Draft

ADVISORY BOARD ON
RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

REVIEW OF PETITION EVALUATION REPORT FOR SEC-00224, ARGONNE NATIONAL LABORATORY-WEST REGARDING THE USE OF GENERAL AREA AIR SAMPLING FOR INTERNAL DOSE ASSESSMENT

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ABBREVIATIONS AND ACRONYMS

ABRWH	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
ANL-W	Argonne National Laboratory-West
BZ	breathing zone
CAM	continuous air monitor
cfm	cubic feet per minute
CFR	*Code of Federal Regulations*
Cs	cesium
DAC	derived air concentration
DOL	U.S. Department of Labor
dpm/m^3	disintegrations per minute per cubic meter
EBR-II	Experimental Breeder Reactor-II
EE	energy employee
FCF	Fuel Cycle Facility
GA	general area
HFEF	Hot Fuel Examination Facility
H.P.	Health Physics
IAEA	International Atomic Energy Agency
INEL	Idaho National Engineering Laboratory
µCi/cm^3	microcurie per cubic centimeter
µCi/ml	microcurie per milliliter
MAP	mixed activation products
MFP	mixed fission products
MPC	maximum permissible concentration
Na	sodium
NIOSH	National Institute for Occupational Safety and Health
NUMEC	Nuclear Materials and Equipment Corporation
Pu	plutonium
PuO_2	plutonium oxide
SEC	Special Exposure Cohort
Sr	strontium

SRDB	Site Research Database
TAN	Test Area North
Th	thorium
ThO_2	thorium oxide
TREAT	Transient Reactor Test Facility
TRU	transuranic
U	uranium
UO_2	uranium oxide
ZPPR	zero power plutonium reactor

1.0 RELEVANT BACKGROUND INFORMATION

1.1 FUEL CYCLE FACILITY OPERATIONS

The Fuel Cycle Facility (FCF) performed radiological activities from July 1963 through 1979 and beyond. The FCF was constructed as a pyrometallurgical reprocessing plant to meet the Experimental Breeder Reactor-II's (EBR-II's) nuclear fuel needs by reprocessing the breeder reactor's fuels.

Steps to the pyrometallurgical reprocessing process took place in the FCF's two hot cells (i.e., the Air Cell and Argon Cell). The Hot-Line included processes for disassembling, refining, refabricating, and reassembling EBR-II fuel subassemblies.

This irradiated fuel process was referred to at the FCF as Hot-Line fuel production. By 1969, the FCF had successfully completed its mission of demonstrating the processing and recycling of spent fuel to support EBR-II reactor operations. As a result, the FCF's Hot-Line was phased out, and the Air and Argon Cells would only be used for shipping, inspecting, and testing irradiated reactor fuels. In support of EBR-II reactor operations, the FCF handled, packaged, and shipped spent fuels to the Idaho Chemical Processing Plant for reprocessing and packaged blanket and reflector subassemblies for disposal. The FCF also provided interim and post-irradiation handling, along with destructive and nondestructive examinations of fuel and material experiments.

1.2 RADIONUCLIDES OF RELEVANCE TO INTERNAL EXPOSURES AT THE FCF

The following categories of radionuclides that may have contributed to internal exposures include the following:

- Mixed fission and activation products
- Plutonium (Pu-238, -239, -240, -241, -242)
- Uranium (U-232, -233, -234, -235, -236, -238)
- Thorium (Th-228, -230, -232)
- Other actinides
- Other radionuclides (tritium, carbon-14, sodium-22 [Na-22], Na-24)

Important to note and relevant to the interpretation of air sampling data discussed below is that while <u>most</u> dispersible sources of <u>plutonium</u> and <u>thorium</u> were present with mixed fission products (MFPs), <u>freshly</u> chemically separated Pu and Th would <u>not</u> have appreciable levels of MFPs. In contrast, the <u>majority</u> of dispersible forms of uranium was <u>without</u> MFPs.

1.3 MONITORING FOR INTERNAL EXPOSURES

Section 5.1.6.3 of ORAUT-TKBS-0007-5, Revision 03, *Idaho National Laboratory and Argonne National Laboratory – West – Occupational Internal Dose*, provides a timeline of summary data pertaining to available internal monitoring, including the following statement:

> ***Routine bioassay*** *of radiation workers has occurred since the beginning of site operations. However, formal documentation of the bioassay programs was* ***not found for periods before 1981***. [Emphasis added.]

The term "routine bioassay," as used above, was limited in number and performed under restrictive conditions, as given by the following statement:

> *In general, workers were* ***asked*** *to submit to bioassay measurements whenever they were in an area where a* ***CAM*** [continuous air monitor**]** ***alarm sounded***. *In addition, the* ***fixed location*** *and retrospective air-sampling system signaled the need for bioassay if elevated air sample results were detected.* [Emphasis added.]

The role of air monitoring for the protection of workers from internal exposures was further explained in the following statements:

Section 5.1.6.2 of ORAUT-TKBS-0007-5 states:

> *The monitoring of radioactivity in the air in occupied areas was a basic element of the internal exposure* ***prevention program***. *Beta/gamma-detecting* ***CAMs*** *were used from the beginning of all facility and program operations in routinely occupied areas….the primary contaminant radionuclides by activity were either MFPs or MAPs, which were beta/gamma emitters with maximum permissible concentrations/derived air concentrations (MPCs/DACs) above 1E-09 µCi/cm^3*.
> ***TRU materials*** *and* ***uranium*** *were available at some of the INEL facilities, but they were nearly always well-tagged with beta/gamma-emitting radioactivity that allowed beta/gamma-detecting CAMs to be used to warn of possible* ***alpha*** *contamination or internal exposures*. [Emphasis added.]

Section 6.3 of the SEC-00224 petition evaluation report (NIOSH 2016) states:

> *…ANL-W used air sampling and radiological contamination monitoring programs as* ***qualitative indicators*** *of internal exposures, with* ***routine bioassay*** *programs serving as verification programs that internal exposures had not occurred.*
>
> *…The monitoring of radioactivity in the air in occupied areas was a fundamental component of the internal exposure control program. Beta/gamma CAMs were used from the beginning of all facility and program operations in routinely-occupied areas. The CAM systems provided real-time air-activity evaluations while fixed air samplers provided retrospective data and an average air concentration in an area or building.*
>
> *…The conventional air-sampling units used were continuously-operating devices sampling at relatively low flow rates. Typical units sampled room air at 2 cfm on 2-in.-diameter HV-70 or Millipore filters. Samples were removed daily, Monday through Friday, and counted for alpha and beta-gamma activities.*

Section 7.2.2.2 of the SEC-00224 petition evaluation report (NIOSH 2016) states:

> *…In the instances where the air samples were counted for alpha radioactivity more than once due to the presence of short-lived alpha-emitting radionuclides, the **latest** result for gross alpha radioactivity will be used….* [Emphasis added.]

1.4 OVERVIEW OF NIOSH'S APPROACH FOR THE RECONSTRUCTION OF INTERNAL DOSES AT THE FCF POST-1957

Fission and Activation Products. Based on Argonne National Laboratory-West's (ANL-W's) bioassay program after 1957, the National Institute for Occupational Safety and Health (NIOSH) believes that it has sufficient in-vitro and in-vivo bioassay data to allow for sufficiently accurate estimation of internal doses attributable to mixed fission and activation products for EBR-II/FCF Complex workers during the entire period that radiological operations took place.

Actinides with Mixed Fission Products. For the majority of instances where MFPs accompanied actinides, intake levels of actinides will be estimated by multiplying the bioassay assessed strontium-90 (Sr-90) and/or cesium-137 (Cs-137) intakes by actinide-to-Sr-90 and/or actinide-to-Cs-137 ratios.

Uranium, Thorium, and Plutonium without Fission Products. Due to the availability of extensive air sampling data, NIOSH believes that air sampling data are sufficient for bounding internal radiation doses to uranium, thorium, and plutonium by means of the following criteria:

- Uranium. For some EBR-II facilities and exposure to uranium without MFPs, intakes will be bounded by using 10% maximum permissible concentration (MPC_{air}) values from available air monitoring data.

  At the FCF, estimates of internal dose to uranium (without MFPs) for the time period between August 1967 and June 1983 will be based on inhalation intakes using gross alpha radioactivity of air samples. (Note: After July 1983, bioassay, when available, may be used instead of air monitoring data.)

- Thorium. During the period of 1963–1967, dispersible thorium without MFPs may have exposed workers at the FCF in Room 205 due to the use of thoria (thorium dioxide [ThO_2]) to coat crucibles and molds for the FCF's hot line. For this period, NIOSH intends to bound potential intakes of thorium by assuming intakes at 10% of the MPC_{air} that ANL-W was using.

- Plutonium. The plutonium-bearing Mark-II loops that were handled at the FCF mostly contained enriched uranium oxide (UO_2) with lower quantities of plutonium oxide (PuO_2). But due to the much shorter half-life of plutonium (and, therefore, the higher specific activity of plutonium), NIOSH will conservatively assume that 100% of gross alpha activity represents plutonium. Using available records that identify each period when plutonium-bearing loop experiment test sections were handled in FCF Rooms 22 and 27, acute intakes for plutonium will be estimated from corresponding available air sample data. For chronic plutonium intakes, NIOSH simply states that "…chronic intakes will be assessed as a bounding approach with specifying a method such as a fraction of the MPC_{air} value for Pu."

1.5 SUMMARY CONCLUSIONS

Based on statements presented above, internal dose assessment for FCF workers post-1957 will be derived using the following data:

1. For fission and activation products, internal dose is based on in-vitro and in-vivo bioassay data.

2. For all actinides (that include uranium, thorium, and plutonium) associated with MFPs, internal doses are derived by multiplying the bioassay-derived intakes of Sr-90 and/or Cs-137 with actinide-to-Sr-90 and/or actinide-to-Cs-137 ratios. Thus, internal doses for actinides are derived indirectly from bioassay data that reflect in-vitro urinalysis data and/or in-vivo whole body counting.

3. For uranium and thorium without MFPs, bounding estimates of internal exposures are based on 10% of the MPC_{air} values that ANL-W used.

4. For plutonium without MFPs, acute internal doses are based on available air sample data. For chronic exposures, intakes will be assessed using a bounding approach.

Relevant to this report is NIOSH's proposed use of air monitoring data for the assignment of internal dose to FCF workers exposed to uranium, thorium, and plutonium without the presence of MFPs.

