Draft White Paper

REVIEW OF NIOSH WHITE PAPER: NEUTRON EXPOSURES AT AREA IV OF THE SANTA SUSANA FIELD LABORATORY AND RELATED SITES

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ABBREVIATIONS AND ACRONYMS

Advisory Board	Advisory Board on Radiation and Worker Health
AETR	Advanced Epithermal Thorium Reactor
AI	Atomics International
DOE	(U.S.) Department of Energy
ER	Evaluation Report
ETEC	Energy Technology Engineering Center
GM	geometric mean
GSD	geometric standard deviation
ICRP	International Commission on Radiological Protection
IREP	Interactive RadioEpidemiological Program
keV	kiloelectron volt
MeV	megaelectron-volt, 1 million electron-volts
NIOSH	National Institute for Occupational Safety and Health
N-P	neutron-to-photon
NTA	Neutron Track Analysis
OCAS	Office of Compensation Analysis and Support
ORAUT	Oak Ridge Associated Universities Team
POC	probability of causation
rem	Roentgen equivalent man
SC&A	S. Cohen and Associates (SC&A, Inc.)
SEC	Special Exposure Cohort
SGR	Sodium Graphite Reactor
SNAP	Systems for Nuclear Auxiliary Power
SRDB	Site Research Database
SRE	Sodium Reactor Experiment
SSFL	Santa Susana Field Laboratory
TBD	Technical Basis Document
TLD	thermoluminescent
WB	whole body

1.0 STATEMENT OF PURPOSE

The purpose of this review is to examine the proposed National Institute for Occupational Safety and Health (NIOSH) model for assigning neutron doses at the Santa Susana Field Laboratory (SSFL). NIOSH's proposed neutron model is presented in the white paper entitled, *Neutron Exposures at Area IV of the Santa Susana Field Laboratory and Related Sites* (Hughes 2010). The neutron model and underlying data were evaluated for relevance to potential neutron exposures at SSFL and claimant favorability.

2.0 HISTORICAL MILESTONES LEADING UP TO THIS REVIEW

In August of 2008, SC&A submitted a draft report entitled, *Review of the NIOSH Site Profile for the Santa Susana Field Laboratory* (SC&A 2008). In the review of ORAUT-TKBS-0038-6, *Technical Basis Document for Atomics International – Occupational External Dosimetry* (ORAUT 2006, also referred to as TBD-6), SC&A identified a total of seven findings that were subsequently summarized by SC&A in the *Issues Resolution Matrix for the Santa Susana Site Profile Review*[1] and discussed by the SSFL Work Group in August 2008, April 2009, and again in April 2010. Included among seven findings pertaining to external monitoring for neutrons were **Findings 4.6-2 and 4.6-4**, which state the following:

Finding 4.6-2. Workers were unlikely to have been monitored for thermal neutrons

> *As stated in Section 6.2, "…Both fast and* ***thermal*** *neutrons were* ***measured*** *and* ***recorded*** *as whole-body (WB) dose in rem." This statement is contradicted in Section 6.4, where it states, "…It is assumed that the dose recorded was the result of* ***fast*** *neutron exposure."*
>
> *The second statement is likely to be correct, since the common practice at DOE facilities was to assess NTA film for tracks produced by proton recoil. It is unlikely that NTA dosimeters were modified and calibrated for track analysis of* ***thermal*** *neutrons. [Tracks in emulsions exposed to thermal neutrons may be produced by nitrogen in the gelatin that captures a thermal neutron and releases a 0.58 MeV proton –* $N^{14}(n, p)\ C^{14}$*.]*

Finding 4.6-4. NTA film applicability to neutrons at energies below 500 keV

> *This TBD assumes that the NTA film effectively measured all neutron exposure received at AI, and does not consider correction factors for the insensitivity of NTA to neutrons at energies below 500 keV. Actual neutron energy spectrum data is limited to a few facilities (i.e., SRE). There is no discussion of neutron-to-photon ratios in the site profile; however, it is mentioned as an option for calculating thermal neutron exposure in the ER report.*

In response to Findings 4.6-2, 4.6-4, and SSFL Work Group discussions, NIOSH issued the white paper Hughes 2010 on June 14, 2010. SC&A was asked by the Advisory Board to review Hughes 2010 as an action item arising from the April 2010 Work Group meeting.

[1] The issues matrix is a "living document" that was originally created by SC&A and has been updated several times by both NIOSH and SC&A based on Work Group discussions and any additional guidance or information that comes to light over time.

3.0 OVERVIEW OF NIOSH N-P COWORKER MODEL

NIOSH performed an extensive review of available documentation, records, and site-specific interviews that characterize neutron monitoring practices and overall radiological monitoring and control at the SSFL and related sites.[2] Based on this review, it was determined that, while there was a well-documented radiation safety program, there may have been a lack of consistent access control to prevent unmonitored workers from entering restricted radiological areas. In addition, while neutron monitoring was in place to some extent, the limitations of the monitoring technology employed at the time (NTA Film) and inconsistent application of neutron monitoring led to the decision that an alternate method needed to be developed to evaluate neutron doses to SSFL workers.

