# Metals and Controls Corp. Thorium And Welding Exposure Model

**White Paper**

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**National Institute for Occupational Safety and Health**

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# INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) presented the Evaluation Report (ER) for SEC-00236, Metals and Controls Corp. (M&C) to the Advisory Board on Radiation and Worker Health (Board) on August 24, 2017. At the conclusion of that presentation, a petitioner raised a concern about the adequacy of the ER in addressing maintenance type work. The petitioner stated that he "took great care to define the class of workers under evaluation in this petition as precisely and as *narrowly* as possible to coincide with workers for whom there is a high degree of confidence that they received elevated exposures to residual radioactive contamination."

In response to this concern, on September 5, 2017, NIOSH initiated strategies to continue M&C research and further develop SEC-00236. These strategies included plans to review monitoring records in the Site Research Database (SRDB) and plans to search for former M&C workers so that NIOSH could conduct interviews with them.

From October 24, 2017, through October 26, 2017, NIOSH, Oak Ridge Associated Universities (ORAU), and Sanford Cohen & Associates (SC&A) personnel interviewed 12 former M&C workers and individuals knowledgeable about maintenance work. Interviewers asked questions regarding the frequency and duration of work, including heating, ventilation, and air conditioning (HVAC), utility and drain line maintenance, and new equipment installations.

In addition to the interviews, other notable actions included the following:

- November 8, 2017 - The Metals and Controls Working Group (Working Group), SC&A, Division of Compensation Analysis and Support (DCAS), and ORAU team members held a teleconference to discuss technical issues associated with developing exposure models regarding maintenance work.
- February 6, 2018 - NIOSH obtained additional monitoring data regarding remediation work performed by Creative Pollutions Solutions (CPS) in 1992 and 1994 (CPS 1992-b; CPS 1994).
- February 13, 2018 - NIOSH received a report by SC&A titled *Review of SEC Petition ER SEC-00236 (Mauro, 2018).*
- April 23, 2018 - NIOSH issued the *Metals and Controls Corp. Subsurface Exposure Model* white paper (NIOSH, 2018-a) and made it available to SC&A and the Working Group.
- May 3, 2018 - During a Working Group meeting, SC&A presented their findings and observations associated with the SEC-00236 ER. The petitioners also made a statement and provided a letter with their concerns. After the meeting, an issues matrix was created.
- August 22, 2018 - During a full Board meeting, the Working Group presented their findings and observations associated with the SEC-00236 ER and NIOSH provided an update. The petitioners also made a statement and provided a letter with their concerns at the meeting.

- November 20, 2018 - During a Working Group meeting, NIOSH presented the *Metals and Controls Corp. Maintenance Exposure Model* white paper (NIOSH, 2018-b) that included HVAC maintenance and Building 10 overhead exposure models. SC&A presented their observations associated with the *Metals and Controls Corp. Subsurface Exposure Model* and *Metals and Controls Corp. Maintenance Exposure Model* white papers (NIOSH, 2018-a; NIOSH, 2018-b), and the petitioners also made a statement with their concerns.
- December 13, 2018 - During a full Board meeting, the Working Group presented an update. The petitioners also made a statement and provided a letter with their concerns at the meeting.

This white paper addresses two concerns recently raised by the petitioner; it provides an exposure model for exposures that occurred during welding activities and provides a method for bounding thorium exposures while working inside Building 10.

## INTERNAL EXPOSURES TO THORIUM

### Background

The SEC-00236 petitioner raised the following issue, which was designated as P5 in the M&C Issues Matrix (https://www.cdc.gov/niosh/ocas/pdfs/dps/dc-metcontimsec236-101218-508.pdf):

*The 1995 Drainage System Characterization Report (Weston 1996) included 15 grab samples of accumulated sediment or surrounding soils in discrete locations of the pipe where elevated direct measurements were observed. The grab sample analyses reported an isotopic analysis of uranium but no other radionuclides. In retrospect, we now know that thorium would have also been present, as it was historically processed on the same manufacturing equipment as uranium during the Atomic Weapons Employer (AWE) program. But given the limitation of the 1995 survey measurements, we have no way of knowing how much thorium source term was present in the residual radioactivity to which the M&C maintenance workers were exposed (Elliott, 2018, PDF p. 7).*

#### NIOSH September 12, 2018, Response to Issue P5

NIOSH is aware that a small amount of thorium work was done on the same equipment in the same areas as the uranium work. NIOSH is also aware that the equipment was cleaned or shipped offsite and the areas cleaned (not decontamination and decommissioning [D&D]) when those operations ceased prior to the start of the residual period. NIOSH relies on the available data and models thorium exposures for those areas where we have thorium data. If the petitioner is aware of new information, NIOSH will consider it.