2.0 REVIEW OF FCF AIR SAMPLING DATA THAT MAY BE USED FOR DERIVING INTERNAL DOSE

Air sampling data for Room 25. During the period of the FCF Hotline fuel production between August 1963 and November 1967, ThO_2 was used to coat crucibles and mods in Room 25 as a refractory coating. NIOSH's SEC-00224 petition evaluation report provides the following example of air sampling data that may be used for assigning a bounding value for Th intake (NIOSH 2016):

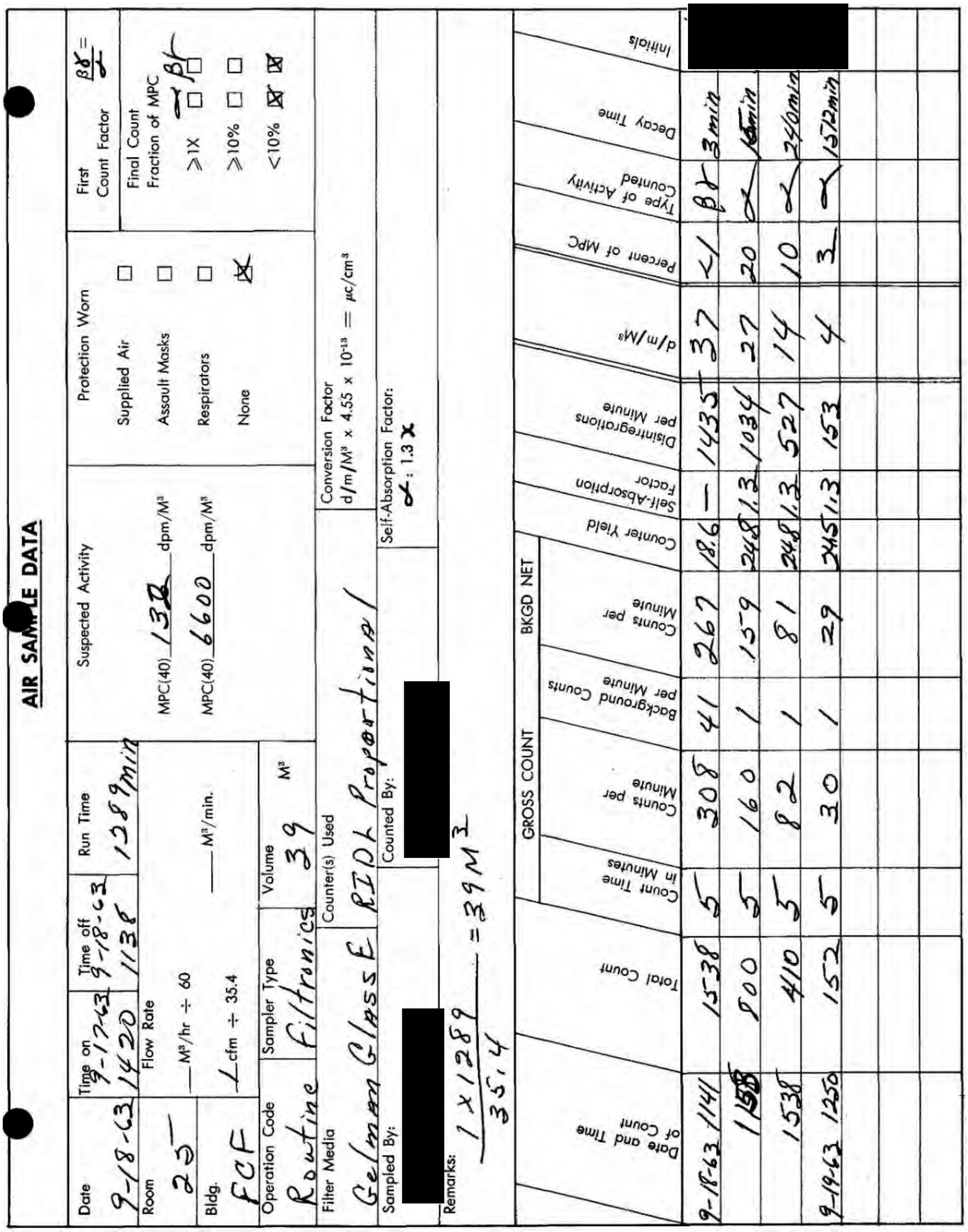
> *Figure 7-2 provides an example of a 1963 air sample result for FCF Room 25. During the collection period for this sample, some thoria was spilled on the floor from one of the hoods in Room 25 (FCF Survey Reports, 1963).*

Figure 1 shows the air sampling data referenced in the preceding quotation as Figure 7-2. Inspection of Figure 1 identifies the following information/sampling parameters:

- The "routine" air sampling started at 2:20 p.m. on September 17, 1963, and terminated at 11:38 a.m. on September 18, 1963, for a total air sampling time of 1,289 minutes (21.5 hours).
- With an air flowrate of 1 ft^3/minute, the total air volume sampled was 39 m^3, which corresponds to an air flow rate of 1.81 m^3/hr.
- The air sample was counted for alpha activity following three decay times of 15 minutes, 240 minutes, and 1,512 minutes.
- With the decay of short-lived alphas, a final decay time of 1,512 minutes (or 25.2 hours), the residual alpha of thorium activity on the filter media corresponded to 4 disintegrations per minute per cubic meter (dpm/m^3) or 3% of the MPC_{air} for a 40-hour per week exposure (MPC(40)). (Note: MPC_{air} for thorium natural is given in Appendix B of 10 CFR 20 as 6×10^{-11} microcurie per milliliter, which converts to 133.2 dpm/m^3.)

Figure 7-2 of the SEC-00224 petition evaluation report, as shown in Figure 1, is 1 of 11 "routine" air samples taken for the month of September 1963 along with 3 "special" air samples, which reflect the assessment of a ThO_2 floor spill on September 18, 1963. Air sampling data sheets for the 11 routine and 3 special air samples are enclosed in this report as Attachment 1 and cited in chronological order.

Figure 1. Figure 7-2 from NIOSH's SEC-00224 Petition Evaluation Report



AIR SAMPLE DATA

Date	Time on	Time off	Run Time	Suspected Activity	Protection Worn	First Count Factor
9-18-63	9-17-63 1420	9-18-63 1138	1289 min	MPC(40) 132 dpm/M³; MPC(40) 6600 dpm/M³	Supplied Air ☐; Assault Masks ☐; Respirators ☐; None ☒	βγ = α

Room: 25 — Flow Rate: __ M³/hr ÷ 60; 1 cfm ÷ 35.4; __ M³/min. — Final Count Fraction of MPC: ≥1X ☐ ☐; ≥10% ☐ ☐; <10% ☒ ☒ (α, βγ)

Bldg.: FCF

Operation Code: Routine — Sampler Type: Filtronics — Volume: 39 M³

Filter Media: Gelman Glass E — Counter(s) Used: RIDL Proportional — Conversion Factor: d/m/M³ × 4.55 × 10^{-13} = μc/cm³

Sampled By: [redacted] — Counted By: [redacted] — Self-Absorption Factor: α: 1.3 X

Remarks: $\frac{1 \times 1289}{35.4} = 39 M^3$

Date and Time of Count	Total Count	Count Time in Minutes	GROSS COUNT Counts per Minute	Background Counts per Minute	BKGD NET Counts per Minute	Counter Yield	Self-Absorption Factor	Disintegrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-18-63 1141	1538	5	308	41	267	18.6	—	1435	37	<1	βγ	3min	[redacted]
1158	800	5	160	1	159	24.8	1.3	1034	27	20	α	15min	
1538	410	5	82	1	81	24.8	1.3	527	14	10	α	240min	
9-19-63 1250	152	5	30	1	29	24.5	1.3	153	4	3	α	1572min	

Source: FCF Survey Reports 1963, Figure 7-2: Example FCF Room 25 Air Sample Result from 1963.

3.0 LIMITATIONS PERTAINING TO AIR SAMPLING DATA FOR THE ASSIGNMENT OF INTERNAL DOSE TO FCF WORKERS

In addition to the sampling data sets enclosed as Attachment 1, SC&A reviewed several other representative data sets and concludes the following:

- For uranium, thorium, and plutonium without MFPs, air sampling data reviewed by SC&A support NIOSH's claim that the recorded air concentrations typically were below 10% of the MPC_{air} (40) value. On the assumption that measured general area (GA) air sampling data accurately represent levels of contamination breathed by workers, NIOSH's proposal to assign 10% of the MPC_{air} (40) as a bounding intake value would appear appropriate/claimant favorable for the unmonitored workers.

- The assumption that measured air concentrations obtained from GA air sampling are truly representative of air concentrations respired by workers during facility operations, however, has to be questioned at two levels, as explained in Sections 3.1 and 3.2 below.

3.1 LONG AIR SAMPLING TIMES EMPLOYED AT FCF

For routine GA air sampling at the FCF, the low flowrate of 1 ft^3/minute corresponds to 1.695 m^3/hr, which is only marginally greater than the respiration rate of 1.2 m^3/hr assumed for a worker. In order to sample a sufficiently large volume of air, sampling times for the 11 routine air samples (see Attachment 1) ranged from a low of 1,289 minutes (or 21.5 hours) up to 5,690 minutes (or 94.8 hours), with a mean duration of 2,443 minutes (or 40.7 hours). A check of the dates on which these air samples were taken reveals that three were initiated on a Friday and terminated on the next workday. The longest sample time of 5,690 minutes (or 94.8 hours) represents a 4-day time period that corresponds to the entire Labor Day weekend of 1963 (see air sample #1 of Attachment 1). SC&A's investigation into the typical duration of daily radiological activities at FCF indicates a mix of "typical single-shift" operations (assumed to be 0800–1700 hours), as well as indications of "swing-shift" or "double-shift" operations, which would be outside of the typical work hours. Additionally, it appears that "off-normal" operations, such as unique maintenance, installation, or removal operations, may have occurred sporadically at the facility during the period of interest (1963–1969).[1] However, SC&A did not observe a clear temporal pattern to discern when site practices may have transitioned from a typical work shift to activities that required expanded radiological work hours. The reader is referred to Attachment 2 for a description of available information used by SC&A to characterize typical operational work duration at FCF.

Given the relatively long sampling times of the fixed air samplers, which necessarily measured both operational and non-operational air concentrations at FCF, recorded GA air concentrations

[1] The period of 1963–1969 represents the time frame for which the FCF was conducting activities related to disassembling, refining, refabricating, and reassembling EBR-II fuel subassemblies. After this time, the main activities at FCF involved inspecting, testing, and shipping irradiated reactor fuels to the Chemical Processing Plant for reprocessing and refining.

should not be considered representative of air concentrations encountered by workers during typical facility operations.

3.2 GENERIC LIMITATIONS AND UNCERTAINTIES ASSOCIATED WITH GENERAL AREA AIR SAMPLING FOR ASSESSING WORKER INTAKES

As acknowledged in Section 5.1.6.2 of ORAUT-TKBS-00070-5, GA air sampling was intended neither to serve the purpose of assessing internal exposures nor to replace the need for bioassay monitoring, as given in the following statements:

> *The monitoring of radioactivity in the air in occupied areas was a basic element of the internal exposure* ***prevention program****….*
>
> *In general, workers were asked to submit to bioassay measurements whenever they were in an area where a CAM alarm sounded. In addition, the* ***fixed location*** *and* ***retrospective air-sampling system signaled the need for bioassay*** *if elevated air sample results were detected*. [Emphasis added.]