NIOSH has elected to utilize ratios of neutron-to-photon (N-P) dose, based on available survey reports from SSFL, so that individual external exposure records could be used to evaluate and bound the potential neutron dose received by individual workers. A summary of available survey reports is presented in Table 1 (recreated from Table 1 of Hughes 2010). Many of the reports were similarly structured and contained important information, such as purpose of the survey, measurement location, reactor power level, and important shielding configurations. The paired neutron and photon measurements contained in the survey reports were transcribed by NIOSH into an Microsoft Excel® file for analysis [the Excel file can be found at (O:\AB Document Review\Santa Susana\Neutron white paper files\NP data analysis worksheet_LDH_05252010.xls)]. Table 1 shows a reasonably positive correlation between the photon and neutron dose based on the Pearson (r) and Spearman (ρ) coefficients; the only exceptions are the SRE and SNAP 8 reactors, the data for which did not show a very strong correlation.

Table 1. Summary of Available Neutron-Photon Survey Reports for Various SSFL Reactor Areas (Recreation of Table 1 of Hughes 2010)

Reactor	Reactor Operating Dates	Survey Data Range	# of Data Points	Pearson (r)	Spearman (ρ)	SRDB Ref IDs for Survey Reports*
AE-6/ L-85	1955–1980	1959–1974	826	0.87	0.79	74959, 74972, 75034, 75037–75039, 75042, 75043, 75048, 75054, 75058, 75064, 75065, 75066, 75261, 75415, 75416, 75418, 75050, 75070
SNAP CTR	1962–1964	1964	2	Not Enough Data	Not Enough Data	74987
SRE	1957–1964	1963	186	0.04	0.44	74841–74846, 74849, 74850, 74852, 74854
STIR	1960–1972	1968	33	0.93	0.92	75032
SGR	1956–1967	1967	18	0.98	0.94	74999
SNAP 8	1968–1969	1969	82	0.02	0.65	77450, 77451, 77561
AETR	1960–1974	1972	21	0.97	0.71	75055
L-77	1960–1976	1964	8	0.998	0.62	77526

* Incorporated by reference in Hughes 2010.

[2] The SSFL is considered part of the Energy Technology Engineering Center (ETEC), which consisted of the Canoga Avenue Facility, Downey Facility, and DeSoto Facility in addition to Area IV of the SSFL.

In selecting an appropriate model for the N-P data, NIOSH found that the data from all reactors except the SRE, SNAP 8 and L-77 fit reasonably well to a lognormal distribution. Lognormal parameter values for the N-P data from the seven reactors are presented in Table 2. In Table 2, GM refers to the geometric mean and GSD to the geometric standard deviation. It was determined that data from SRE, SNAP 8, and L-77 would be omitted from the analysis because they did not fit the lognormal model. In addition, NIOSH considered it claimant favorable to exclude these data, since most N/P values associated with those three reactors were less than 1.

Table 2. Lognormal Fit of N-P Data for Individual Reactors

Reactor	GM	GSD	Upper 95th Percentile
AE-6/ L-85	1.73	2.76	9.22
SRE	**0.24**	4.91	3.32
STIR	1.07	2.07	3.54
SGR	5.73	1.42	10.19
SNAP 8	**0.45**	8.92	16.46
AETR	1.23	2.41	5.2
L-77	**0.60**	6.84	14.29

Source: Hughes 2010, Table 2

The remaining data were fit to a lognormal distribution with a GM of 1.73, a GSD of 2.76, and a 95th percentile value of 9.18. Hughes 2010, page 9, instructs the dose reconstructor to apply this distribution in the following manner:

> *The neutron to photon ratio should be applied to all workers at SSFL sites who worked in or near the reactor areas and who were expected to have been exposed to neutron radiation in addition to photon radiation, regardless whether they were issued a radiation monitoring badge for neutrons or photons… The distribution should be multiplied by the measured and missed photon dose (or coworker dose if unmonitored worker* [sic] *suspected of exposure) using Monte Carlo combination methods.*

NIOSH indicates that any existing neutron monitoring records for a specific worker should be analyzed individually by the dose reconstructor to determine the claimant favorability of using existing data over the aforementioned approach.

4.0 DETAILED REVIEW

This section provides detailed discussions of the following seven areas of focused investigation in the SC&A review:

- Sources of Data Utilized in N-P Ratio Development
- Comparison of Rank Ordered N-P Ratios to Lognormally Fit N-P Ratios
- Comparison of N-P Ratio Data by General Area of Survey Measurement
- Selection of Neutron Survey Data When Multiple Paired Measurements Exist
- Omission of Data from Three Reactors
- Age of the Reactor Core at Time of Survey
- Use of Latest International Commission on Radiological Protection (ICRP) Guidance on Radiation Weighting Factors

4.1 SOURCES OF DATA UTILIZED IN N-P RATIO DEVELOPMENT

Although the NIOSH coworker model uses data from five reactors (comprising 911 data points), more than 90% are from the AE-6/L-85 reactor. This would obviously be of concern if the N-P ratios for that facility were generally lower than those for the other reactor facilities, as the site-wide N-P distribution parameters that are derived from the data would not be claimant favorable. SC&A rank-ordered the N-P ratios for the AE-6/L-85 reactor area, as well as the other reactor areas used in the NIOSH analysis, to determine how the AE-6/L-85 data might bias the overall results. The rank-ordered survey data are shown in Figure 1.

