Review of ORAUT-RPRT-0060, Revision 00, "Neutron Dose from Highly Enriched Uranium"

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November 8, 2024

ORAUT-RPRT-0060

- NIOSH issued RPRT-0060, rev. 00, on March 28, 2019
- Provides neutron-to-photon (N:P) ratios for assigning neutron dose from highly enriched uranium (HEU) compounds during periods when the site's neutron dose data were not reliable, not available, or not recorded
- Sites include three gaseous diffusion plants (GDPs) and one uranium metal processing facility:
  - Oak Ridge GDP (K-25), Oak Ridge, TN (prior to 1992)
  - Portsmouth GDP (PORTS), Piketon, OH (prior to 1995)
  - Paducah GDP (PGDP), Paducah, KY (prior to 1998)
  - National Security Complex (Y-12), Oak Ridge, TN (as needed)

RPRT-0060 source of data

- Data from measured neutron and photon dose rates near storage cylinders, vaults, and monitored work areas
  - Surveyed areas contained depleted uranium (DU), natural uranium (NU), low-enriched uranium (LEU), and HEU
- Personnel photon and neutron dosimetry results

Results of neutron dose data from facilities

- **PGDP:** Neutron and photon dose measurements around cylinder painting and storage yard; average N:P ratio = 0.2. No personnel dosimetry used.
- **PORTS:** Neutron and photon dose measurements around storage cylinders, vaults, and area monitoring. However, personnel dosimetry data used; average N:P ratio = 0.369 ±0.2 from 3,727 N:P pairs.
- **K-25:** Neutron and photon dose measurements around cylinder storage yards, equipment and area monitoring surveys, also modeling studies. However, personnel dosimetry data used; average N:P ratio = 0.420 from 375 N:P pairs.
- **Y-12:** N:P ratios derived from area survey data; average N:P ratio = 0.40. RPRT-0060 used limited Y-12 personnel dosimetry data:
  - not used to determine average N:P ratio
  - 89 N:P pairs used in quantile regression analysis (QRA) for Y-12

Summary of NIOSH's application of data

- Table 5-2 of RPRT-0060 summarizes:
  - Average N:P ratios for K-25 and PORTS
  - N:P quantile regression relationships for K-25, PORTS, and Y-12
- For dose reconstruction (DR) purposes, QRA was used to yield the most accurate N:P ratios
- Recommended neutron DR methodology summarized in attachment A of RPRT-0060

Issuance of RPRT-0060 and NIOSH's 2019 White Paper

- RPRT-0060 was issued in March 2019
- NIOSH issued a white paper, "Neutron Dose Assignment for K-25 and Portsmouth Gaseous Diffusion Plants," in May 2019
- RPRT-0060 and NIOSH's 2019 White Paper contain essentially the same information

SC&A observations concerning NIOSH's 2019 White Paper

- **September 16, 2019:** SC&A issued a review of NIOSH's May 2019 White Paper
  - SC&A had no findings and three observations
- **February 6, 2020:** NIOSH responded to SC&A's three observations
- **July 13, 2020:** SC&A issued a review of NIOSH's February 6, 2020, response to the three observations and added a fourth observation
- **January 20, 2021:** NIOSH issued a response in the form of a memorandum to the GDP Work Group concerning SC&A's four observations

Observation 1: Apparent inconsistence in use of lower limit of detection (LOD)

- In 2020, NIOSH responded that the text from the May 2019 White Paper will be revised when this verbiage is added to the site profile technical basis documents (TBDs) to make their approach clear
- SC&A concurs with NIOSH's plan to use consistent LOD terminology in revised TBDs
- SC&A will review revised TBDs when available

Observation 2: Use of PORTS dosimetry values near zero

- NIOSH responded that uncensored neutron and photon dose data were available for PORTS, so were modeled as is
- SC&A concludes that NIOSH's model is a mathematically accurate method for assessing censored bioassay data in absence of other information
- SC&A considers this observation resolved and recommends closure

Observation 3: Use of standard N:P ratios versus the quantile-regression and Monte Carlo approach

- NIOSH's finds that QRA is the preferred methodology for assigning neutron dose based on photon measurements
- SC&A is currently reviewing the use of the QRA method as outlined in ORAUT-RPRT-0087 (2018)

Observation 4: Use of neutron plus photon for photon dose to calculate N:P

- SC&A found that in deriving the N:P ratio of 0.369 in table 6 of the May 2019 White Paper, NIOSH used N:P ratio = n/(n + p) instead of N:P ratio = n/p
- This would create a lower-than-normal value for N:P ratio from the PORTS data
- If the QRA method is used for DR, then the incorrect N:P ratio of 0.369 would not be used in DRs
- Either the correct N:P ratio should be derived and used in future documents, or NIOSH should clarify why the current value is correct

Observation 4 status

- NIOSH concurs with SC&A
  - Any corrections or clarifications needed will be made when the site profile TBDs are revised
- NIOSH intends to use the QRA method for determining neutron doses
  - This will be reflected in the TBDs for both PORTS and K-25 when revised
- SC&A will review NIOSH's revision of the TBDs concerning N:P ratios when available

SC&A's 2024 review of RPRT-0060

- SC&A issued its review of RPRT-0060 January 31, 2024
- SC&A's review of RPRT-0060 found that it contains essentially the same information as NIOSH's May 2019 White Paper
- SC&A's review and observations for NIOSH's May 2019 White Paper apply to RPRT-0060
- RPRT-0060 contained radiological properties of uranium materials in section 2.0, not included in the May 2019 White Paper
- SC&A reviewed section 2.0 of RPRT-0060 for technical accuracy and validity of data using appropriate references
- SC&A identified one finding and two observations concerning tables 2-1 and 2-2 of RPRT-0060