While air sampling is an important component in radiological protection, it is equally important to understand the limitations of air monitoring data and their interpretation. There are two major categories of air sampling that are represented by (1) fixed or GA air sampling and (2) lapel air samplers, commonly called personal breathing zone (BZ) air samplers. In contrast to the fixed-location GA samplers, BZ air samplers are worn with a filter located on the lapel, where air is sampled that closely corresponds to the air respired by the worker.

Under conditions where a radioactive contaminant has been uniformly dispersed, data obtained from a GA and a BZ air sample can be expected to show similar values. In reality, however, release of dispersible contaminants and their distribution in air results in concentration gradients that vary over space and time. Not surprisingly, a number of studies have consistently shown that GA air samples poorly correlate with BZ lapel air samples (Brunskill and Holt 1967; Caldwell et al. 1967).

Salient Data from the Brunskill and Holt 1967 Study. Aerosol studies of plutonium and uranium plants at the Windscale and Springfields Works of the United Kingdom Atomic Energy Authority were conducted to compare the data from static and personal air samplers in a number of plant and laboratory areas in order to formulate a general policy for air sampling.

From study data, it was concluded that for any specific area of investigation, the integrated “exposure” shown by a personal air sampler is almost invariably greater than the integrated “exposure” shown by static samplers over the same period. The ratio of “exposures” varies with the operation being carried out and varies between wide limits for operators carrying out nearly similar duties.

In uranium-active areas, the ratios (i.e., BZ/GA) varied by as much as 80-fold during a particular shift cycle, with significant variations of BZ “exposures” among individuals in a given shift.

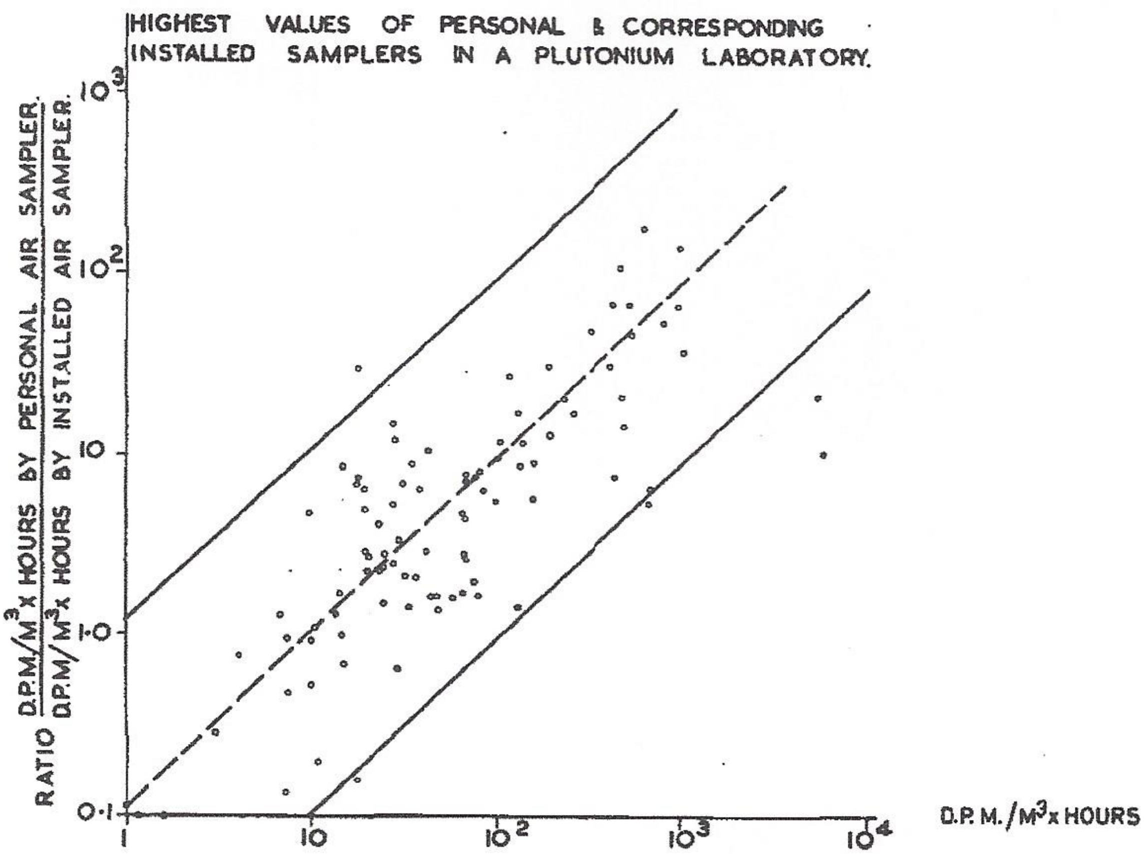
In plutonium-active areas, the ratio of exposures varied between even wider limits over comparable periods of investigation. Figure 2 shows the variations in the ratios of personal BZ air exposures to fixed GA air sampler exposures, with activity shown by the BZ air samplers in units of dpm/m^3 x Hours. Figure 2 shows the following relationship between BZ and GA sample values:

- Nearly all GA air samples are within a factor of 100 of the lapel BZ air samples, while most are within a factor of 10.

- Secondly, Figure 2 shows that for increasing BZ air concentrations, there is decreasing correlation with the GA air sample.

On the basis of these data, the authors concluded that (1) for any specific area monitored, the integrated exposures shown by personal BZ air samplers are consistently greater than the integrated exposure shown by a fixed GA air sampler over the same time period, and (2) results from all uranium and plutonium areas investigated show that the fixed GA air samplers are incapable of indicating the true conditions in the BZ of the operators. However, the option exists that by applying a multiplying factor to the GA air sampling result, a reasonable prediction of the BZ air concentration may be estimated. A reasonable multiplying factor of 10 should be considered for converting GA air sample values to BZ air concentrations.

Figure 2. The Variation in the Ratio of Personal to Static Daily Air Exposures with Activity Shown by the Personal Sampler



Source: Brunskill and Holt 1967.

3.3 SALIENT DATA FROM THE CALDWELL ET AL. (1967) STUDY

Nuclear Materials and Equipment Corporation (NUMEC) is a nuclear fuel facility where uranium and plutonium workers were monitored by lapel BZ air samplers, as well as by fixed GA air samplers.

Fixed-station air sampler data that span a 2-year period were compared with 594 BZ samples at the plutonium laboratory and 459 BZ samples at the uranium plant. The BZ samplers were for single shifts of an 8-hour day. These data were matched for time and location to fixed station air sample data for comparison. Results of this comparison are summarized below.

Figure 3 reveals the following relationships for the distribution of BZ samples and corresponding GA air samples for plutonium and uranium:

<u>Pu Laboratory Data</u>

- Generally "good" agreement (+100% to -50%) between plutonium BZ and GA air samples corresponded to 27% of plutonium BZ samples.

- Almost 9% of the plutonium BZ samples were less than 50% lower than the GAs.
- 64% of plutonium BZs exceeded the GA concentration by a factor of 2 or more.
- 23% of plutonium BZs exceeded the GA concentration by more than a factor of 10.
- The single highest plutonium BZ sample-to-GA ratio observed was 9,870.

Uranium Plant Data

- Generally good agreement (+100% to -50%) between uranium BZ samples and GA air samples corresponded to about 19%.
- 35% of uranium BZs exceeded fixed GA concentrations by a factor of 10 or more.

Important to note is the fact that, while the median BZ/GA ratios for both the plutonium and uranium facilities were below 10, the very skewed distribution for higher air concentrations makes high-level exposures important when computing the average exposures that may be based on fixed GA sample data, as shown in Figure 3.

The importance of personal BZ samples under conditions of higher air concentration is more clearly demonstrated in Figure 4. BZ/GA ratios for all plutonium exposures exceeding 10 MPCs for an 8-hour shift are plotted against the BZ concentration. Inspection of Figure 4 demonstrates three features that define the relationship between BZ and GA data.

The first is the high variability of the BZ/GA ratio for any given BZ air concentration. For example, for BZ values between 40 to 50 dpm/m^3, the fixed-area air sample concentration varied from one-half to one-eight hundredth of the BZ concentration. Given the high degree of variability, the authors of this study questioned the ability to select a meaningful factor (such as the factor of 10 proposed by Brunskill and Holt [1967]) by which the GA concentration is multiplied by 10 to estimate the actual exposure(s) to individual workers.

Secondly, as BZ air concentrations increase, there is an upward trend (i.e., increase) in the BZ/GA ratios. For example, for BZs between 400 to 480 dpm/m^3, the fixed-station air concentrations varied from about one-hundredth to about one-three hundredth of the BZ concentration.

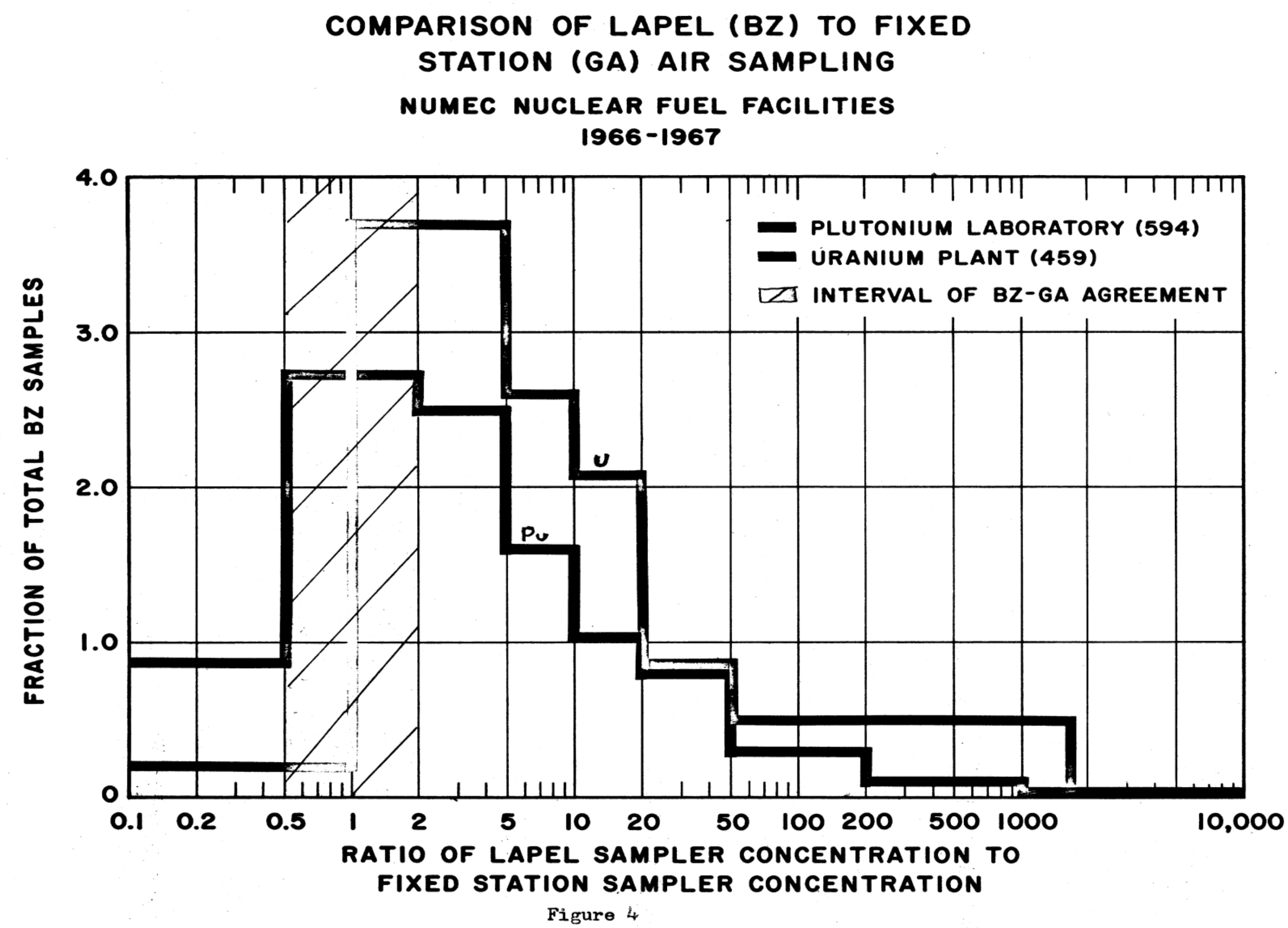
Thirdly, the solid line in Figure 4 represents the line where the fixed GA air samplers would indicate the soluble MPC_{air} (given as "MPC_a" in the figure) value for plutonium. For all the data above the line, the GA value was less than MPC_a. Only those below the line indicated that a hazardous air concentration existed.

