SEC Petition Evaluation Report
Petition SEC-00173

Report Rev #: Addendum 1 Report Submittal Date: August 4, 2011

Subject Expert(s):	Mike Mahathy
Site Expert(s):	N/A

Petition Administrative Summary

Petition Under Evaluation

Petition #	Petition Type	Petition Receipt Date	Qualification Date	DOE/AWE Facility Name
SEC-00173	83.13	May 17, 2010	July 21, 2010	Norton Co.

Petitioner Class Definition

All employees of the Norton Company who worked in any building or area at the Norton Company location on New Bond Street in Worcester, Massachusetts, from 1960 through 1972.

Class Evaluated by NIOSH

All atomic weapons employees who worked in any building or area at the facility owned by the Norton Co. in Worcester, Massachusetts, during the residual radiation period from January 1, 1958 through October 31, 2009.

NIOSH-Proposed Class to be Added to the SEC

All Atomic Weapons Employer employees who worked in any building or area at the facility owned by the Norton Co. (or a subsequent owner) in Worcester, Massachusetts, during the period from January 1, 1958 through October 10, 1962, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the Special Exposure Cohort.

Related Petition Summary Information

SEC Petition Tracking #(s)	Petition Type	DOE/AWE Facility Name	Petition Status
SEC-00148	83.14	Norton Co.	Class added to SEC for January 1, 1945-December 31, 1957
SEC-00173	83.13	Norton Co.	Class added to SEC for January 1, 1958-October 10, 1962

Related Evaluation Report Information

Report Title	DOE/AWE Facility Name
SEC Petition Evaluation Report for Petition SEC-00148 (January 1, 1945 through December 31, 1957)	Norton Co.
SEC Petition Evaluation Report for Petition SEC-00173 (January 1, 1958 through October 31, 2009)	Norton Co.

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ORAU Peer Review Completed By: Michael Kubiak

Peer Review Completed By:	[Signature on File] *Frank C. Crawford*	8/5/2011 *Date*
SEC Petition Evaluation Reviewed By:	[Signature on File] *J. W. Neton*	8/8/2011 *Date*
SEC Evaluation Approved By:	[Signature on File] *Stuart L. Hinnefeld*	8/8/2011 *Date*

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Addendum to Norton Co. (SEC-00173)
Special Exposure Cohort Evaluation Report

ATTRIBUTION AND ANNOTATION: This is a single-author document. All conclusions drawn from the data presented in this evaluation were made by the ORAU Team Lead Technical Evaluator: Mike Mahathy, Oak Ridge Associated Universities. The rationales for all conclusions in this document are explained in the associated text.

NIOSH presented a Special Exposure Cohort (SEC) evaluation report (NIOSH, 2011) regarding the Norton Company for the period from January 1, 1958 through October 31, 2009 to the Advisory Board on Radiation and Worker Health (Advisory Board) during the Advisory Board's meeting held February 23-25, 2011. In its report, NIOSH evaluated the feasibility of reconstructing radiation doses of all atomic weapons employees who worked in any building or area at the facility owned by the Norton Co. in Worcester, Massachusetts, during the residual radiation period from January 1, 1958 through October 31, 2009. Based on its full research of the class under evaluation, NIOSH determined that decontamination and decommissioning activities were conducted during the period from January 1, 1958 through October 10, 1962, for which NIOSH has insufficient source term and monitoring data to bound internal and external doses potentially received from exposures during that work. As such, NIOSH defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class included all atomic weapons employees who worked in any building or area at the facility owned by the Norton Co. (or a subsequent owner) in Worcester, Massachusetts, during the period from January 1, 1958 through October 10, 1962, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the SEC. The class was added to the SEC, effective May 29, 2011.

Further, NIOSH found that it does have sufficient data to bound doses for the period from October 11, 1962 through October 31, 2009 (NIOSH 2011). NIOSH proposed to use guidance in ORAUT-OTIB-0070 to bound doses potentially received from exposures to residual uranium, thoria, and thoron. In its proposal to bound residual radiation period doses starting October 11, 1962, NIOSH used the residual activity depletion rate of 1% per day as described in ORAUT-OTIB-0070. Since the publication of *SEC Petition Evaluation Report for Petition SEC-00173, Norton Co.* (NIOSH, 2011), NIOSH has studied source-term depletion at other Atomic Weapons Employer sites and has revised its depletion-rate guidance to now specify a value of 0.067% per day. This addendum provides discussion of the revised depletion rate and subsequent changes in annual intake rates and annual external dose rates during the Norton Co. residual radiation period from October 11, 1962 through October 31, 2009. The dose reconstruction feasibility conclusions published in *SEC Petition Evaluation Report for Petition SEC-00173, Norton Co.* (NIOSH, 2011) are not impacted by the changes discussed in this addendum. That is, NIOSH still concludes that it lacks sufficient monitoring records, process descriptions, and source term data to complete dose reconstructions for the evaluated class of employees for the period from January 1, 1958 through October 10, 1962. However, available monitoring records, process descriptions, and source term data are sufficient to complete dose reconstructions for the evaluated class of employees for the period from October 11, 1962 through October 31, 2009.