#### Thorium Operations

During AWE operations, thorium-bearing component fabrication occurred (including reactor fuel, metallic alloys, and metallic foils). The only definitive information regarding the amount of thorium at M&C is from a 1962 nuclear safety analysis that listed the total quantity of thorium as 244 kg.

By comparison, during AWE operations, **uranium**-bearing component fabrication occurred (including reactor fuel, metallic alloys, and metallic foils). Inventory information for 1962 indicated the presence of 7,097 kg uranium (ASTRA 1962, PDF p. 47).

The uranium to thorium-232 ratio in the 1962 inventory data was dominated by uranium. There was approximately 29 times as much uranium as there was thorium-232 (assuming the mass of natural thorium consisted almost entirely of thorium-232), and the activity ratio was even more dominated by uranium where there was 188 times more uranium (assuming natural uranium and thorium-232).

As M&C cleaned the areas used for AWE operations prior to 1968, they buried waste and materials in the area between Buildings 11 and 12. M&C personnel made the U.S. Nuclear Regulatory Commission (NRC) aware of this burial area in 1982 as part of their D&D effort. The NRC performed verification sampling of the burial area in 1984 and notified M&C personnel of the presence of contamination above release limits, including the presence of thorium. The M&C contractor, CPS, performed additional sampling of the burial area in 1992 and corroborated the presence of thorium in their report to M&C (CPS 1992-a).

In addition, NIOSH determined the radioactivity ratio of uranium to thorium-232, using data from samples taken of waste and materials removed from the former AWE areas and placed in the burial area. There were 754 samples taken of the outside perimeter of Building 10 and the burial area that were analyzed for both uranium and thorium-232. NIOSH determined a paired activity ratio of uranium to thorium-232 for each of these samples and calculated a geometric mean ratio of uranium to thorium-232 as 9.88:1.

## New NIOSH Bounding Method (April 17, 2019)

Although M&C only analyzed Building 10 subsurface samples for uranium in 1995, NIOSH can bound thorium exposures during maintenance work by assuming that the subsurface sediments contained equivalent amounts of natural uranium and thorium-232.

NIOSH previously determined in the *Metals and Controls Corp. Maintenance Exposure Model* white paper (NIOSH, 2018-b) that the 95$^{th}$-percentile measured uranium activity in the sediment/sludge was 6,888 pCi/g, and since the specific activity of natural uranium is 7.1E+5 pCi/g, this corresponds to a mass of 9.7 mg of natural uranium per gram of sludge or about 1% by weight.

If we assume that the subsurface was contaminated with equal amounts of thorium and uranium, then 1% of the sediment/sludge and the subsequent dust loading created from maintenance work would have resulted in a thorium air concentration of 2.2 µg/m$^3$. Using the thorium-232 specific activity (0.11 µCi/g), the air concentration would have been 2.42 E-13 µCi/mL during the one month of subsurface maintenance each year.

To provide some perspective, using the largest ICRP 60 dose conversion factors (DCF) for thorium-232 and its progeny, this concentration would amount to an inhalation committed effective dose (CED) of 10.42 mrem/yr. If we also add ingestion this estimated dose becomes 14.78 mrem/yr.

NIOSH can use our calculated air concentration to bound internal thorium exposures that occurred while performing subsurface maintenance within Building 10.

For those areas where gross alpha contamination surveys are available, NIOSH will continue to estimate worker doses using the most claimant-favorable isotope of thorium or uranium.

For the burial area and Building 10 outside perimeter, NIOSH can use isotopic thorium-232 results to model air concentrations breathed by maintenance workers as previously described in the *Metals and Controls Corp. Maintenance Exposure Model* white paper (NIOSH, 2018-b).

## INTERNAL EXPOSURES FROM WELDING

### Welding Operations

During the residual period, while performing maintenance work in the Building 10 overhead area, M&C workers were potentially exposed to contamination remaining from AWE operations. This work included installing pipe racks, welding supports to the trusses to fortify the roof, and cutting and drilling up through the roof to make penetrations for running services to rooftop equipment, such as air-conditioning systems, recirculation water, chilled water supply and return and steam and condensate return, and installing equipment on the roof (ORAUT, 2017-a, October 24, 2017, PDF p. 4; ORAUT, 2017-b, October 25, 2017, PDF p. 7; NIOSH, 2018-c.

A June 1981, NRC Inspection Report stated that Texas Instruments used a "Cutting and Welding Permit" program. This program required that a Cutting and Welding Permit was needed any time a cutting or welding job causing hot slag had to be done outside of a designated cutting and welding area.