Similar discrepancies between BZ and GA air samples were documented for the uranium facility at NUMEC (Table 1). For the 459 BZ air samples that were matched against GA values, 333 indicated air concentrations above MPC values, while GA samples suggested air concentrations below MPC values. This implies that for almost 73% of the time the GA sampling network failed to warn personnel when greater than permissible exposure conditions existed.

Caldwell et al. (1967) concluded with the following warning:

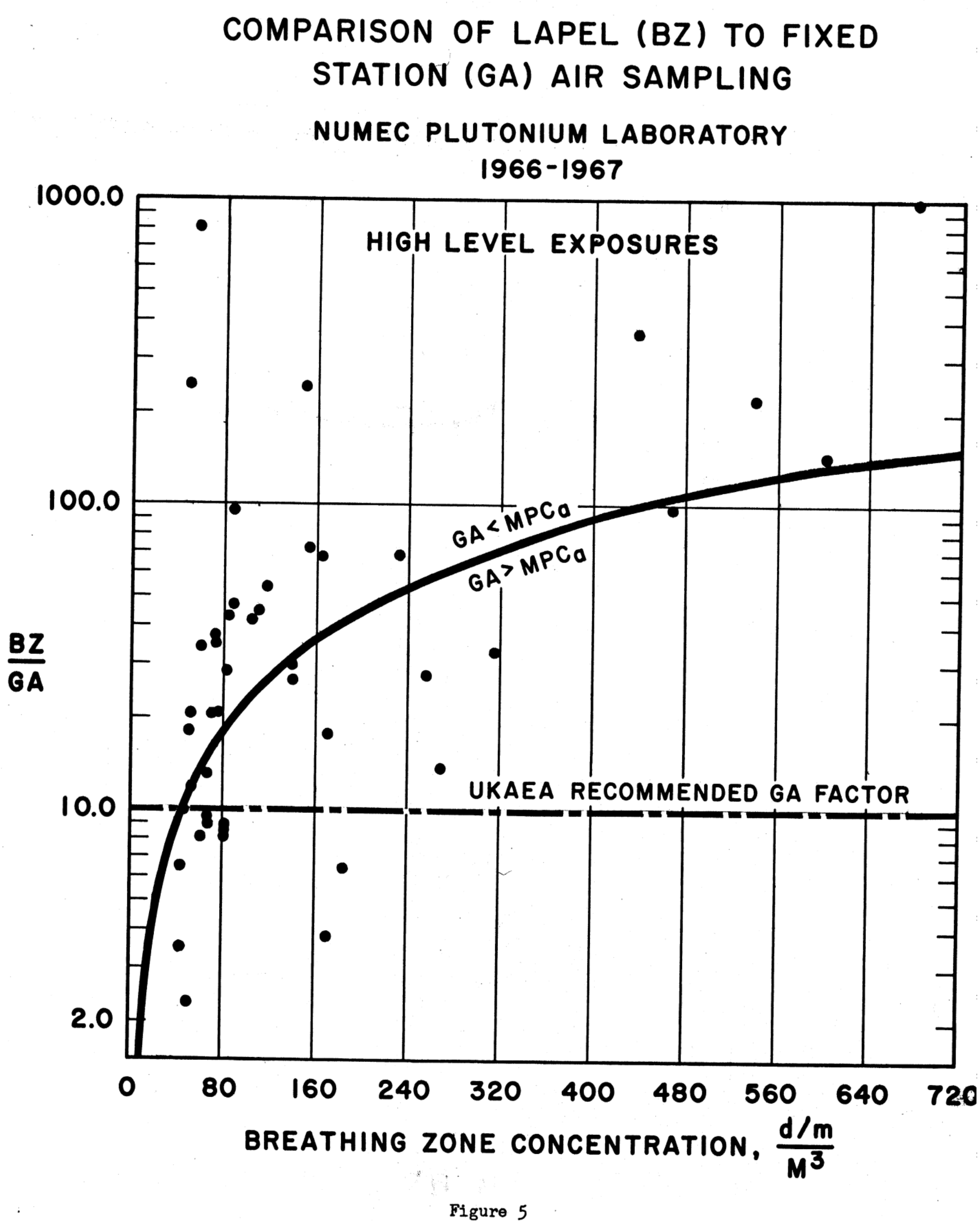
> *This is an important point. Many radioaerosol exposures are going unnoticed because the nuclear industry is depending on fixed station air sampling.*
>
> *…The failure of fixed station samplers could not be more graphic.*

Figure 3. Ratio of Lapel Sampler Concentration to Fixed Station Sampler Concentration, NUMEC Nuclear Facilities 1966–1967



Source: Caldwell et al. 1967.

Figure 4. Breathing Zone Concentration, NUMEC Plutonium Laboratory 1966–1967



Source: Caldwell et al. 1967.

Table 1. Hazard Indicability, Lapel Samples (BZ) vs. Fixed Station Samples (GA), NUMEC Uranium Plant, 1966–1967

Condition Indicated	Number Recorded	Frequency
BZ>MPC GA<MPC	300	.654
BZ>10 MPC GA<MPC	33	.072
BZ<MPC GA<MPC	54	.118
BZ<MPC GA>MPC	2	.004
BZ>MPC GA>MPC	70	.152

Total BZ Samples = 459
Total GA>MPC = 72
Tota403l BZ>MPC = 403
Source: Reproduced from Caldwell et al. 1967.

4.0 SUMMARY CONCLUSIONS

In the absence of sufficient bioassay data for deriving internal exposures for years 1958 and after, NIOSH proposes the use of GA sampling data. Specifically, GA air sampling data will be used for bounding inhalation intakes of uranium, thorium, and plutonium that may have existed in the absence of MFPs.

On the basis of recorded/available GA air sample data, NIOSH concluded that an air concentration of 10% MPC_{air} defined for a 40-hour work week provides a bounding value for potential intakes of uranium, thorium, and plutonium at the FCF (and other work locations at ANL-W).

SC&A's review of GA air sampling data confirms that the recorded air concentrations most often were below the 10% level of MPC(40) as shown in Attachment 1. In principle, the recorded data would support NIOSH's selection of this value as a "bounding" estimate for assigning internal doses.

Support and commitment for the use of the 10% MPC value, however, would have to rely on the unconfirmed assumption that GA air concentrations closely correspond to operational air concentrations to which workers were exposed.

SC&A's review of FCF air data, typical daily operations, and assessment of NIOSH's proposed use of GA air sampling data identified two issues of concern. The first concern centers around the use of GA air samplers with a low airflow. Low airflow rates required sampling times of up to 4 days, which necessarily correspond to periods when no work was performed (and no workers were present). Thus, it is reasonable to conclude that air concentrations during non-working hours differed significantly from air concentrations that would have exposed workers during normal facility operations that were likely limited to an 8-hour shift Monday through Friday during many periods.

A second and more serious concern regarding the use of GA air sampling data is the generic lack of parity between air concentrations measured by GA air samplers and lapel air samplers worn by the individual workers. Study data, including those of two nuclear fuel processing facilities cited in this review, have consistently demonstrated the poor correlation between GA and BZ air sample data with BZ/GA ratios that spanned several orders of magnitude.

Given the high degree of uncertainty surrounding GA sampling data at the FCF (and possibly other locations at ANL-W), SC&A concludes that NIOSH's proposed value of 10% MPC(40) as a bounding value for internal dose assessment lacks credibility.

5.0 REFERENCES

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ATTACHMENT 1: GENERAL AREA AIR SAMPLE DATA FOR ROOM 25 (FCF) FOR THE MONTH OF SEPTEMBER 1963

AIR SAMPLE DATA

Date: 9-3-63
Time on: 8-30-63 1222
Time off: 9-3-63 1114
Run Time: 5690 min
Room: 25
Bldg.: FCF
Flow Rate: __ M³/hr ÷ 60 __ M³/min. 1 cfm ÷ 35.4
Operation Code: Routine
Sampler Type: Filtronics
Volume: 160.7 M³

Suspected Activity:
α MPC(40) 132 dpm/M³
βγ MPC(40) 6600 dpm/M³

Protection Worn:
Supplied Air ☐
Assault Masks ☐
Respirators ☐
None ☒

First Count Factor: βγ/α =
Final Count Fraction of MPC: α βγ
≥1X ☐ ☐
≥10% ☐ ☐
<10% ☒ ☒

Filter Media: Gelman Glass E
Counter(s) Used: RIDL Proportional
Conversion Factor: d/m/M³ x 4.55 x 10⁻¹³ = μc/cm³
Sampled By: [redacted]
Counted By: [redacted]
Self-Absorption Factor: α: 1.3 x

$\frac{1 \times 5690}{35.4} = 160.7\ M^3$

Date and Time of Count	Total Count	GROSS COUNT: Count Time in Minutes	GROSS COUNT: Counts per Minute	GROSS COUNT: Background Counts per Minute	BKGD NET: Counts per Minute	Counter Yield	Self-Absorption Factor	Disintegrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-3-63 1117	1617	5	324	41	283	18.2	—	1555	9	<1	βγ	3 mins	[redacted]
1124	729	5	146	1	145	24	1.3	791	5	4	α	10 mins	
1546	371	5	74	1	73	24	1.3	395	2	14	α	272mi	