Table 2-1 of RPRT-0060

- Table 2-1 lists the composition of various uranium materials and three very HEU materials
- SC&A verified that the data were correct for percent by weight (wt %) for U-234, U-235, and U-238. However:
  - SC&A could not find that the referenced document (NAS, 2005) contained the wt % for U-233 or U-236 as listed in table 2-1
- SC&A verified the remaining data in table 2-1 and found them correct, except as outlined in new finding 1

Finding 1: Incorrect values in table 2-1 for recycled NU, LEU, and DU

- **Recycled LEU** mass fraction for U-233 is 0.00E+00 in table 5-7 of ORAUT-TKBS-0014-5 (TBD-5), whereas RPRT-0060 table 2-1 listed the wt % as <0.01 percent
- **Recycled LEU** mass fraction for U-236 is 0.00E+00 in table 5-7 of TBD-5, whereas RPRT-0060 table 2-1 listed the wt % as <0.01 percent
- **Recycled DU** mass fraction for U-233 is 0.00E+00 in table 5-7 of TBD-5, whereas RPRT-0060 table 2-1 listed the wt % as 0.001 percent
- **Recycled DU** mass fraction for U-234 is 1.000E-5 in table 5-7 of TBD-5, whereas RPRT-0060 table 2-1 listed the wt % as 0.2 percent
- **Recycled DU** mass fraction for U-235 is 2.000E-03 in table 5-7 of TBD-5, whereas RPRT-0060 table 2-1 listed the wt % as <0.0001 percent

Finding 1: Implications

- If wt % from table 2-1 are used to calculate the yield values, then the derived yield values do not match those in table 2-2
- Therefore, SC&A used the mass fraction values from table 5-7 of TBD-5 to derive yield values and compare them to the values in table 2-2 of RPRT-0060

Table 2-2 of RPRT-0060

- Table 2-2 lists neutron yields for various uranium isotopes as a function of material
- SC&A verified that the data for U-232, U-233, U-234, U-235, U-236, and U-238 (first six rows of table 2-2) are correct using the referenced document (DOE, 2009)
- SC&A evaluated the remaining data in table 2-2 and found them correct except for new observations 5 and 6, as follows

Observation 5: Clarification needed for NU, LEU, and HEU fission yield data in table 2-2

New observation concerning section 2.0:

- SC&A found that the yield values in table 2-2 for NU, LEU, and HEU (rows 7, 8, & 9) were correct, except for the spontaneous fission (SF) yield values in column 2
  - Table 2-2 SF yield values do not match the values listed in the referenced document (NAS, 2005)
  - SC&A's derived SF yield values were similar to those in the reference document

Observation 6: Incorrect information in table 2-2, footnotes b and c

New observation concerning section 2.0:

- SC&A found footnotes b and c of table 2-2 should refer to table 2-2, not table 2-1

Summary of new finding 1 and observations 5 and 6

- The new finding and two observations are concerned with background information provided in section 2.0 of RPRT-0060 that was not present in the May 2019 White Paper
- The finding and two observations would not affect neutron dose assignment recommended in attachment A, but they should be corrected or clarified

Results of SC&A's review of RPRT-0060

- SC&A reviewed RPRT-0060 and found that it contains essentially the same information as NIOSH's May 2019 White Paper
- SC&A's review and observations for NIOSH's May 2019 White Paper also apply to RPRT-0060
- SC&A's review of section 2.0 of RPRT-0060, containing background information that was not in the May 2019 White Paper, resulted in one additional finding and two observations
- In total, there were one finding and six observations

Status of finding and observations

- **Finding 1: Incorrect values in table 2-1 for recycled NU, LEU, and DU.** This is a new finding concerning section 2.0 of RPRT-0060 for NIOSH's consideration.
- **Observation 1: Apparent inconsistence in use of the lower limit of detection (LOD).** SC&A will review revised TBDs.
- **Observation 2: Use of PORTS dosimetry values near zero.** Resolved, SC&A recommends closure.
- **Observation 3: Use of standard N:P ratios versus the quantile-regression and Monte Carlo approach.** SC&A currently reviewing use of QRA.
- **Observation 4: Use of neutron plus photon for photon dose to calculate N:P.** SC&A will review revised TBDs.
- **Observation 5: Clarification needed for NU, LEU, and HEU fission yield data in table 2-2.** This is a new observation concerning section 2.0 of RPRT-0060 for NIOSH's consideration.
- **Observation 6: Incorrect information in table 2-2, footnotes b and c.** This is a new observation concerning section 2.0 of RPRT-0060 for NIOSH's consideration.

Conclusions

- SC&A's review of RPRT-0060 and NIOSH's 2019 White Paper identified one finding and six observations
- These would not impact the neutron doses assigned using the methods and values recommended in attachment A of RPRT-0060

Questions ?

References

National Academy of Sciences (NAS). (2005). *Monitoring nuclear weapons and nuclear-explosive materials: An assessment of methods and capabilities*. National Academies Press.

U.S. Department of Energy (DOE). (2009). *Guide of good practices for occupational radiological protection in uranium facilities* (DOE-STD-1136-2009). SRDB Ref. ID 97381