work was small, short-duration utility replacement or repair work; however, such maintenance work was intermittent and task related.
- Ergonomics matter: Breathing zone of workers would have been in closer proximity to bottom of trenches near drain pipes being cut and cleaned out.
- SC&A's finding is for the *sufficient accuracy* of Mound project data as a surrogate, given that confined space effects are lacking for it.
  - The issues NIOSH raised—proportion of building with confined spaces, proximity to radiological sources, degree of contamination, etc.— are mitigating but do not change SC&A's finding.
- SC&A considers this to be a TBD issue and, with NIOSH's commitment to review it, recommends this be pended for further follow up.

NIOSH table 2, "Additional information to augment SC&A's *Comparison of AWE sites* table 1"

- Intent of new table is to provide "context regarding the intrusive types of work performed at the other AWE sites where the Advisory Board agreed with NIOSH's ability to bound exposures during residual period work" (NIOSH, 2023b).
- Intrusive work activities cited include grinding, general machine shop maintenance, construction and maintenance of water lines, cleaning and decontamination activities, steel-mill maintenance activities, filtration and duct system maintenance, general nuclear production facility maintenance, metal sanding, excavations, subsurface utility maintenance, facility maintenance, and heavy machinery operations.

NIOSH table 2: SC&A response

- SC&A does not dispute intrusive activities highlighted by NIOSH for other AWEs.
- This is not a new issue: NIOSH responded similarly to the same question raised by the Work Group in 2020 and concluded that “the pathways leading to internal exposures from alpha-emitting radionuclides such as uranium and thorium are identical for workers at all of these sites: the inhalation and ingestion of resuspended, contaminated dust.” (NIOSH, 2020)
- The intent of SC&A’s supplemental review table 1 was to take exception to this broad characterization of M&C maintenance activities as being no different than those of other AWEs
  - SC&A’s table 1, backed by M&C worker interviews, shows that M&C maintenance activities were unique, by degree, proximity, and nature, in bringing workers close to elevated radiological source terms.
- SC&A finds that while residual period activities cited by NIOSH in table 2 somewhat resemble those at M&C, NIOSH by its action to derive six bounding exposure models for intrusive activities at M&C acknowledges they were distinct from more passive scenarios of OTIB-0070 and TBD-6000 and from experience at other AWEs.

Data applicability: NIOSH updated response

- NIOSH validated a bounding source term and applied appropriate resuspension/dust loads for various operations described by interviewees.
- One of the primary reasons for Weston drainage system characterization in 1995 was to quantify risk to ongoing drain line maintenance workers, which was still ongoing.
- Although the frequency of clogged drains may have increased over time, techniques to unclog drains did not change throughout residual period.

Data applicability: SC&A response

- **SC&A's supplemental review:** "The use of a high exposure or concentration value based on a set of specific workplace [pre-D&D sediment survey] data to bound or represent that of other workers in a facility or on a site, particularly over a lengthy time period, would not be appropriate if their exposure potential could be higher, conditions were different, or if there is a lack of information upon which to make that judgment" (SC&A, 2022).
- Different conditions and process may have led to higher exposure potentials in the pre-1995 residual era than accounted for by the inside subsurface bounding source term model:
  - Presence of coagulant oils in drain lines, cutting and cleaning of pipe with contaminated scale, and confined spaces
- Precedent for considering data applicability can be found with Board's SEC recommendation for Linde Ceramic renovation period.
  - Basis for judgment parallels considerations for M&C and is documented in HHS designation.

Worker protection: NIOSH updated response and SC&A response

- **NIOSH:** “Work practices such as those specified in the Work Group’s concern [that maintenance workers were unaware of radioactive contamination and operated without radiological controls and health physics oversight] do not affect the source term or **any** of the ‘three legs of the stool’ that form NIOSH’s bounding method” (NIOSH, 2023b).
- **SC&A:** Distinct differences between how workers conducted their work, the conditions and processes of that work, and the radiological controls under which they performed their activities lead to greater uncertainty over any comparison between D&D-era exposure potentials and those of the pre-1995 residual period (Linde Ceramics precedent).