NOTE: This SEC-00173 Evaluation Report Addendum only addresses those sections and the content in the Norton Co. SEC-00173 Evaluation Report (NIOSH, 2011) that require discussion; therefore, the section numbering is not contiguous. The sections requiring additional discussion begin below.

Evaluation Report Summary

NIOSH-Proposed Class to be Added to the SEC

NIOSH finds that it does have sufficient data to bound doses for the period from October 11, 1962 through October 31, 2009 (the end of the designated residual radiation period). For this period, NIOSH has obtained gross alpha air monitoring results collected at Norton Co. near the end of the Atomic Weapons Employer (AWE) operations period and during the residual radiation period. Using those data, guidance in ORAUT-OTIB-0070, and empirical source-term depletion-rate information, NIOSH can bound the internal doses potentially received from exposures to residual uranium and thoria. NIOSH can use the same set of gross alpha data to bound potential internal doses received from thoron by using decay and in-growth calculations on sample recounts. The gross alpha air contamination data from the operational period and the methods described in Battelle-TBD-6000 allow NIOSH to bound external doses from residual uranium and thoria.

Feasibility of Dose Reconstruction

The NIOSH dose reconstruction feasibility findings are based on the following:

Note: Bullets 1-5 are unchanged.

- NIOSH has identified sufficient information and data to support bounding internal dose for the remaining portion of the residual radiation period (October 11, 1962 through October 31, 2009) using air monitoring data obtained during the operational period, empirical source-term depletion-rate information, and guidance given in ORAUT-OTIB-0070, *Dose Reconstruction during Residual Radioactivity Periods at Atomic Weapons Employer Facilities*.

Note: Bullets 7-9 are unchanged.

7.2.2 Methods for Bounding Residual Radiation Period Internal Dose at Norton Co.

NIOSH does not have adequate internal monitoring or workplace monitoring data to bound doses that were potentially received during the dismantling, clean-up, packaging, and burial of AWE materials and contamination. While NIOSH does have air monitor data obtained during the AWE operations period that can be used to bound doses in the residual period following the burial which culminated on October 10, 1962, those data cannot be assumed to bound all radioactive contamination and radiological contamination levels that could have arisen from the dismantling, clean-up, packaging and burial processes which were documented to have generated dust.

In order to determine the feasibility of bounding potential internal doses received from exposures to residual radiation received after the burial of AWE materials, NIOSH evaluated air monitoring data in the form of long-lived gross-alpha results obtained on May 13, 1958 (reported on May 28, 1958) by

the Massachusetts Department of Labor and Industries (Pagnotto, 1958) to derive the air concentration starting on October 11, 1962 through the end of the residual radiation period, October 31, 2009. The average of the long-lived alpha results was calculated from the data shown in Table 7-1 to estimate the starting air concentration (4.662 dpm/m^3) on October 11, 1962.

Table 7-1: Air Monitoring Results, Long-Lived Alpha Emitters

Sample Number	Time Sampling Completed (hours)	Location	Long-Lived Alpha Emitters (uCi/mL)	Thorium Air Concentration (dpm/m^3)
1M	9.2	End of hood - thoria area	4E-13	-
7M	2.5	End of hood - thoria area	4E-13	-
13	2.5	End of hood - thoria area	2E-12	-
5M	1.15	Thoria processing area	2E-12	-
3	10	General area on bench	2E-12	-
7	11.2	Hood - thoria area	1E-12	-
11	2	Bench near thoria area	2E-12	-
14	2.5	By glass cutting wheel	7E-12	-
		Average - thoria area samples	2.1E-12	4.662

Average daily intake rates for inhalation and ingestion were calculated based on an inhalation rate of 1.2 m^3/hr, 8-hour workday, and 250 workdays per year, resulting in a value of 30.654 dpm/day for the period from October 11, 1962 through December 31, 1963. Intake rates for the following years through October 31, 2009 have been adjusted according to an empirically-derived source-term depletion rate. NIOSH has previously determined the activity removal rates during the residual radiation periods for the four sites shown in Table 7-1A (DCAS-TKBS-0002; Battelle-TBD-6000 Appendix C; ORAUT-TKBS-0045; ORAUT-TKBS-0032). In these cases, contemporary estimates of airborne radioactivity at the beginning and end of each site's residual radiation period were used to estimate the effective exponential clearance of the contamination over an extended period of time for each site (ORAUT-OTIB-0070). The source-term depletion rates calculated for these sites are provided in Table 7-1A below.