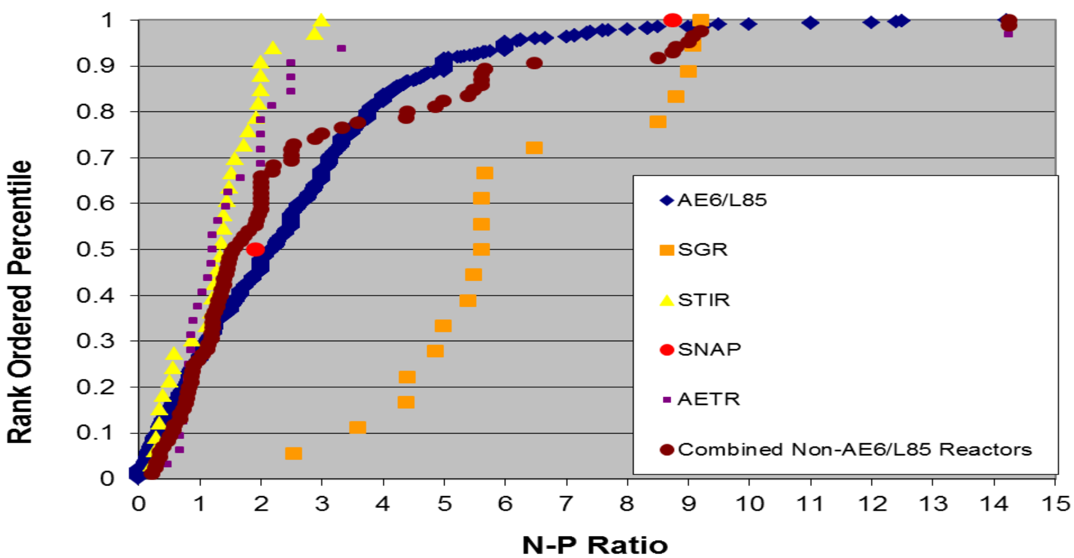

Figure 1. Rank-Ordered N-P Data by Reactor

As seen in Figure 1, the AE-6/L-85 reactor N-P ratios are generally limiting (i.e., higher) when compared to three of the four other reactors. Although the SGR reactor had higher N-P ratios than the AE-6/L-85, that survey was based on a set of 18 measurements taken on a single day in 1967 at various locations outside the reactor building and distant from normal work locations. In addition, the SGR reactor ceased operating in 1967. Thus, its N-P data may not represent typical operations and neutron exposure potential through the relevant portion of the post-SEC period (1965 through 1987). It is also worth noting that the SGR data were taken with the more conservative Eberline PNC-1 neutron detector, while most of the AE-6/L-85 measurements were taken with the less conservative Ludlum Tissue Equivalent detector. The differences in measured neutron dose rates between these two types of detectors are further discussed in Section 4.4.

When comparing the AE-6/L-85 data to the data for the four other reactors combined, the AE-6/L-85 is limiting from about the 20th percentile to the 80th percentile. Therefore, it does not appear that the AE-6/L-85 data unduly bias the derived site-wide N-P ratio distribution.

4.2 COMPARISON OF RANK ORDERED N-P RATIOS TO LOGNORMALLY FIT N-P RATIOS

SC&A performed a simple rank order of the raw data to see how the lognormally fit values compare at the 50th and 95th percentile. The resulting comparison is shown in Figure 2. As seen in Figure 2, the rank ordered 50th percentile N-P ratio is higher (2.07) than the lognormally fit 50th percentile (1.73), which represents approximately a 20% increase over the white paper value. Conversely, the rank ordered 95th percentile is lower (6.25) than the lognormally fit 95th percentile (9.16), which represents a 33% decrease over the white paper value. Therefore, when comparing the data to the lognormal model, the simple rank ordering of the data appears to be more claimant favorable at the 50th percentile, while the fitted values are more claimant favorable at the upper end of the distribution.