Claimant-favorable assumptions: NIOSH updated response

- Information presented at the August 16, 2023, Advisory Board meeting is inaccurate, especially regarding ORAUT-OTIB-0070 (NIOSH, 2023b)
- SC&A and the Work Group are misinterpreting NIOSH's use of "extreme conservatism" to mean "implausibly high" (NIOSH, 2023b)

Claimant-favorable assumptions: SC&A response

- SC&A questions the application of standard modeling approaches (as provided in OTIB-0070 and TBD-6000) for unique conditions and processes at M&C; makes the "thoughtful selection" of appropriate resuspension and dust loading factors important.
- NIOSH itself found that the M&C ER "models resuspension (OTIB-0070) and does not specifically address potential exposures from digging, snaking/replacing clogged drain lines, or repurposing M&C equipment" (NIOSH, 2017).
- SC&A goes further and has identified coagulants, scale, and confined spaces.
- SC&A has cited NIOSH's defined application and scope of "extreme conservatism" precisely as given and in the context it was given by NIOSH in its January 2023 response paper. Its application is manifest in the substantial conservative assumptions and statistical margins relied upon in M&C bounding models.
- If NIOSH's bounding model cannot account for M&C's "intrusive activities, high exposure conditions, uncertain facility activities, or unknown contamination sources" (NIOSH, 2023a) without resorting to extreme conservatism, *sufficient accuracy* and *plausibility* become concerns.

AWE equipment: NIOSH updated response and SC&A response

- **NIOSH:** has previously responded to this concern. AWE operations were decontaminated and decommissioned, and all radioactive material was removed during 1955–1968: “contaminated noncombustible scrap material and machinery were collected in 55-gallon steel drums and disposed of” (Sowell, 1985).
- **SC&A:** NIOSH’s response does not address the potential exposure pathway posed to M&C maintenance workers from moving, repurposing, and subsequent maintenance of AWE-era equipment that remained during the residual period. D&D activities would not have addressed residual contamination under and within AWE-era machinery and equipment that was not decontaminated and decommissioned.

Burial area: NIOSH updated response and SC&A response

- **NIOSH:** Regarding the Work Group comment that intrusive M&C activities included “excavating contaminated soils, including those near or within radioactive waste burial sites” (ABRWH, 2023), NIOSH noted that it has developed a model to bound exposure during subsurface work in areas outside of Building 10, including the burial ground.
- **SC&A:** has already addressed its concerns about the subsurface outside bounding approach in previous Work Group discussions and has no new technical information to add.

Work Group findings, August 2023

- Intrusive work activities by maintenance workers at M&C during the residual period led to potential exposures for which there are no available monitoring data.
- NIOSH applies 1995 D&D survey data as basis for an upper bound for residual period exposure. For radiological data from one time period to be considered informative about exposures during another time period, there should be sufficient similarity of conditions and processes between the two periods.
- Although NIOSH has proposed a claimant-favorable “inside subsurface” bounding concentration (6,887 pCi/g), there remains uncertainty about source terms and exposure pathways during the residual period prior to pre-D&D characterization, 1968–1995. [dates corrected]
- There is insufficient information available to account for the exposure contribution of confined spaces, pipe scale releases, and released coagulants in a workplace not controlled as a radiation environment, unlike that of the later D&D era at M&C from which NIOSH draws its data.
- The application of “extreme conservatism” in formulating the proposed upper bound concentration to account for “intrusive activities, high exposure conditions, uncertain facility activities, or unknown contamination sources” may not be a plausible approach to compensate for inadequate or insufficient information.

Work Group proposed conclusion

Because of the identified differences between the two periods (residual vs. D&D era), there is insufficient basis to conclude that radiological data from D&D efforts (including pre-D&D surveys) are sufficiently informative about exposures arising during the entirety of the M&C residual period to be applied in the manner proposed by NIOSH.

SC&A conclusions

- SC&A's review of NIOSH's August 22, 2023, response paper did not identify information or analyses that materially affect the Work Group's concerns and proposed conclusion.
- NIOSH has a pathway to address the confined space issue, which is acknowledged as a TBD concern.
- Uncertainties remain for source terms related to in-pipe contaminated sediments (due to the presence of coagulants) and interior surface contamination (scale) during the pre-1995 M&C residual period.
  - These were the basis for finding 1 of SC&A's supplemental review that "the back application of a high 1995 sediment survey result to bound inside subsurface activities is not adequately supported by information for M&C worker activities from the earlier residual time period" (SC&A, 2022).
- Uncertainties compounded by:
  - Undetermined worker exposure due to repurposing of AWE-era machinery and equipment
  - Intrusiveness of M&C maintenance worker activities as compared with other AWEs

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