Note: This is a new table that is not in SEC Petition Evaluation Report for Petition SEC-00173, Norton Co (NIOSH, 2011). This table does not replace an existing table.

Table 7-1A: Source-Term Depletion Rates During Residual Period

Facility	Depletion Rate (per day)
Blockson	0.00076
Dow Madison	0.00027
General Atomics	0.00116
Simonds Saw and Steel	0.00049
Average	**0.00067**

Because these values were empirically derived at operating facilities, NIOSH considers them more appropriate than a value based solely on theoretical considerations. As such, the 1% per day depletion rate proposed for the residual radiation period in *SEC Petition Evaluation Report for Petition SEC-00173, Norton Co.* (NIOSH, 2011) is being replaced by the average value of 0.067% per day, as calculated using the data in Table 7-1A.

The Norton Co. air monitoring results are reported in units of gross alpha and are not isotopic-specific; therefore, the most claimant-favorable radionuclide and solubility class will be assigned by NIOSH. The Norton Co. processed both uranium oxide and thoria. Because Norton Co. processed both uranium and thorium oxides, uranium can be assumed to be U-234 (Types M and S) and thorium can be assumed to be Th-232 (Types M and S). The calculated intake rates are shown in Table 7-2.

Table 7-2: Intake Rates for Uranium or Thorium

Applicable Period	Source Term Depletion Adjustment	Inhalation (dpm/day)	Ingestion (dpm/day)	Distribution
01/1958 - 10/10/1962	not feasible	not feasible	not feasible	N/A
10/11/1962 - 12/31/1963	1.000	30.654	0.747	Constant
1964	0.783	24.002	0.585	Constant
1965	0.613	18.791	0.458	Constant
1966	0.480	14.714	0.359	Constant
1967	0.376	11.526	0.281	Constant
1968	0.294	9.012	0.220	Constant
1969	0.231	7.081	0.173	Constant
1970	0.181	5.548	0.135	Constant
1971	0.141	4.322	0.105	Constant
1972	0.111	3.403	0.083	Constant
1973	0.087	2.667	0.065	Constant
1974	0.068	2.084	0.051	Constant
1975	0.053	1.625	0.040	Constant
1976	0.042	1.287	0.031	Constant
1977	0.033	1.012	0.025	Constant
1978	0.026	0.797	0.019	Constant
1979	0.020	0.613	0.015	Constant
1980	0.016	0.490	0.012	Constant
1981	0.012	0.368	0.009	Constant
1982	0.010	0.307	0.007	Constant
1983	0.008	0.245	0.006	Constant
1984	0.006	0.184	0.004	Constant
1985	0.005	0.153	0.004	Constant
1986	0.004	0.123	0.003	Constant
1987	0.003	0.092	0.002	Constant
1988	0.002	0.061	0.001	Constant
1989	0.002	0.061	0.001	Constant
1990	0.001	0.031	0.001	Constant
1991	0.001	0.031	0.001	Constant
1992	0.001	0.031	0.001	Constant
1993 and later	0.001	0.031	0.001	Constant

NIOSH does not consider radon as an exposure source, as Norton Co. only had uranium metals and associated dust onsite. NIOSH has identified thoron monitoring data in the form of short-lived thoria results obtained on May 13, 1958 (reported on May 28, 1958) (Pagnotto, 1958). NIOSH used the reported average short-lived values as actual values of thoron, as provided in Table 7-3 to calculate the intake rate of thoron from the end of the burial operation through December 31, 1963. Working level (WL) and working level months (WLM) were calculated for each result and for the average of the reported short-lived results.