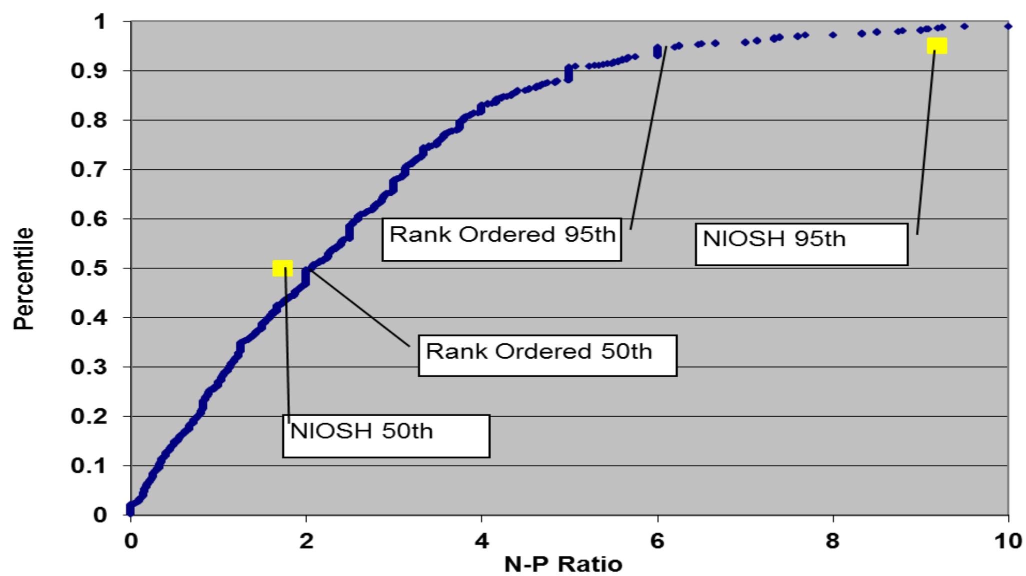

Figure 2. Comparison of NIOSH White Paper 50th and 95th Percentile Values with the Rank-Ordered Raw Data

In summary, it appears that for the NIOSH model, a slightly lower fitted median value is compensated by the higher 95th percentile, and results in a generally claimant-favorable neutron dose distribution for the purposes of assessing probability of causation (POC) in the Interactive RadioEpidemiological Program (IREP).

4.3 COMPARISON OF N-P RATIO DATA BY GENERAL AREA OF SURVEY MEASUREMENT

The location where survey measurements were taken is an important factor to consider when analyzing and developing realistic or bounding neutron exposures. For example, if the survey measurements were taken directly on the reactor face, then the resulting N-P ratio is likely to be smaller because of the large unattenuated gamma fluence that close to the reactor. Additionally, this would not be consistent with a normal working configuration for workers. Conversely, if the measurements were taken outside of the reactor building, such as around an exclusion fence, the N-P ratio is likely to be higher due to increased attenuation of the gamma component from shielding from the reactor building walls and other obstructions. Ideally, the survey measurements would be taken in established working areas, such as the reactor control room or other surrounding work areas of the building.

In order to gain insight into where the survey measurements were taken and what implications that might have on a site-wide N-P ratio, SC&A compiled general location data from the original survey reports. Survey locations were classified in three general categories: outside the reactor building, within a structure adjacent to the reactor building,[3] and normal working locations within the reactor building.

A summary of the number of measurements in each category is shown in Table 3. Of the 911 data points used in the coworker model, approximately76% were measured outside the reactor building, about 9% were taken in an adjacent structure and only about 13% were taken in a typical working location of the reactor building. It is not surprising that a comparison of the magnitude of N-P ratios by location show that the measurements taken outside the reactor building are limiting.

Table 3: Locations of Measurement Samples Used in White Paper

Location	Number of Samples	Percentage of Total
Outside and Away from Reactor Building	541	59.4%
Directly Outside Reactor Building	153	16.8%
In Adjacent Structure	78	8.6%
Work Area in Reactor Building	117	12.8%
Other/Unknown Location	22	2.4%

The samples in each category were also rank ordered to determine the magnitude of the N-P ratios in each location category; the results are shown in Figure 3.

[3] Some AE-6/L-85 surveys contained data labeled for the 'KEWB Office,' the KEWB reactor was located in a building adjacent to the AE-6/L-85 and operated up until 1966. It has been assumed that the KEWB Office was located within the KEWB reactor building. Reports containing survey data for the KEWB reactor prior to its permanent shutdown in 1966 contain the heading, "Weekly Doses from the AE-6 in the KEWB Office," so it is unclear if the KEWB reactor operations contributed to the listed doses in AE-6/L-85 work spaces.