IHS-ID-1*

AIR SAMPLE DATA

Date	Time on	Time off	Run Time	Suspected Activity	Protection Worn	First Count Factor
9-6-63	9-5-63 1253	9-6-63 1325	1471 min	~~α~~MPC(40) 132 dpm/M³	Supplied Air ☐	βγ = α
Room: 25	Flow Rate: ___ M³/hr ÷ 60; 1 cfm ÷ 35.4	___ M³/min.		βγ MPC(40) 6600 dpm/M³	Assault Masks ☐	Final Count Fraction of MPC (α / βγ): ≥1X ☐ ☐; ≥10% ☐ ☐; <10% ☐ ☒
Bldg.: FCF					Respirators ☐	
Operation Code: Routine	Sampler Type: Filtronics	Volume: 41.6 M³			None ☒	

Filter Media: Gelman Glass E

Counter(s) Used: RIDL Proportional

Conversion Factor: d/m/M³ x 4.55 x 10⁻¹³ = μc/cm³

Sampled By: [redacted]

Counted By: [redacted]

Self-Absorption Factor: α: 1.3 x

Remarks: $\frac{1 \times 1471}{35.4} = 41.6\ M^3$

Date and Time of Count	Total Count	GROSS COUNT: Count Time in Minutes	GROSS COUNT: Counts per Minute	Background Counts per Minute	BKGD NET: Counts per Minute	Counter Yield	Self-Absorption Factor	Disintregrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-6-63 1329	1350	5	270	1	269	24	1.3	1451	35	25	α	4 mins	[redacted]
1335	2070	5	414	41	373	18.1	—	2061	50	<1	βγ	10 mins	
1550	600	5	120	1	119	24.1	1.3	642	15	11	α	145 min	
9-9-63 1100	11	5	2	1	1	23.5	1.3	6	<1	<1	α	4185 min	

IHS-ID-1*

AIR SAMPLE DATA

Date	Time on	Time off	Run Time	Suspected Activity	Protection Worn	First Count Factor
9-9-63	9-6-63 1325	9-9-63 1114	4185 min	α MPC(40) 132 dpm/M³; βγ MPC(40) 6600 dpm/M³	Supplied Air ☐; Assault Masks ☐; Respirators ☐; None ☒	$\frac{\beta\gamma}{\alpha}$ =

Room: 25

Flow Rate: __ M³/hr ÷ 60 __ M³/min. 1 cfm ÷ 35.4

Bldg.: FCF

Final Count Fraction of MPC (α / βγ): ≥1X ☐ ☐; ≥10% ☐ ☐; <10% ☒ ☒

Operation Code: Routine

Sampler Type: Filtronics

Volume: 118.2 M³

Filter Media: Gelman Glass F

Counter(s) Used: RIDL Proportional

Conversion Factor: d/m/M³ x 4.55 x 10^{-13} = μc/cm³

Sampled By: [redacted]

Counted By: [redacted]

Self-Absorption Factor: α: 1.3 X

Remarks: $\frac{1 \times 4185}{35.4}$ = 118.2 M³

Date and Time of Count	Total Count	Count Time in Minutes	GROSS COUNT Counts per Minute	Background Counts per Minute	BKGD NET Counts per Minute	Counter Yield	Self-Absorption Factor	Disintregrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-9-63 1118	1317	5	263	1	262	23.5	1.3	1450	12	9	α	4 min	[redacted]
1124	2075	5	415	43	362	18.2	–	1990	17	<1	βγ	10 min	
9-10-63 1052	192	5	38	1	37	24.1	1.3	200	~~17~~ 2	1	α	1414 min	

IHS-ID-1*

AIR SAMPLE DATA

Date: 9-10-63	Time on: 9-9-63 1114	Time off: 9-10-63 1158	Run Time: 1483 min
Room: 25	Flow Rate: __ M³/hr ÷ 60; 1 cfm ÷ 35.4; __ M³/min.		
Bldg.: FCF			
Operation Code: Routine	Sampler Type: Filtronics	Volume: 41.9 M³	

Suspected Activity:
- α MPC(40) 132 dpm/M³
- βγ MPC(40) 6600 dpm/M³

Protection Worn:
- Supplied Air ☐
- Assault Masks ☐
- Respirators ☐
- None ☒

First Count Factor: βγ/α =

Final Count Fraction of MPC:

	α	βγ
⩾1X	☐	☐
⩾10%	☐	☐
<10%	☐	☒

Filter Media: Gelman Glass E

Counter(s) Used: RIDL Proportional

Conversion Factor: d/m/M³ x 4.55 x 10⁻¹³ = μc/cm³

Sampled By: [redacted]

Counted By: [redacted]

Self-Absorption Factor: α: 1.3 x

Remarks: 1 x 1483 / 354 = 41.9 m³

Date and Time of Count	Total Count	GROSS COUNT: Count Time in Minutes	GROSS COUNT: Counts per Minute	Background Counts per Minute	BKGD NET: Counts per Minute	Counter Yield	Self-Absorption Factor	Disintegrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-10-63 1200	1923	5	385	43	342	18.2	—	1879	45	<1	βγ	2 mins	[redacted]
1206	1094	5	219	[illegible]	218	24.1	1.3	1176	28	21	α	8 min	
1541	449	5	90	1	89	24.1	1.3	480	11	9	α	223 min	
9-11-63 1130	140	5	28	1	27	24.5	1.3	144	3	<3	α	1412 min	

IHS-ID-1*

AIR SAMPLE DATA

Date: 9-11-63	Time on: 9-10-63 1158	Time off: 9-11-63 1232	Run Time: 1473 min	Suspected Activity: α MPC(40) 132 dpm/M³; βγ MPC(40) 6600 dpm/M³	Protection Worn: Supplied Air ☐; Assault Masks ☐; Respirators ☐; None ☒
Room: 25-	Flow Rate: __ M³/hr ÷ 60; 1 cfm ÷ 35.4 __ M³/min.				First Count Factor: βγ/α =
Bldg.: FCF					Final Count Fraction of MPC (α / βγ): ≥1X ☒ ☐; ≥10% ☐ ☐; <10% ☒ ☒
Operation Code: Routine	Sampler Type: Filtronics	Volume: 41.6 M³			
Filter Media: Gelman Glass E	Counter(s) Used: RIDL Proportional		Conversion Factor: d/m/M³ x 4.55 x 10^{-13} = μc/cm³		
Sampled By: [redacted]	Counted By: [redacted]		Self-Absorption Factor: α: 1.3 X		

Remarks: $\frac{1 \times 1473}{35.4} = 41.6\ M^3$

Date and Time of Count	Total Count	GROSS COUNT: Count Time in Minutes	GROSS COUNT: Counts per Minute	Background Counts per Minute	BKGD NET: Counts per Minute	Counter Yield	Self-Absorption Factor	Disintegrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-11-63 1236	1367	5	273	1	272	24.5	1.3	1443	35	26	α	4 min	[redacted]
1242	2127	5	426	48	378	18.2	—	2077	50	<1	βγ	10 min	
1536	586	5	117	1	116	24.5	1.3	~~473~~ 515	12	9	α	184 min	
9-12-63 1105	185	5	37	1	36	24.6	1.3	190	5	3	α	1353 min	

IHS-ID-1*

AIR SAMPLE DATA

Date	Time on	Time off	Run Time
9-13-63	9-11-63 1232	9-13-63 1123	2809

Room: 25

Flow Rate: __ M³/hr ÷ 60   1 cfm ÷ 35.4   __ M³/min.

Bldg.: FCF

Operation Code: Routine   Sampler Type: Filtronics   Volume: 79.3 M³

Suspected Activity:
α MPC(40) 132 dpm/M³
βγ MPC(40) 6600 dpm/M³

Protection Worn:
- Supplied Air ☐
- Assault Masks ☐
- Respirators ☐
- None ☒

First Count Factor $\frac{\beta\gamma}{\alpha}$ =

Final Count Fraction of MPC:
- ≥1X α ☐ βγ ☐
- ≥10% ☐ ☐
- <10% ☒ ☒

Filter Media: Gelman Glass E

Counter(s) Used: RIDL Proportional

Conversion Factor: d/m/M³ x 4.55 x 10^{-13} = μc/cm³

Sampled By: [redacted]

Counted By: [redacted]

Self-Absorption Factor: α: 1.3 X

Remarks: $\frac{1 \times 2809}{35.4} = 79.3\ M^3$

Date and Time of Count	Total Count	GROSS COUNT: Count Time in Minutes	GROSS COUNT: Counts per Minute	Background Counts per Minute	BKGD NET: Counts per Minute	Counter Yield	Self-Absorption Factor	Disintegrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-13-63 /1125	1387	5	278	44	234	18.3	—	1279	16	<1	βγ	2min	[redacted]
1131	694	5	139	1	138	24.6	1.3	729	9	6	α	8min	
1527	477	5	95	1	94	24.6	1.3	497	6	4	α	244min	

IHS-ID-1*

AIR SAMPLE DATA

Date	Time on	Time off	Run Time	Suspected Activity	Protection Worn	First Count Factor
9-18-63	9-17-63 1420	9-18-63 1138	1289 min	MPC(40) 132 dpm/M³	Supplied Air ☐	βγ/α =
Room: 25	Flow Rate: __ M³/hr ÷ 60; 1 cfm ÷ 35.4; __ M³/min.			MPC(40) 6600 dpm/M³	Assault Masks ☐	Final Count Fraction of MPC: α βγ
Bldg.: FCF					Respirators ☐	⩾1X ☐ ☐
Operation Code: Routine	Sampler Type: Filtronics	Volume: 39 M³			None ☒	⩾10% ☐ ☐
						<10% ☒ ☒

Filter Media: Gelman Glass E

Counter(s) Used: RIDL Proportional

Conversion Factor: d/m/M³ x 4.55 x 10⁻¹³ = μc/cm³

Sampled By: [redacted]

Counted By: [redacted]

Self-Absorption Factor: α: 1.3 X

Remarks: $\frac{1 \times 1289}{35.4} = 39 M^3$

Date and Time of Count	Total Count	GROSS COUNT: Count Time in Minutes	GROSS COUNT: Counts per Minute	Background Counts per Minute	BKGD NET: Counts per Minute	Counter Yield	Self-Absorption Factor	Disintregrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-18-63 1141	1538	5	308	41	267	18.6	—	1435	37	<1	βγ	3 min	[redacted]
1158	800	5	160	1	159	24.8	1.3	1034	27	20	α	[illegible] min	
1538	410	5	82	1	81	24.8	1.3	527	14	10	α	240 min	
9-19-63 1250	152	5	30	1	29	24.5	1.3	153	4	3	α	1512 min	

IHS-ID-1*

AIR SAMPLE DATA

Date: 9-19-63
Time on: 9-18-63 1426
Time off: 9-19-63 1305
Run Time: 1358 min

Suspected Activity: Thoria
MPC(40) 66.6 dpm/M³
MPC(40) 6600 dpm/M³

Protection Worn:
- Supplied Air ☐
- Assault Masks ☐
- Respirators ☐
- None ☒

First Count Factor $\frac{\beta\gamma}{\alpha}$ =

Final Count Fraction of MPC (α / βγ):
- ⩾1X ☐ ☐
- ⩾10% ☐ ☐
- <10% ☒ ☒

Room: 25
Flow Rate: ___ M³/hr ÷ 60 ___ M³/min.
Bldg.: FCF
1 cfm ÷ 35.4

Operation Code: Routine
Sampler Type: Filtronics
Volume: 38.4 M³

Filter Media: Gelman Glass E
Counter(s) Used: RIDL Proportional
Conversion Factor: d/m/M³ x 4.55 x 10⁻¹³ = μc/cm³