Table 7-3: Air Monitoring Results, Short-Lived Alpha Emitters

Sample Number	Time Sampling Completed (hours)	Location	Short-Lived Alpha Emitters (uCi/mL)	Thoron (WL)	Thoron (WLM)
1M	9.2	End of hood - thoria area	3.3E-11	0.00440	0.0518
7M	2.5	End of hood - thoria area	4E-11	0.00533	0.0627
13	2.5	End of hood - thoria area	3.6E-11	0.00480	0.0565
5M	1.15	Thoria processing area	4.2E-11	0.00560	0.0659
3	10	General area on bench	5.2E-11	0.00693	0.0816
7	11.2	Hood - thoria area	4.1E-11	0.00547	0.0643
11	2	Bench near thoria area	2.26E-10	0.03013	0.3545
14	2.5	By glass cutting wheel	3.1E-11	0.00413	0.0486
		Average - thoria area samples	6.2625E-11	0.00835	0.0982

Intake rates for the following years have been adjusted due to source term depletion per the discussion above (i.e., 0.067% per day depletion rate). Thoron intake rates for the Norton Co. residual radiation period are provided in Table 7-4.

Table 7-4: Intake Rates for Thoron
(Table 7-4 spans two pages.)

Applicable Period	ORAUT-OTIB-0070 Adjustment	Thoron (WLM))	Distribution
01/1958 - 10/10/1962	not feasible	not feasible	N/A
10/11/1962 - 12/31/1963	1.000	0.0982	Constant
1964	0.783	0.077	Constant
1965	0.613	0.060	Constant
1966	0.480	0.047	Constant
1967	0.376	0.037	Constant
1968	0.294	0.029	Constant
1969	0.231	0.023	Constant
1970	0.181	0.018	Constant
1971	0.141	0.014	Constant
1972	0.111	0.011	Constant
1973	0.087	0.009	Constant
1974	0.068	0.007	Constant
1975	0.053	0.005	Constant
1976	0.042	0.004	Constant

Table 7-4: Intake Rates for Thoron *(Table 7-4 spans two pages.)*			
Applicable Period	**ORAUT-OTIB-0070 Adjustment**	**Thoron (WLM))**	**Distribution**
1977	0.033	0.003	Constant
1978	0.026	0.003	Constant
1979	0.020	0.002	Constant
1980	0.016	0.002	Constant
1981	0.012	0.001	Constant
1982	0.010	0.001	Constant
1983	0.008	0.001	Constant
1984	0.006	0.001	Constant
1985	0.005	0.000	Constant
1986	0.004	0.000	Constant
1987	0.003	0.000	Constant
1988	0.002	0.000	Constant
1989	0.002	0.000	Constant
1990	0.001	0.000	Constant
1991	0.001	0.000	Constant
1992	0.001	0.000	Constant
1993 and later	0.001	0.000	Constant

7.3.3 Methods for Bounding Residual Radiation Period External Dose at Norton Co.

In order to determine the feasibility of bounding potential external doses received from exposures to residual radiation, NIOSH evaluated air monitoring data obtained during the operations period. The 95th percentile of the gross alpha air dust results was calculated to estimate the highest contamination levels present after the AWE materials had been buried starting on October 11, 1962. It is assumed that the material deposited on the floor with a deposition velocity of 0.00075 m/s from October 11, 1962 through December 31, 1963. This results in a maximum contamination level of 1.83×10^{6} dpm/m^2. Using these assumptions, daily doses can be calculated based on the maximizing potential radionuclide. The external doses are from penetrating photons with energies between 30 and 250 keV and electron energy range of >15 keV for penetrating exposures. Table 7-5 shows the external dose rates for the residual radiation period adjusted for the 0.067% per day source term depletion discussed in 7.2.2 above and per the guidance provided in ORAUT-OTIB-0070 and Battelle-TBD-6000.

NIOSH has identified no personnel or workplace monitoring data that can be used to quantify such contamination or accurately bound external doses potentially received during the period from January 1, 1958 through October 10, 1962, during the clean-up and burial operations. Therefore, NIOSH finds that it is not feasible to reconstruct doses received from potential external exposures to radioactive contamination during the period of January 1, 1958 through October 10, 1962.