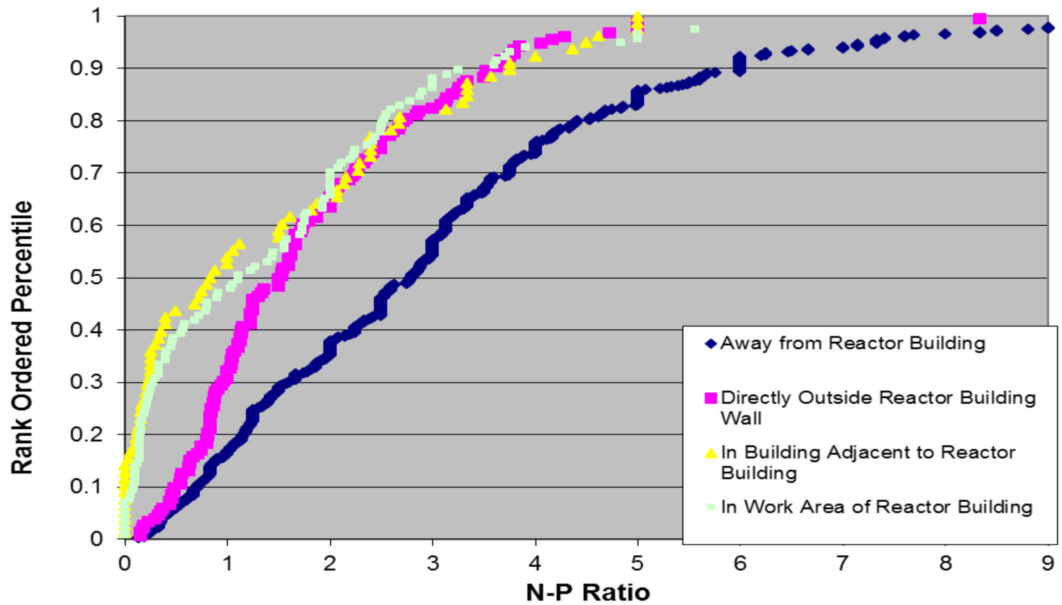

Figure 3: Rank-Ordered N-P Ratios by Measurement Location

It is evident from Figure 3 that the measurements that were taken outside and away from the reactor building resulted in the highest N-P ratios, for the reasons cited above. While locations outside of the reactor building are not considered to be a realistic or consistent work location, the fact that the majority of samples under consideration are taken in such areas will bias the resulting site-wide N-P ratio in the claimants' favor.

4.4 SELECTION OF NEUTRON SURVEY DATA WHEN MULTIPLE PAIRED MEASUREMENTS EXIST

It was found in at least two reports (Owen 1971and SSFL 1968) that neutron dose rates were measured using two different survey meter types (Ludlum Tissue Equivalent Neutron Meter and the Eberline PNC-1 Neutron Meter) at the same time and location. The Eberline PNC-1 meter provided doses for both thermal and fast neutrons, while the Ludlum meter provided only a single neutron dose rate. In these cases, it appears that only the results from the Ludlum were used in the development of the N-P ratio, though the Eberline PNC-1 dose rates were consistently higher. There were 50 such paired measurements from the two identified reports and the neutron dose rate from the Eberline PNC-1 meter was, on average, approximately **3 times higher** than the Ludlum Tissue Equivalent meter. In only one instance did the Ludlum neutron result surpass the Eberline measurements.

Figure 4 shows the magnitude of the ratio of the Eberline to Ludlum results, ranked from lowest to highest, for all 50 neutron measurement pairings.

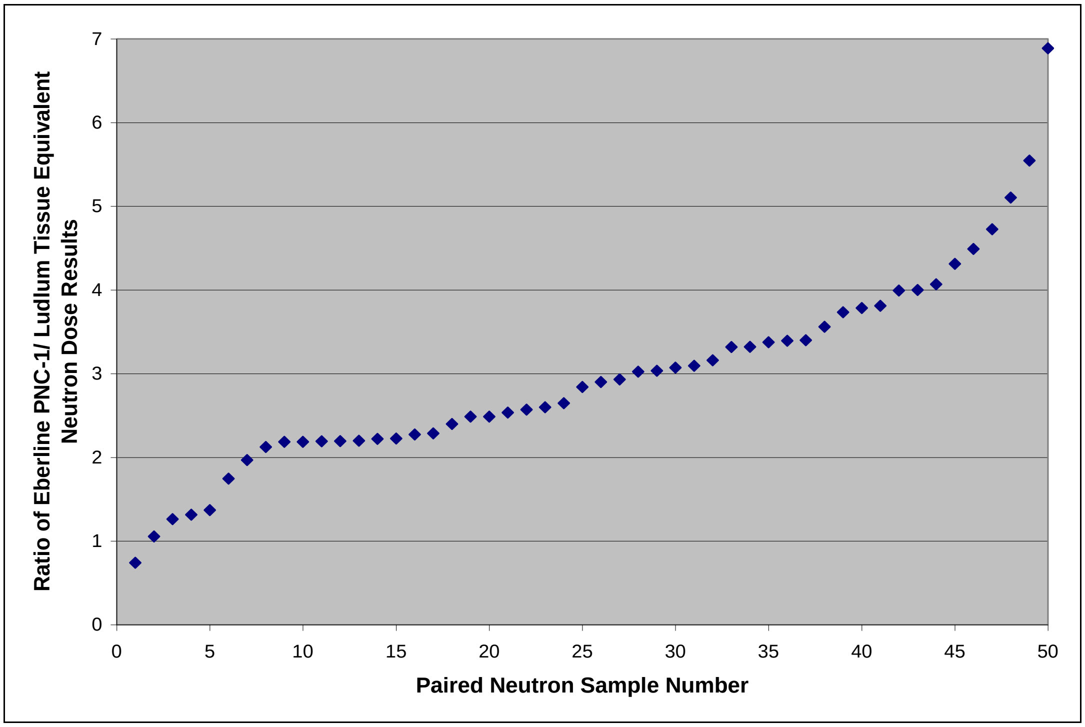

Figure 4: Ratio of Neutron Dose Rates (Eberline PNC-1 Neutron Detector/Ludlum Tissue Equivalent)

Because the Eberline PNC-1 neutron measurements are typically higher than the Ludlum Tissue Equivalent results and there is no apparent technical reason to reject the Eberline measurements, it would be claimant favorable to choose the Eberline measurements over the Ludlum measurements. NIOSH provides no justification as to why the Ludlum Tissue Equivalent results were used while the Eberline PNC-1 results were ignored. It would seem prudent to at least include both sets of measurements when developing a site-wide neutron/photon ratio. It is worth noting that results from an Eberline PNC-1 meter were accepted in the analysis when there were no available Ludlum neutron measurements. An example of where Eberline readings were used in the analysis is found in Klostermann 1967for the SGR reactor which, not surprisingly, is the limiting reactor out of those used in the analysis (see Figure 1, Section 4.1).