Sampled By: [redacted]
Counted By: [redacted]
Self-Absorption Factor: α: 1.3 X

Remarks: $\frac{1 \times 1358}{35.4} = 38.4 M^2$

Date and Time of Count	Total Count	GROSS COUNT: Count Time in Minutes	GROSS COUNT: Counts per Minute	Background Counts per Minute	BKGD NET: Counts per Minute	Counter Yield	Self-Absorption Factor	Disintregrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-19-63 1309	590	5	118	1	117	24.5	1.3	621	16	12	α	4 min	[redacted]
1318	1000	5	200	42	158	18.4	—	859	23	<1	βγ	13 min	
1522	360	5	72	1	71	24.5	1.3	377	10	15	α	137 min	
9-20-63 1255	70	5	14	1	13	24.5	1.3	69	2	1	α	1430 min	

IHS-ID-1*

AIR SAMPLE DATA

Date: 9-20-63
Time on: 9-19-63 1305
Time off: 9-20-63 1240
Run Time: 1415 min
Room: 25
Bldg.: FCF
Flow Rate: ___ M³/hr ÷ 60 ___ M³/min. 1 cfm ÷ 35.4
Operation Code: Routine
Sampler Type: Filtronics
Volume: 40 M³

Suspected Activity:
α MPC(40) 132 dpm/M³
βγ MPC(40) 6600 dpm/M³

Protection Worn:
Supplied Air ☐
Assault Masks ☐
Respirators ☐
None ☒

First Count Factor: βγ/α =

Final Count Fraction of MPC: α βγ
≥1X ☐ ☐
≥10% ☐ ☐
<10% ☒ ☒

Filter Media: Gelman Glass E
Counter(s) Used: RIDL Proportional
Conversion Factor: d/m/M³ x 4.55 x 10⁻¹³ = μc/cm³

Sampled By: [redacted]
Counted By: [redacted]
Self-Absorption Factor: α : 1.3 x

Remarks: $\frac{1 \times 1415}{35.4} = 40 M^3$

Date and Time of Count	Total Count	Count Time in Minutes	GROSS COUNT: Counts per Minute	Background Counts per Minute	BKGD NET: Counts per Minute	Counter Yield	Self-Absorption Factor	Disintegrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-20-63/1242	1072	5	214	~~84~~ 42	172	18.4	—	935	23	<1	βγ	2 min	[redacted]
1248	581	5	116	1	115	24.5	1.3	621	16	11	α	8 min	
1538	304	5	61	1	60	24.5	1.3	318	8	6	α	178 min	

IHS-ID-1*

AIR SAMPLE DATA

Date: 9-23-63
Time on: 9-20-63 1240
Time off: 9-23-63 1119
Run Time: 4239min

Room: 25
Bldg.: FCF

Flow Rate: ___ M³/hr ÷ 60 ___ M³/min.
1 cfm ÷ 35.4

Operation Code: Routine
Sampler Type: Filtronics
Volume: 119.7 M³

Suspected Activity:
α MPC(40) 132 dpm/M³
βγ MPC(40) 6600 dpm/M³

Protection Worn:
Supplied Air ☐
Assault Masks ☐
Respirators ☐
None ☒

First Count Factor: βγ/α =

Final Count Fraction of MPC (α, βγ):
≥1X ☐ ☐
≥10% ☐ ☐
<10% ☒ ☒

Filter Media: Gelman Glass E
Counter(s) Used: RIDL Proportional
Conversion Factor: $d/m/M^3 \times 4.55 \times 10^{-13} = \mu c/cm^3$

Sampled By: [redacted]
Counted By: [redacted]
Self-Absorption Factor: α: 1.3 X

Remarks: $\frac{1 \times 4239}{35.4} = 119.7 M^3$

Date and Time of Count	Total Count	GROSS COUNT: Count Time in Minutes	GROSS COUNT: Counts per Minute	GROSS COUNT: Background Counts per Minute	BKGD NET: Counts per Minute	Counter Yield	Self-Absorption Factor	Disintregrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-23-63 1123	2183	5	437	41	396	18	—	2200	19	<1	βγ	4min	[redacted]
1129	916	5	183	1	182	25	1.3	946	8	6	α	10min	
1555	414	5	83	1	82	25	1.3	533	4	3	α	276min	
9-24-63 1050	124	5	25	1	24	24.3	1.3	129	1	<1	α	1411min	

IHS-ID-1*

AIR SAMPLE DATA

Date	Time on	Time off	Run Time
9-24-63	9-23-63 1119	9-24-63 1458	1657 min

Room: 25

Bldg.: FCF

Flow Rate: __ M^3/hr ÷ 60; ✓ cfm ÷ 35.4; __ M^3/min.

Operation Code: Routine

Sampler Type: Filtronics

Volume: 47 M^3

Suspected Activity:
α MPC(40) 132 dpm/M^3
β MPC(40) 6600 dpm/M^3

Protection Worn:
- Supplied Air ☐
- Assault Masks ☐
- Respirators ☐
- None ☒

First Count Factor: βγ/α =

Final Count Fraction of MPC:

	α	βγ
≥1X	☐	☐
≥10%	☐	☐
<10%	☒	☒

Filter Media: Gelman Glass E

Counter(s) Used: RIDL Proportional

Conversion Factor: d/m/M^3 x 4.55 x 10^{-13} = μc/cm^3

Sampled By: [redacted]

Counted By: [redacted]

Self-Absorption Factor: α: 1.3 X

Remarks: $\frac{1 \times 1657}{35.4} = 47 M^3$

Date and Time of Count	Total Count	Count Time in Minutes	GROSS COUNT Counts per Minute	Background Counts per Minute	BKGD NET Counts per Minute	Counter Yield	Self-Absorption Factor	Disintregrations per Minute	d/m/M^3	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-24-63 1500	492	5	98	1	97	24.3	1.3	517	11	9	α	2 min	[redacted]
1506	1020	5	204	38	166	17.5	–	949	20	<1	βγ	8 min	
2019	249	5	50	1	49	24.3	1.3	~~201~~ 261	6	4	α	321 min	

IHS-ID-1*

Log 9-7

Attachment #1

AIR SAMPLE DATA

Date	Time on	Time off	Run Time	Suspected Activity	Protection Worn	First Count Factor
9-18-63	9-18-63 1140	9-18-63 1426	166 min	Thoria		$\beta\gamma / \alpha$ =

Room: 25

Bldg.: FCF

Flow Rate: __ M³/hr ÷ 60; 1 cfm ÷ 35.4; __ M³/min.

α MPC(40) 66.6 dpm/M³

$\beta\gamma$ MPC(40) 6600 dpm/M³

Protection Worn:
- Supplied Air ☐
- Assault Masks ☐
- Respirators ☒
- None ☐

Final Count Fraction of MPC (α / $\beta\gamma$):
- ⩾1X ☐ ☐
- ⩾10% ☐ ☐
- <10% ☒ ☒

Operation Code: Special

Sampler Type: Filtronics

Volume: 4.7 M³

Filter Media: Gelman Glass E

Counter(s) Used: RIDL Proportional

Conversion Factor: d/m/M³ x 4.55 x 10⁻¹³ = μc/cm³

Sampled By: [redacted]

Counted By: [redacted]

Self-Absorption Factor: α: 1.3 x

Remarks: $\frac{1 \times 166}{35.4} = 4.7$ Taken while cleaning floor

Date and Time of Count	Total Count	Count Time in Minutes	GROSS COUNT Counts per Minute	Background Counts per Minute	BKGD NET Counts per Minute	Counter Yield	Self-Absorption Factor	Disintregrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-18-63 1428	287	5	57	1	56	24.8	1.3	299	64	96	α	2 min	[redacted]
1434	567	5	113	41	72	18.6	—	387	83	62	$\beta\gamma$	8 min	
9-19-63 1240	30	5	6	1	5	24.5	1.3	27	6	9	α	1326 m	

IHS-ID-1*

Log 9-7
Attachment #3

AIR SAMPLE DATA

Date: 9-19-63
Time on: 9-19-63 0859
Time off: 9-19-63 0906
Run Time: 7min

Room: 25
Bldg.: FCF
Flow Rate: ___M³/hr ÷ 60 ___M³/min.
40cfm ÷ 35.4

Suspected Activity: Thoria
α MPC(40) 66.6 dpm/M³
βγ MPC(40) 6600 dpm/M³

Protection Worn:
Supplied Air ☐
Assault Masks ☐
Respirators ☐
None ☒

First Count Factor $\frac{\beta\gamma}{\alpha}$ =

Final Count Fraction of MPC: α βγ
⩾1X ☐ ☐
⩾10% ☐ ☐
<10% ☒ ☒

Operation Code: Special
Sampler Type: Gelman Hurricane
Volume: # 2 M³

Filter Media: TFA #41
Counter(s) Used: RIDL Proportional
Conversion Factor: d/m/M³ x 4.55 x 10⁻¹³ = μc/cm³

Sampled By: [redacted]
Counted By: [redacted]
Self-Absorption Factor: α: 1.3 X

$\frac{40 \times 7}{35.4} = 8 M^3$ $\frac{1}{4} \times 8 = 2 M^3$ $\frac{1}{4}$ of sample counted.

