Review of Data Used by NIOSH in Support of OCAS-RPT-001 for Assigning NP Ratios in Behalf of the Hanford Site Single Pass Reactors

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Prepared by

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RELEVANT BACKGROUND INFORMATION

In June 2008, NIOSH issued OCAS-RPT-001 – *A Bounding Estimate of Neutron Dose Based on Measured Photon Dose around Single Pass Reactors at the Hanford Site*.

In October 2008, SC&A submitted its evaluation of OCAS-RPT-001 as part of the Hanford SEC Evaluation Review under Task Order 5. As stated in Section 5.0 of our report, SC&A concluded “. . . that the approach taken by NIOSH for amending neutron-to-photon (NP) ratios in behalf of Hanford’s single pass reactors is technically sound.”

However, this conclusion was based on limited information and was, therefore, deemed conditional. As part of our conclusion (on page 9 of the report), SC&A raised the two following issues/concerns:

(1) **Selection of Survey Data.** From among 238 boxes of available survey data, NIOSH requested 83 boxes, received 81 boxes, and found that 64 boxes contained survey data for the Hanford 100 Area production reactors. Of the 64 boxes, 57 boxes contained survey data that met the selection criteria for paired neutron and photon measurements.

*The initial request for 83 boxes from a pool of 238 boxes represents a statistically sound sample set. At this time, however, OCAS-RPT-001 provides no information regarding the process by which the 83 boxes were identified/selected.*

(2) **Selection of Paired Measurements.** NIOSH’s selection of 5,773 paired measurements provides a reasonable distribution of data in behalf of (1) individual reactors, (2) years of operation, and (3) facility location. (**Note, as part of this review, however, SC&A has not been provided the raw data that defines the 5,773 paired measurements.**)

In response to the above-cited concerns, NIOSH, on December 19, 2008, provided Dr. Melius and members of the Hanford Work Group with the “. . . supporting data file . . . used in the preparation of the report OCAS-RPT-001.”

The data file consists of an Excel® spreadsheet that represents data in behalf of 5,773 paired neutron and photon measurements that NIOSH had gleaned from survey records contained in the aforementioned 57 DOE file boxes. (Important to note here is that the supporting data file does not contain original records, but represents collated and transcribed data entered into an Excel® spreadsheet from original survey reports.)

Provided herein as Exhibit 1 are salient data (Columns H through V from the Excel® spreadsheet) for the first 271 paired NP survey measurements. Presented below are preliminary comments and questions regarding the data file that makes reference to Exhibit 1.
PRELIMINARY COMMENTS AND THE NEED FOR ADDITIONAL INFORMATION

After a cursory inspection of the 5,773 paired NP data points, SC&A has the following comments and requests for information/data clarification.

Comments:

Columns P and Q are identified as “neutron” and “photon,” respectively, but do not identify the unit(s) of measurement. However, based on Columns T, U, and V, which correspond to SN (or slow neutrons), IN (or intermediate neutrons), and FN (or fast neutrons), respectively, the metric for “neutron” is in the unit of “mrem.”

Questions:

(1) Is the metric for Columns P and Q a dose rate for both neutrons and photons that is normalized in the units of mrem/hour?

(2) How were the original neutron survey measurements recorded? Were they recorded as neutron flux (i.e., η/cm² sec) or in neutron flux dose equivalent (i.e., mrem/hr)?

(3) If either AEC/DOE or NIOSH converted neutron flux to dose equivalent values, what were the assumed quality factors for neutrons?

Comments:

Column M in Exhibit 1 identifies the metric “PWR.” SC&A assumes that “PWR” identifies the power level of the single pass production reactor at the time of the NP survey.

For many paired data entries throughout the 5,773 paired measurements, this entry is blank. For example, Exhibit 1 shows entries 2 through 84 as blanks.

In addition, it is assumed that the reactor power level directly and proportionately affects the neutron flux, but affects the photon dose rate in a more complex way (in addition to Rx power levels, the duration of reactor operation and build-up of fission and activation products is another critical variable that affects photon levels). For example, entries #271 and #272 identifies two datasets at the identical location and time for the 105 F reactor. While paired measurements for entry #271 identify a NP ratio of 0.0717, entry #272 shows the identical photon dose rate, but a 13-fold higher neutron dose rate, which proportionately raises the NP ratio to 0.9383. This difference is likely the result of a transient change of Rx power level.
Questions:

(1) What assumptions should be made for paired measurements that do **not** identify the Rx power level? Should these values be excluded?