The permit system used a card on which the necessary precautions required to be taken were listed. Authorization to perform the cutting and/or welding was shown by the signature of the "Fire Safety Supervisor." The card had a section that called for checking the work and all adjacent areas to which sparks and heat might have spread for a period of 30 minutes after the work was completed. The fact this check was done was shown by a signature (NRC 1981-1982, PDF p. 15).

The 1964 M&C Safety Manual specified welding and flame-cutting precautions for fire safety, including pre-work cleaning of combustible debris, removal of deposits inside of ductwork, use of curtains and shields to protect personnel from glare and sparks, and use of “permit required” areas for sewers, pits, drains, ventilators, and ducts. The manual also stated that barricades were required for overhead work (M&C Nuclear, 1964, PDF pp. 10-12, 24).

NIOSH obtained the following information during M&C worker interviews:

> *Worker #1: When you're cleaning beams so you can weld onto them… I would just go up on a high-lift and blow it all off with a compressed air tank. Then you would prep it with a wire brush, and then grind it to prep it for welding. For that period when you were doing that, you really made a heck of a mess. I used oxyacetylene all the time for brazing and silver soldering.*
>
> *Dr. Mauro: Did you use it for cutting steel pipe or for rebar and things like that?*
>
> *Worker #1: Yes, that job eventually became a job for the millwrights, but I did plenty of it because we had to make supports for my pipe racks and things like that. They were busy with their own stuff, so we did ours* (Interview Worker #1, October 24, 2017, PDF p. 10).

## NIOSH Bounding Method

Interviews of M&C maintenance personnel indicated that welding in the dusty overhead area was only one of their many duties that also included subsurface and HVAC work. This bounding scenario applies to only those maintenance workers that performed welding tasks in the Building 10 overhead area.

NIOSH previously modeled maintenance work in the overhead area with an occupancy rate of 1 month (168 hours) per year (NIOSH, 2018-b). Interviews conducted by NIOSH indicated that welding was one of the activities frequently performed while in the overhead area and that the amount of time spent was approximately 4 hours per month or 48 hours per year on average (ORAUT, 2017-b, October 25, 2017). NIOSH will assume that welding tasks occupied this amount of time per year.

NIOSH previously characterized the overhead work environment using the total surface activity and assumed 10% of that activity was removable and available to generate airborne activity. NIOSH will continue to assign doses using this method for other work in the overhead area (e.g., light bulb replacements); however, for welding, NIOSH will assume 100% of the activity is resuspended.

In addition, NIOSH modeled exposures for the entire overhead area uniformly using the 95th-percentile contamination level and a $10^{-4}$ resuspension factor. We are aware that good work practice requires clean bare metal prior to welding, which can include wire brushing and grinding as described by Worker #1 above. NIOSH believes this weld preparation work to be the portion of the welding task capable of generating the highest airborne concentration. In addition, NUREG-1400 (NRC, 1993) Section 1.2.3 indicates that a dispersibility factor of 10 should be used when modeling intakes that involve grinding operations. Therefore, NIOSH will increase the resuspension factor and apply a value of $10^{-3}$ to the $95^{th}$-percentile contamination level.

In summary, the $95^{th}$-percentile gross-alpha contamination level was calculated as 89.94 dpm/100 $cm^2$ and the geometric standard deviation (GSD) at 3.61. NIOSH increased the resuspension factor to $10^{-3}$ because of the enhanced airborne generation caused by grinding, to determine an air concentration of 4.05E-12 μCi/mL during the 48 hours of welding each year.

To provide some perspective, using the largest ICRP 60 DCF for uranium-234, this concentration would amount to an inhalation CED of 5.88 mrem/yr. The uranium ingestion dose associated with this estimate is negligible. In addition, using the largest ICRP 60 DCFs for thorium-232 and its progeny, this concentration would amount to an inhalation CED of 16.75 mrem/yr. If we also add ingestion, this estimated dose becomes 16.77 mrem/yr.

This air concentration would be assumed to be inhaled for the 48 hours of welding that occurred per year for M&C personnel that performed welding in the Building 10 overhead area and will be in addition to other assigned exposures.

## CONCLUSION

NIOSH has considered all of the information presented in this white paper and has used it to develop exposure models for Metals and Controls Corp. that account for the descriptions of work by former employees, pre-remediation sample data, and a realistic dust resuspension model. NIOSH believes that this model adequately bounds maintenance exposures experienced by M&C workers during the residual radiation period.

## REFERENCES

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