Taken to Check air contamination After 16 hours of Ventilation

Date and Time of Count	Total Count	GROSS COUNT: Count Time in Minutes	Counts per Minute	Background Counts per Minute	BKGD NET: Counts per Minute	Counter Yield	Self-Absorption Factor	Disintegrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-19-63 0915	119	5	24	1	23	24.5	1.3	122	61	90	α	9min	[redacted]
0921	482	5	96	41	55	18.6	—	296	148	2	βγ	15min	
1513	8	5	2	1	1	24.5	1.3	6	3	4	α	307min	

IHS-ID-1*

Log 9-5

Attachment #1

AIR SAMPLE DATA

Date	Time on	Time off	Run Time	Suspected Activity	Protection Worn	First Count Factor
9-16-63		9-16-63 1032	3851 mins	α MPC(40) 132 dpm/M³	Supplied Air ☐	βγ/α =
Room: Passage way	Flow Rate: __ M³/hr ÷ 60 __ M³/min.			βγ MPC(40) 6600 dpm/M³	Assault Masks ☐	Final Count Fraction of MPC (α, βγ)
Bldg.: FCF	1 cfm ÷ 35.4				Respirators ☐	≥1X ☐ ☐
Operation Code: Special ~~Routine~~	Sampler Type: Filtronics	Volume: 109 M³			None ☒	≥10% ☐ ☐
						<10% ☐ ☐

Filter Media: Gelman Glass E

Counter(s) Used: RIDL Proportional

Conversion Factor: d/m/M³ × 4.55 × 10⁻¹³ = μc/cm³

Sampled By: [redacted]

Counted By: [redacted]

Self-Absorption Factor: α: 1.3 X

Remarks: $\frac{1 \times 3851}{35.4} = 109\ m^3$

Date and Time of Count	Total Count	Count Time in Minutes	GROSS COUNT Counts per Minute	Background Counts per Minute	BKGD NET Counts per Minute	Counter Yield	Self-Absorption Factor	Disintegrations per Minute	d/m/M³	Percent of MPC	Type of Activity Counted	Decay Time	Initials
9-16-63 1035	1011	5	202	1	201	24.5	1.3	1067	10	7	α	3 min	[redacted]
1041	1981	5	396	42	354	18.7	—	1900	17	<1	βγ	9 min	
1437	1242	5	248	42	206	18.7	—	1101	10	<1	βγ	245 min	
1443	480	5	96	1	95	24.5	1.3	504	5	4	α	257 min	

IHS-ID-1*

ATTACHMENT 2: INVESTIGATION AND CHARACTERIZATION OF POTENTIAL PERIODS OF SHIFT WORK AT THE FUEL CYCLE FACILITY

As described in the main body of this report, reconstruction of chronic intakes to alpha-emitting contaminants that are independent from associated fission products are dependent on fixed air samples, which operated at relatively low flow rates that are averaged over a day or more. It is currently assumed that certain areas of the Experimental Breeder Reactor-II (EBR-II) complex (such as the main reactor areas) operated on essentially a 24-hour schedule. However, the Fuel Cycle Facility (FCF) appears to have operated on a regular work schedule during certain periods (8 hours per day, 5 days per week) and a two-shift schedule that would expand radiological work hours during other periods.

Consultation with NIOSH during a programmatic internal technical call (held on June 15, 2016) confirmed that the FCF was not operated on a continuous 24-hour-per-day schedule. Increases in the operation of the facility beyond a typical 40-hour work week were most likely dependent on the production requirements of the EBR-II complex at the time, as well as any off-normal maintenance activities required at FCF. As noted in Section 3.1 of this report, continuous fixed air samples averaged over a 24-hour period (or more) may underestimate the intake potential for workers during the actual operational activities at FCF. This would be particularly important for periods when the FCF operated on a single-shift schedule, as well as periods for which air samples were taken over the course of a weekend and/or holiday in which no radiological work was likely to take place.

In order to attempt to characterize the practice of multiple shifts and/or radiological work occurring outside of typical working hours at FCF, SC&A examined available interviews with former FCF workers, as well as a focused review of health physics coverage activities that occurred during the principal period of interest from 1963 to 1969.[1] These activities include, but are not limited to, external radiation surveys, routine area contamination swipes, and Health Physics (H.P.) oversight of individual operations. The former mode of investigation (review of worker interviews) provides firsthand knowledge of typical work practices at FCF; however, often this information is more anecdotal than quantitative, and the number of relevant interviewees is limited. The latter mode of investigation (H.P. activities) provides a more quantitative characterization, though this method is not without unavoidable uncertainties that are described later in this section.

SC&A's examination of available worker interviews available in the Site Research Database (SRDB) identified only five interviews that provided relevant information germane to the potential for shift work at FCF. The relevant information is summarized in Table 2-1. Two of the five interviewees worked at FCF, but outside the main period of interest. One worker interviewed indicated shift work took place and that, in some cases, "*coverage around the clock*" took place. However, this worker was mainly located at the EBR-II reactor building and may not

[1] The period of 1963–1969 represents the time frame for which the FCF was conducting activities related to disassembling, refining, refabricating, and reassembling EBR-II fuel subassemblies. After this time, the main activities at FCF involved inspecting, testing, and shipping irradiated reactor fuels to the Chemical Processing Plant for reprocessing and refining.

have been referring directly to FCF. Still another interviewee indicated around-the-clock shifts (i.e., triple shifts). However, this was specific to a construction project that only lasted three weeks. The most pertinent interview (SRDB Ref. ID 147446) worked at FCF during the period of interest and also provided general dates as to when the facility added a continuous second shift (described as the late 1960s).

Table 2-1. Summary of Information Relevant to the Potential for Shift Work at FCF from Former Worker Interviews Available in the SRDB

SRDB Reference for Interview	Relevant Information from Worker Statements
142386	– Energy employee (EE) is a claimant with U.S. Department of Labor (DOL) Covered employment at Argonne National Laboratory-West (ANL-W) from [redacted], 1967, to [redacted], 1995. – Worked primarily at EBR-II main building, also worked at L&O (chemistry labs), Transient Reactor Test Facility (TREAT), Zero Power Plutonium Reactor (ZPPR), research labs. Promoted to a Radiation Safety Tech [redacted] RadTechs at Hot Fuel Examination Facility (HFEF), FCF, and L&O. – The interviewee notes that sometimes he worked 12-hour shifts with *"coverage around the clock,"* also notes sometimes shift work took place. – There was no direct connection between overtime/shift work and FCF specifically. For example, those statements could represent work in the main EBR-II building.
147010	– Statement from interviewee: "*EBR-II was a 24 hour operations* [sic] *but FCF was typically just a day operation*." – EE is not a claimant, and employment at ANL-W did not begin until February 1977.
147011	– Statement from interview: "*FCF was a day operation*." – EE is not a claimant but appears to only have worked at FCF beginning in 2000.
147022	– EE was a pipefitter who started work at FCF in 1963. – Interviewee describes shift work on a specific construction project: three shifts, eight men per shift, 3 weeks in duration. – EE worked for Atlas Mechanical, which was a subcontractor at the ANL-W site. Typically, construction work in or near radiological areas was performed by the prime contractor.
147446	– Statement from interview: "*In September 1964 (or 1965)* [the EE] *transferred to the Fuel Fabrication Facility as a technician.* ***Originally FCF operated only one shift, but by the late 1960's a second shift was added and continued until HFEF-North came online***."*† [Emphasis added.] – EE is a claimant; however, additional information was not identified in the available claim files other than that the EE indicated they worked overtime (i.e., 40+ hours per week).

*SC&A assumes that the claimant's reference to the "Fuel Fabrication Facility" is actually representative of the Fuel Cycle Facility.
†Note: Construction of HFEF-North appears to have been completed sometime during 1972.

The second facet of SC&A's analysis involved the examination of available H.P documentation, including routine area surveys and contamination measurements. The documentation of such activities typically contains a start and end time for a given activity. The general concept behind this study is that H.P. monitoring activities, which take place after the standard "single-shift" work (assumed to be 0800 to 1700, or 8:00 am to 5:00 pm), could be potentially indicative of shift work occurring on that day.

As mentioned previously, this type of investigation carries considerable uncertainty when drawing firm conclusions as to when regular shift work may have been implemented versus non-routine maintenance activities. For example, some activities occurring outside of standard working hours may have taken place as a matter of necessity or convenience. Examples of which may include:

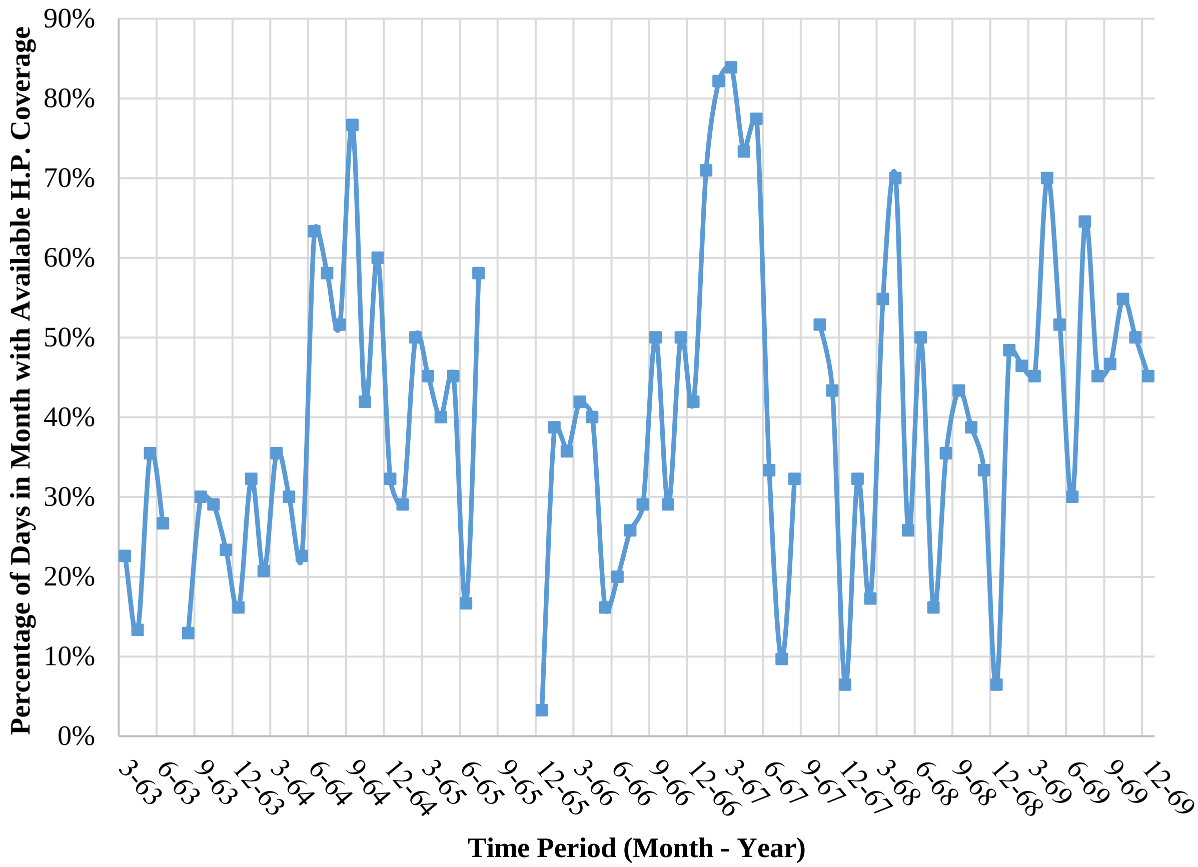
- Surveys of areas of FCF that may pose a considerable difficulty during normal working hours due to the particular operations occurring in those areas

- Special or "off-normal" maintenance, decontamination, or installation activities that may interrupt normal radiological operations

Additionally, survey reports currently available in the SRDB appear to be incomplete for the period of interest. SC&A assumes that the unavailable records are the result of data capture efforts aimed at obtaining a representative sample of area monitoring records rather than a complete dataset. The practice of capturing a representative and/or example set of records has been utilized during similar data capture efforts at other sites.

The percentage of total days in a given month for which H.P. monitoring data were captured is shown in Figure 2-1. As seen in the figure, the number of days in a given month for which H.P. area survey measurements are available for FCF varied significantly across the period of interest. Notably, no area survey data were found for the following time periods: July 1963, August–November 1965, and September 1967. The time period that generally displayed the highest number of days with available H.P. area monitoring was January through May 1967 (~84% of the days in the month).