(2) Were surveys conducted on a **fixed** routine schedule during reactor operations, or was the timing of surveys dictated by other variables that included or affected the reactor power level? For example, surveys that coincide with pulling targets at reduced power levels would bias NP ratios toward a lower value. In the absence of assigning time-weighted values to NP ratios, paired NP measurements may have to be restricted to those time periods when the reactor was operating at its normal production power level.

Comments:

As noted in OCAS-RPT-001, surveys involving **neutron** measurements at different reactors and over time involved several types of instruments, which included single and double moderated BF$_3$ detectors and the Cheng and Eng neutron detector.

Information regarding instrumentation used for **photon** dose rate measurements is **not** described in OCAS-RPT-001.

Reported dose rates for neutrons included dose rates as low 0.1 mrem/hour. Dose rates for photons were frequently reported at 1 mrem/hour.

Questions:

(1) For neutron and photon survey instruments, what were the lower limits for detection of dose rates? For example, entries #75 through #78 cite 10 mrem/hour as a minimum reportable gamma dose; however, dose rates as low as 1 mrem/hour are frequently cited elsewhere.

(2) What is the **uncertainty** of dose rate measurements for these instruments at the low end of the detection level? For example, the uncertainty of BF$_3$ neutron flux detectors is driven by counting statistics, energy distribution, etc.

Currently, OCAS-RPT-001 provides NP ratios along with geometric standard deviation value that do not include the uncertainty of the individual measurements.

Before SC&A conducts a more comprehensive and detailed analysis of the 5,773 paired survey measurements, we are requesting the Hanford Work Group to arrange a forum for the purpose of answering these and other questions.
EXHIBIT 1: EXCERPTS FROM EXCEL® SPREADSHEET DATA USED TO DERIVE NP RATIOS FOR HANFORD SINGLE PASS REACTORS

<table>
<thead>
<tr>
<th>Reactor</th>
<th>General</th>
<th>Specific</th>
<th>Date</th>
<th>Power</th>
<th>QA</th>
<th>Neutron</th>
<th>Photon</th>
<th>NP Ratio</th>
<th>Notes</th>
<th>SN (in mm)</th>
<th>IN (in mm)</th>
<th>FN (in mm)</th>
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## Exhibit 1 (Continued)

| Reactor | General | Specifications | Date | Power | Neutron | Photon | E0 Ratio | Notes | H | J | K | L | M | N | O | P | Q | R | S | T | U | V |
|---------|---------|----------------|------|-------|---------|--------|----------|-------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10DF   | Front Face | Tube 3654 | 3/2/1948 | 1498 | 275 | 80.00 | 170 | 0.00706 | 30 | 50 |
| 10DF   | Front Face | Hole 8 Max | 3/2/1948 | 1498 | 275 | 14.01 | 1.171 | 0.58574 | 8.0 |
| 10DF   | Front Face | Hole 8 Min | 3/2/1948 | 1498 | 275 | 14.01 | 1.171 | 0.58574 | 6.0 |
| 10DF   | Front Face | Hole 0 | 3/2/1948 | 1498 | 275 | 14.01 | 1.171 | 0.58574 | 4.0 |
| 10DF   | Front Face | Hole 0 | 3/2/1948 | 1498 | 275 | 14.01 | 1.171 | 0.58574 | 2.0 |
| 10DF   | Front Face | Hole 0 | 3/2/1948 | 1498 | 275 | 14.01 | 1.171 | 0.58574 | 1.0 |
| 10DF   | Front Face | Hole 0 | 3/2/1948 | 1498 | 275 | 14.01 | 1.171 | 0.58574 | 0.5 |
| 10DF   | Front Face | Hole 0 | 3/2/1948 | 1498 | 275 | 14.01 | 1.171 | 0.58574 | 0.25 |
| 10DF   | Front Face | Hole 0 | 3/2/1948 | 1498 | 275 | 14.01 | 1.171 | 0.58574 | 0.125 |
| 10DF   | Front Face | Hole 0 | 3/2/1948 | 1498 | 275 | 14.01 | 1.171 | 0.58574 | 0.0625 |
| 10DF   | Front Face | Hole 0 | 3/2/1948 | 1498 | 275 | 14.01 | 1.171 | 0.58574 | 0.03125 |
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### Exhibit 1 (Continued)

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