Table 7-5: External Dose Rates for the Residual Radiation Period				
Applicable Period	**Source Term Depletion Adjustment**	**Gamma (rem/year)**	**Beta (rem/year)**	**Distribution**
01/1958 - 10/10/1962	not feasible	not feasible	not feasible	N/A
10/11/1962 - 12/31/1963	1.000	0.026	0.233	Constant
1964	0.783	0.020	0.182	Constant
1965	0.613	0.016	0.143	Constant
1966	0.480	0.012	0.112	Constant
1967	0.376	0.010	0.088	Constant
1968	0.294	0.008	0.069	Constant
1969	0.231	0.006	0.054	Constant
1970	0.181	0.005	0.042	Constant
1971	0.141	0.004	0.033	Constant
1972	0.111	0.003	0.026	Constant
1973	0.087	0.002	0.020	Constant
1974	0.068	0.002	0.016	Constant
1975	0.053	0.001	0.012	Constant
1976	0.042	0.001	0.010	Constant
1977	0.033	0.001	0.008	Constant
1978	0.026	0.001	0.006	Constant
1979	0.020	0.001	0.005	Constant
1980	0.016	0.000	0.004	Constant
1981	0.012	0.000	0.003	Constant
1982	0.010	0.000	0.002	Constant
1983	0.008	0.000	0.002	Constant
1984	0.006	0.000	0.001	Constant
1985	0.005	0.000	0.001	Constant
1986	0.004	0.000	0.001	Constant
1987	0.003	0.000	0.001	Constant
1988	0.002	0.000	0.000	Constant
1989	0.002	0.000	0.000	Constant
1990	0.001	0.000	0.000	Constant
1991	0.001	0.000	0.000	Constant
1992	0.001	0.000	0.000	Constant
1993 and later	0.001	0.000	0.000	Constant

8.0 Evaluation of Health Endangerment for Petition SEC-00173

Note: The first paragraph in this section was unchanged.

NIOSH has obtained gross alpha air monitoring results collected at the Norton Co. near the end of the AWE operations period and during the residual radiation period. Using those data, the guidance in ORAUT-OTIB-0070, and empirical depletion-rate information, NIOSH can bound the internal doses potentially received from exposures to residual uranium and thoria for the period from October 11, 1962 through October 31, 2009. The gross alpha air contamination data from the operational period

and the methods described in Battelle-TBD-6000 allow NIOSH to bound external doses from residual uranium and thoria for the period from October 11, 1962 through October 31, 2009. NIOSH's evaluation determined that it is feasible to estimate radiation dose for members of the NIOSH-evaluated class for the period from October 11, 1962 through October 31, 2009, with sufficient accuracy based on the sum of information from available resources. Modification of the class definition regarding health endangerment and minimum required employment periods, therefore, is not required for the October 11, 1962 through October 31, 2009 period. However, NIOSH's evaluation determined that it is not feasible to estimate radiation dose for members of the NIOSH-evaluated class for the period from January 1, 1958 through October 10, 1962, with sufficient accuracy. Modification of the class definition regarding health endangerment and minimum required employment periods, therefore, is required for the January 1, 1958 through October 10, 1962 period.

10.0 References (for this Addendum)

Battelle-TBD-6000, *Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium Metals*, Rev. F0; Battelle Team Dose Reconstruction Project for NIOSH; December 13, 2006; SRDB Ref ID: 30671

Battelle-TBD-6000 Appendix C, *Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium Metals, Appendix C-Dow Chemical Co. (Madison Site)*, Rev. 0; Office of Compensation Analysis and Support; September 8, 2008; SRDB Ref ID: 49802

DCAS-TKBS-0002, *Technical Basis Document for Atomic Energy Operations at Blockson Chemical Company, Joliet, Illinois*, Rev. 03; Division of Compensation Analysis and Support (DCAS); December 20, 2010; SRDB Ref ID: 91205

NIOSH, 2011, *SEC Petition Evaluation Report for Petition SEC-00173, Norton Co.*; National Institute for Occupational Safety and Health (NIOSH); January 24, 2011; SRDB Ref ID: 94436

ORAUT-OTIB-0070, *Dose Reconstruction During Residual Radioactivity Periods at Atomic Weapons Employer Facilities*, Rev. 00; March 10, 2008; SRDB Ref ID: 41603

ORAUT-TKBS-0032, *Site Profile for Simonds Saw and Steel*, Rev. 01; ORAU Team Dose Reconstruction Project for NIOSH; April 18, 2011; SRDB Ref ID: 94105

ORAUT-TKBS-0045, *Site Profile for General Atomics*, Rev. 00; ORAU Team Dose Reconstruction Project for NIOSH; September 26, 2008; SRDB Ref ID: 49950

Pagnotto, 1958, *Study of Air Samples and Urinalysis Data (From May 13, 1958 Visit) in Regards to Thoria Handling*, correspondence to Harvey Elkins; Leonard Pagnotto and Harold Bavley; May 28, 1958; SRDB Ref ID: 78700, pdf pp. 3-5