Finding

In summary, when measurements from two different types of neutron survey instruments were available, NIOSH chose to use measurements from the less conservative Ludlum Tissue Equivalent neutron meter in developing the neutron exposure model. SC&A believes that NIOSH should provide justification as to why the less claimant-favorable neutron measurement technique was deemed more appropriate for these data.

Observation

SC&A believes it is noteworthy to comment on the issue of intrinsic bias and uncertainty in the individual neutron and gamma data pairs. Hughes 2010 does not address the intrinsic bias and uncertainty in the N-P ratios that arise from factors such as instrument response characteristics and variations in measurement technique among operators. A review of ORAUT-TKBS-0038-6 (ORAUT 2006) and OCAS-IG-001 (OCAS 2006) Section 3.2.2.3, "Neutron Dose Reconstruction – Survey Data - Uncertainty," revealed that both documents are silent on intrinsic bias and uncertainty in survey data, though the subject is covered in detail for film badge and thermoluminescent (TLD) dosimeters. Given NIOSH's recommendation to use Monte Carlo methods, bias and uncertainty factors unique to this dataset could be derived and incorporated in the algorithm for neutron dose calculation. The introduction of a new uncertainty term would increase the GSD to some extent, and result in a more credible and claimant-favorable neutron dose distribution.

4.5 OMISSION OF DATA FROM THREE REACTORS

As described in Section 3, data for three reactors (SRE, L-77, and SNAP 8) were omitted in developing the site-wide N-P ratio distribution. The rationale provided was that the data did not fit the lognormal distribution, which was the basis for the site-wide N-P distribution. SC&A examined the data from these three omitted reactors to determine how the N-P ratios compared to the derived values presented in the NIOSH white paper.

All surveys for the SRE reactor were taken directly on the core face and therefore do not represent a normal working configuration for the purposes of dose assessment. Because the surveys were taken so close to the actual reactor core, the resulting N-P ratios are all very small, with only 4 of the 186 N-P ratios above the NIOSH-derived 50th percentile of 1.73. One of these four measurements appears to be the result of data being entered into the wrong fields and is likely a typo; the other three N-P ratios ranged from 2-2.5, which is well below the NIOSH-derived 95th percentile of 9.18.

The L-77 reactor had only eight N-P ratio data points, all of which were below the NIOSH 95th percentile. The rank-ordered 50th percentile N-P ratio for the L-77 reactor was only 0.16 and only three N-P ratios were greater than the NIOSH-derived 50th percentile. Of those three values, two were taken at locations labeled 'N. Port' and 'S. Port' which do not appear to be routine work locations, though the third value was taken in a doorway that is assumed to be a normal work area.

When reviewing the survey report for the L-77 (Wildanger 1964), it was found that neutron dose data were provided for three separate energies: 'thermal,' '1 MeV,' and '2.5 MeV.' When NIOSH compiled data from this report, the '2.5 MeV' dose rate data were considered for the fast neutron component and the '1 MeV' dose rate data were ignored.

Finding

SC&A believes that NIOSH should provide justification as to why the '1 MeV' neutron dose was not considered when analyzing the N-P ratios for this reactor. For example, NIOSH could have added the '1 MeV' and '2.5 MeV' dose rates together to obtain the combined "fast neutron" component. If the two fast neutron components are added, this results in an 89% increase in total neutron dose on average, which almost doubles the resulting N-P ratios for the L-77.

The SNAP 8 reactor had 82 N-P ratio data points associated with it. Of the 82 values, 26 (or about 32%) were zero, in that there was a positive gamma dose, but no associated neutron dose. There were also about eight measurements that indicated a positive neutron dose with no associated gamma component (these were incorrectly entered as an N-P ratio of '0' in the NIOSH compilation). If both of these sets of 'zero' measurements are excluded, the rank-ordered 50th percentile N-P ratio for the remaining data is 0.96, which is well below the derived NIOSH median of 1.73. If the correctly transcribed 'zero' N-P ratios are included, the 50th percentile drops to 0.051, though this omits the 'infinite' N-P ratios where there was a positive neutron result with no gamma component.

Figure 5 shows the rank-ordered N-P ratios if the data from the three reactors omitted from the analysis are included with the main data. While the two curves closely match one another for both datasets, one can see that the N-P ratios are slightly higher (up until about the 95th percentile) if those three reactors are omitted from the analysis. Thus, it appears that omitting the data from these three reactors has negligible impact on the overall modeled N-P distribution.