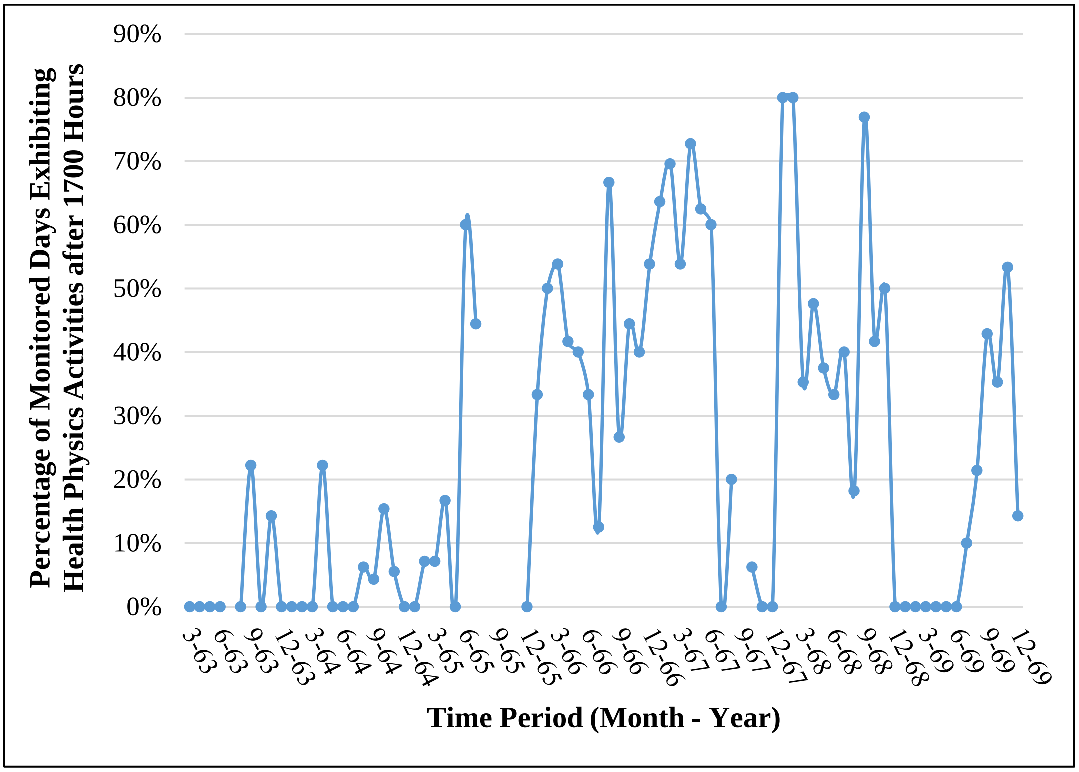
Figure 2-1. Percentage of Days per Month for which Health Physics Area Monitoring Data Are Available in the SRDB



Despite these noted uncertainties, examination of available H.P. area monitoring records provides important insight and perspective as to the operational work history at FCF, particularly in a temporal context. In order to quantify the potential for shift work, SC&A compared the number of days per month for which H.P. area monitoring is available versus the number of those days for which there were demonstrated H.P. activities after a typical single-shift working hours (assumed to be 0800 to 1700 hours). The percentage of such "monitored" days per month exhibiting characteristic is shown in Figure 2-2. As seen in the figure, the percentage of days in which H.P. activities occurred after 1700 hours varied significantly by month. In general, it appears that the occurrence of off-normal activities was relatively low from March 1963 through May 1965, when the percentage ranged from 0 to 20%.

After this timeframe, the observed number of days with "off-normal" H.P. activities generally increased but also varied significantly from month to month. If one accepts that the available H.P. survey reports are a representative sample, then this would indicate that the implementation of a second shift, or "swing shift," may not have occurred as part of general change in policy at FCF but rather was implemented on an "as needed" basis.

Figure 2-2. Percentage of Monitored Days Exhibiting Health Physics Coverage after 1700 Hours (5 p.m.) per Month for the Fuel Cycle Facility



The preceding analysis focused on the observed H.P. survey activities occurring after 1700 hours; however, it is also possible activities occurred prior to the start of a typical single-shift workday (i.e., prior to 0800 hours). Such activities might be indicative of an additional third shift being utilized at FCF. While there were observed H.P. activities identified prior to 0800 hours on a given workday, they were exceedingly rare. Nearly 88% of months reviewed in this analysis showed no H.P. activity prior to 0800 hours. The highest incidence of work occurring prior to 0800 hours occurred in January and February of 1967 (4 of 22 and 6 of 23 days per month, respectively). Examples from this time frame are shown in Table 2-2.

As seen in Table 2-2, the descriptions of H.P. activities occurring prior to 0800 hours during the January–February 1967 time frame appear to be associated with off-normal maintenance and removal of radioactive components for shipment to other areas. SC&A did not find any evidence of a third shift being utilized at FCF, which is consistent with NIOSH's understanding per the technical conference call on June 15, 2016.

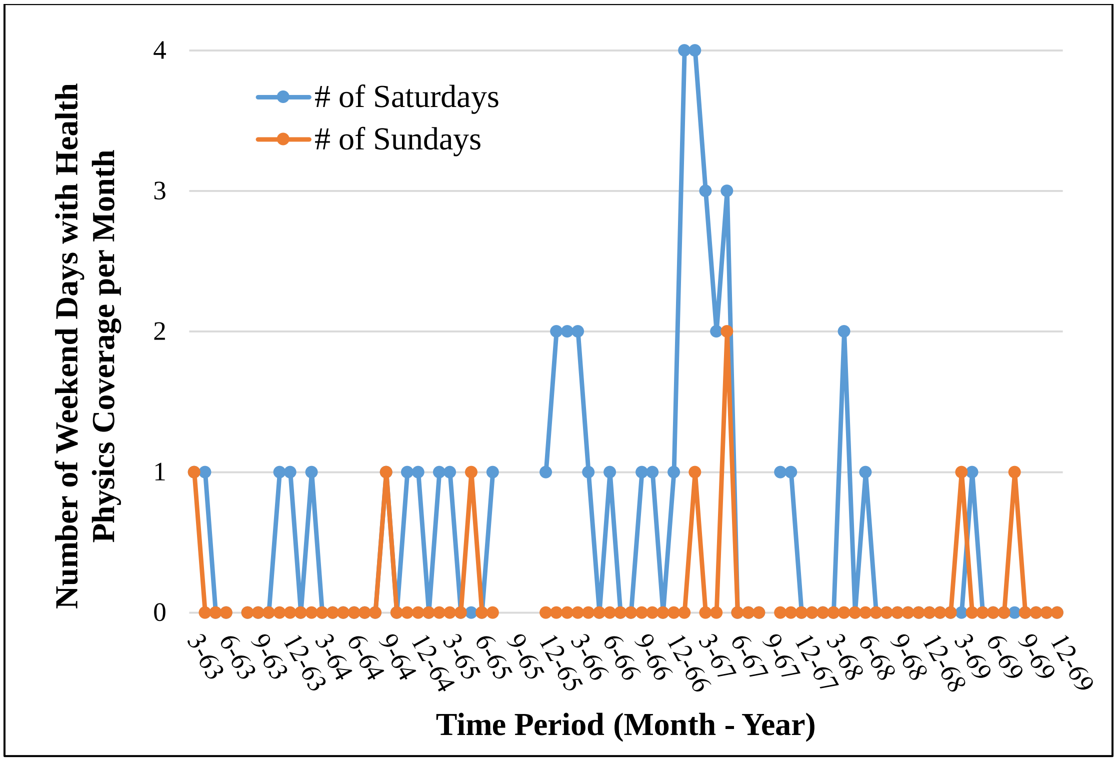
Table 2-2. Examples of H.P. Surveys Performed in January and February 1967 prior to 0800 Hours

Date	Start Time	Description
Thursday, January 12, 1967	0010	Survey of single individual following an attempted decontamination operation. The last H.P. operation on the previous day occurred at 2330 hours involving a maintenance operation to replace cell plugs for the air cell which took place on the roof.
Friday, January 13, 1967	0320	Personnel surveys following decontamination activities on FCF roof.
Monday, January 16, 1967	0430	H.P. coverage on entry to the "Wind and Weather" shelter on the roof and maintenance on a manipulator device.
Friday, January 20, 1967	0030	Continued H.P. coverage on manipulators from the "Wind and Weather" area of the FCF roof (lasted about 4 hours).
Wednesday, February 01, 1967	0100	H.P. coverage of repair work on the cranes within the air cell, special H.P. procedures provided for the work.
Thursday, February 02, 1967	0530	H.P. coverage for the loading of a "glass scrap coffin."
Sunday, February 12, 1967	0330	H.P. coverage during the transfer of vycor molds into the air cell with floor plug removed.
Thursday, February 16, 1967	0700	Survey loading of three rods into EBR-I coffin for shipment to Test Area North (TAN), special H.P. procedures provided for the work.
Saturday, February 18, 1967	0600	Monitoring the transfer of a subassembly from cell to "old" EBR-I coffin. Notes: "*All ASSE to go to Burriel ground* [sic]"
Wednesday, February 22, 1967	0005	Survey at air cell transfer port, for transfer out of 24 slave hands.

In addition to analyzing H.P. activities occurring outside of the typical hours for a single shift operation, SC&A analyzed the number of instances per month for which H.P. activities occurred on Saturday and Sunday. This is particularly important for instances where the fixed air samples may have been set on Friday morning and run continuously until being collected and analyzed on Monday morning. The number of Sundays and Saturdays per month for which H.P. monitoring activities occurred is shown in Figure 2-3.

As the figure shows, the instances of H.P.-related work occurring on Saturday was either zero or one for the majority of months. The highest observed occurrence of Saturday H.P. coverage occurred from roughly January 1967 to May 1967 (two to four Saturdays per month). Notably, this uptick in activities also corresponded to the time frame in which SC&A observed the most days per month with available H.P. survey data (see Figure 2-3), as well as a relatively high incidence of H.P. activity after 1700 hours (see Figure 2-2). The occurrence of H.P.-related work on Sundays was a much rarer occurrence, with over 91% of the available monthly data indicating no work on Sunday at all. Only a single month (May 1967) contained H.P. survey data for more than one Sunday. Aside from the period from January to May 1967, there does not appear to be a clear temporal trend in potential work occurring on weekends.

Figure 2-3. Number of Weekend Days per Month with Health Physics Activities



In summary, SC&A identified several pieces of evidence that shift work (or in some cases off-normal work) occurred at FCF throughout the period of interest. However, SC&A did not find evidence that a uniform temporal shift in plant operations occurred that may have necessitated regular "swing shift" or "off-normal" H.P. activities. The exception to this is the first half of 1967, when there was a relative increase in H.P.-related activities occurring both before and after the typical single-shift hours. In addition, there was a general increase in H.P. activities occurring on weekends during this time.