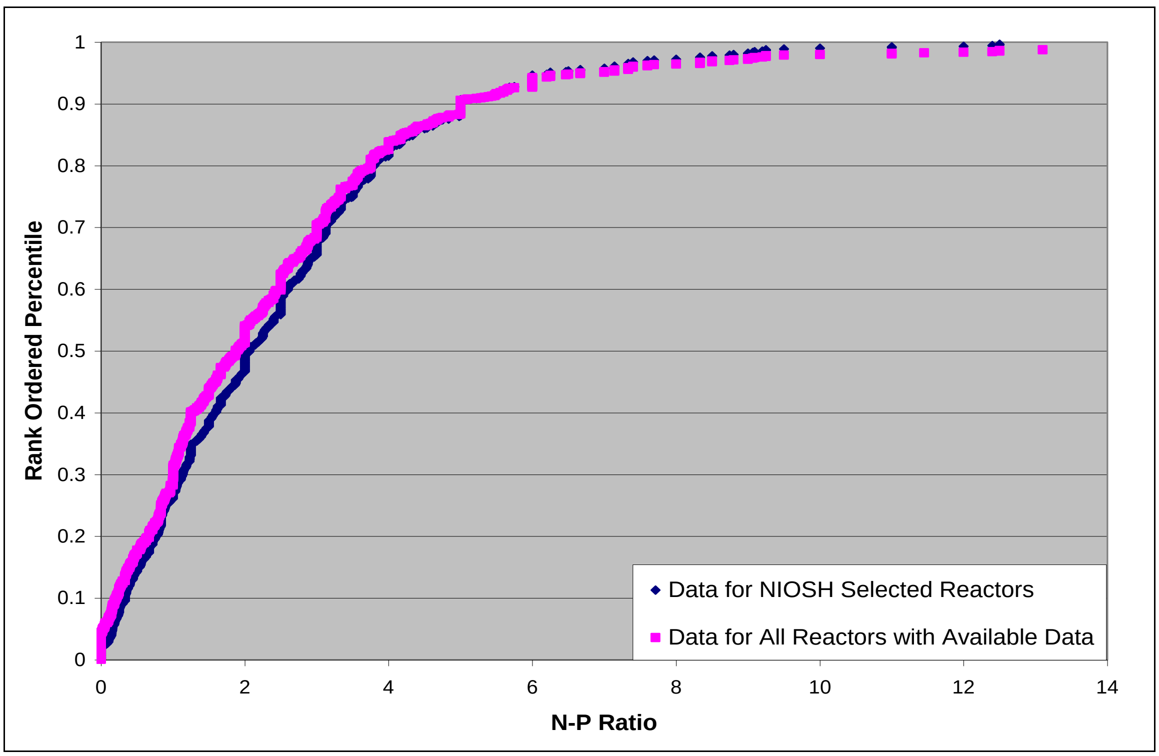

Figure 5: Comparison of White Paper N-P Data versus the Same Data if the Omitted Reactors were Included

4.6 AGE OF THE REACTOR CORE AT TIME OF SURVEY

An important factor to consider when evaluating survey reports and developing a site-wide N-P ratio from neutron and photon dose measurements is the age of the reactor core. It is logical to assume that a reactor core being operated at the start of its lifecycle will have a higher N-P ratio than that same core operating later in its lifecycle. This owes to the fission products that build up over time and give rise to an increased gamma component, while the neutron component remains largely unchanged. Unfortunately, the currently available survey data are not sufficient to quantify this effect because of the large variations in survey locations, operating power and shielding configurations in the available survey reports. That is, it was not possible to identify a sufficient subset of data that used the same survey location, shielding configuration and had multiple samples across a significant period of time.

Information is provided in the NIOSH white paper, as well as the TBD, as to what years the given reactors were operating. However, specific information on any potential reactor core change-outs has not been uncovered. Figure 6 presents the distribution of N-P sampling dates based on the year of operation for each particular facility. As seen in the figure, the majority of sampling (over 78%) occurred in the 15th year of the reactor facility's operational history or later. It would be beneficial to obtain documentation that describes the reactor operations and lists core lifecycles/change-outs for the reactors used in the analysis (particularly the L-85/AE-6 reactor, as this represents the majority of data used).

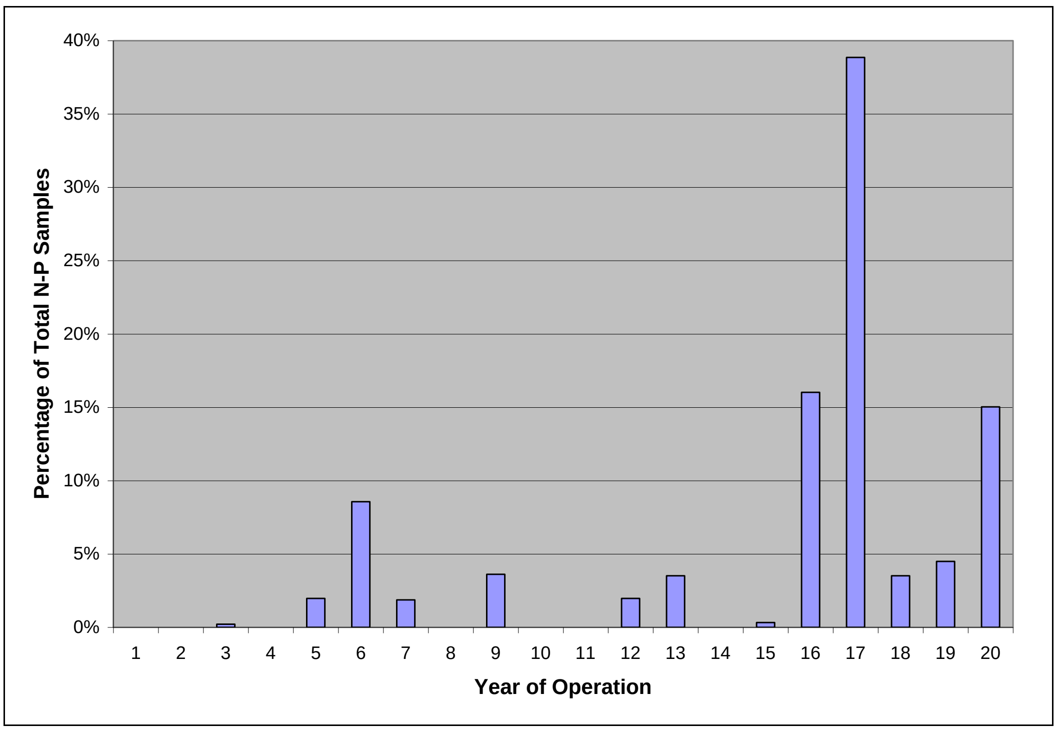

Figure 6. Distribution of N-P Samples by the Year of Operation

4.7 USE OF LATEST ICRP GUIDANCE ON RADIATION WEIGHTING FACTORS

It is not clear from Hughes 2010 or from TBD-6 (ORAUT 2006) what quality factors were applied to the historic neutron dose measurements used in the N-P modeling effort. OCAS-IG-001 (OCAS 2006) states that, "Generally, since the 1950s, a quality factor of 10 has been applied to fast neutron exposures, however this has varied from 5 to 20 across facilities and time frames."

Table 4 provides historical information on quality factors, based on early radiation protection guidance documents and updated radiation weighting factors recommended in the most recent ICRP guidance. The neutron dose data presented in the N-P reports do not appear to have been adjusted for updated radiation weighting factor during model development. It is most likely that the data used in N-P ratio modeling included a quality factor of 10. As is evident from Table 4, current methods, per ICRP Publications 60 (ICRP 1991) and 103 (ICRP 2008), assign a higher weighting factor of 20 for many fast neutron energies.

Table 4: Neutron Quality Factor and Radiation Weighting Factors

Guidance Document	Energy Range	Q, W_R
Neutrons – (10 CFR Part 20, ICRP 26)	Thermal	2
	0.01 MeV	2.5
	0.1 MeV	7.5
	0.5 MeV	11
	1 MeV	11
	10 MeV	6.5
	Unknown	10
Neutrons (ICRP 60, 103)	< 10 keV	5
	10 to 100 keV	10
	> 100 keV to 2 MeV	20
	> 2 MeV to 20 MeV	10
	> 20 MeV	5

Finding

SC&A believes that NIOSH should provide guidance to the dose reconstructors on the use of radiation weighting factors.

5.0 OTHER NOTEWORTHY OBSERVATIONS

This section presents some commentary on other observations identified by SC&A during our review of the NIOSH white paper that were not directly addressed in Section 4.

- Measurements that yielded no positive values for either gamma or neutron in a given survey were omitted from the analysis, which is logical when attempting to characterize potential neutron exposures, and favorable to the claimant (Examples: Swanson 1960 and 1961).

- The L-85/AE-6 reactor had 19 measurements entered into the database as an N-P ratio of '0.' Eighteen of the 19 are correctly labeled, because there was a positive gamma result coupled with a neutron result that was zero. However, 1 of the 19 results input into the NIOSH database as '0' contained a positive neutron result with a 0 gamma result, which is incorrect. Similarly, the SNAP-8 reactor had 34 N-P ratios input into the NIOSH database as '0;' however, 8 of the 34 were incorrectly labeled as '0' when there was a positive neutron component and a 0 gamma component. Note, however, that the SNAP-8 reactor was omitted from the development of a site-wide N-P ratio in Hughes 2010. (Examples: Swanson 1960, Miller 1960, Owen 1970.)

- Three survey measurements for the AE-6 reactor on February 7, 1969, could not be traced back to their listed reference (Johnson 1970). It is not clear from where these data points originated.

- Three of the available survey reports contained additional neutron and gamma monitoring data obtained from film badges placed in working locations within the reactor building. These data were not compiled or considered in developing the site-wide N-P ratios. SC&A recognizes that the NTA film would not have been used to develop N-P ratios due to its limitations, as acknowledged in Hughes 2010. However, the badge data might prove useful in corroborating some gamma survey data and, in comparison to neutron survey data, could help estimate the impact of NTA film insensitivity to low energy neutrons.

- Owen 1972 contains 11 additional data points not compiled in the NIOSH database for the AETR facility that were handwritten on a map of the facility (last page of document). If the handwritten data are included for the AETR, the rank ordered 50th percentile N-P ratio for the AETR facility increases by 40%.

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