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**APPENDIX A**  
**AVAILABLE AIR FORCE DATA**

## APPENDIX A AVAILABLE AIR FORCE DATA

### A.1. INTRODUCTION

This effort required a review of the available exposure monitoring data for use in re-evaluating doses to those who responded to the Thule nuclear accident. Since the accident occurred 33 years ago, this review depended on the ability to identify relevant records, reports and other data to form as complete a picture of the situation as possible. Initial efforts focused on accumulating and reviewing records provided by the Air Force Medical Operations Agency (AFMOA) at Bolling AFB, DC and the Air Force Institute for Environmental, Safety, And Occupational Health Risk Analysis (AFIERA) at Brooks AFB, TX. AFIERA succeeded the USAF Radiological Health Laboratory (USAF RHL) as the Air Force's primary radiological consultant laboratory and custodian of personnel radiation exposure records in the USAF Master Radiation Exposure Registry. Initial contact with both AFMOA and AFIERA identified and provided information on the availability of Palomares records. AFIERA and AFMOA provided their records in the form of:

- Copies of reports of the accident response, correspondence generated in response to inquiries from individual participants, other U.S. agencies, and the Danish authorities, and RHL documents on the evaluation of exposures by urinalysis.
- A computer text file prepared by AFIERA staff that apparently contained the results of sample analyses from the RHL support of the Thule response, called Operation Crested Ice.

Although it is reasonable to assume that the USAF RHL used laboratory analysis and record-keeping procedures that were similar to those used for the Palomares Nuclear Weapons Accident (LABAT, 2001), AFIERA has been unable to locate the hard-copy records to date. Additional efforts may still provide some data, however, this report provides a comprehensive evaluation of the electronic records for use in performing dose estimates. This appendix discusses the results of this review and the modifications and assumptions made to the data for use in the dose assessment. The appendix provides specific details of the three types of records and the concerns they generated, as well as efforts to correct, improve, or interpret those records for this project.

### A.2. TYPES OF RECORDS KEPT

The record prepared and maintained by the Air Force consisted of laboratory forms, computer records of analysis results, and written correspondence and reports. This section provides details of the forms and the data they contained.

#### A.2.1. Forms

USAF RHL, as the central laboratory for providing radiological services to Air Force units, applied their laboratory processes with some modifications to this accident. USAF RHL, an Air Force Logistics Command (AFLC) organization at the time, used AFLC sanctioned forms for recording the data and results of samples processed. Since the Thule accident occurred almost

exactly two years after the Palomares accident, the USAF RHL apparently applied lessons learned from support of that accident to Thule support. We believe that USAF RHL continued use of the AFLC Form 1165, Radiological Sample Data (Jul 67), described in the Palomares Dose Evaluation Report (LABAT, 2001) for recording Operation Crested Ice sample results (Taschner, 2000). We also believe that the USAF RHL also recorded the results on computer punched cards for data analysis and record-keeping purposes. Copies of the punched card images are the only available copies of those results. The content, interpretation and evaluation of the computer records follow.

## **A.2.2. Electronic Record**

### **A.2.2.1 *Format and Content***

Figure A-1 contains an example of the data records that AFIERA provided. The records represent conversion of original USAF RHL punched card records to electronic disk file after several steps that occurred during operation of USAF RHL through 1978, transfer and integration into the USAF Occupational and Environmental Health Laboratory (USAF OEHL) and subsequent organizational realignments to AFIERA.

Each data record contains 80 characters per line or record as shown. Figure A-1 contains a column header that indicates the column for each entry. The records represent results for the sample. The USAF RHL system used two record types - a sample status or identification record, and result records for each sample. Each sample was represented by one status record and as many result records as necessary. The electronic file provided by AFIERA contains only result records.

### **A.2.2.2 *Interpretation of Data Record***

Discussions with AFIERA personnel and knowledge of one of this report's authors about the USAF RHL system produced the following explanation of the information contained in the data records.

The sample number appears to the far right in columns 73 through 80, and is duplicated on each line of data for that sample.

Columns 1 - 20 are alpha-numeric identifiers and include isotope or method of analysis, date of collection, date of counting, etc. Dates are expressed either as a combination of the last digit of the year and the number of the day of the year or as the day of the month and three letter abbreviation for the month. Thus, for the day of the year in 1968, 8031 means January 31, 1968. For the day and month representation, 24JAN means January 24, 1968.

The designation "trhl" in this field indicates a screening result obtained by RHL health lab personnel on-site at Thule.

Column 21 contains a single character, which is a code for the type of sample. Table A-1 below provides the meaning of the sample code.

```

-----1-----2-----3--COLUMN-4-----5-----6-----7-----8
123456789-123456789-123456789-123456789-123456789-123456789-123456789-
-----
DATE COUNTED 8047 D D526327090 E605 P159-16801630
DATE COUNTED 8047 D D526327090 E605 P159-16801630
PU RECOVERY D 78 0 PER CENT D526327090 E605 P159-16801630
PU239 D NDA D526327090 E605 P159-16801630
SAMPLE VOLUME D 1 81 LITERS D526327090 E605 P159-16801630
TRITIUM D NDA D526327090 E605 P159-16801630
DATE COUNTED 8047 D D202125238 E605 P159-16801631
DATE COUNTED 8049 D D202125238 E605 P159-16801631
PU239 D NDA D202125238 E605 P159-16801631
RECOVERY PU D 62 3 PER CENT D202125238 E605 P159-16801631
SAMPLE VOLUME D 3 03 LITERS D202125238 E605 P159-16801631
TRITIUM D NDA D202125238 E605 P159-16801631
DATE COUNTED 8047 D D510260392 E605 P159-16801632
DATE COUNTED 8050 D D510260392 E605 P159-16801632
PU 239 D NDA D510260392 E605 P159-16801632
RECOVERY PU D 68 7 PER CENT D510260392 E605 P159-16801632
SAMPLE VOLUME D 1 77 LITERS D510260392 E605 P159-16801632
TRITIUM D NDA D510260392 E605 P159-16801632
236PU SPIKE RECOVERYD 88 2 PER CENT D432568582 E605 P146-16801642
239PU ALPHA SPEC D 0 00 D432568582 E605 P146-16801642
DATE COUNTED 8047 D D432568582 E605 P146-16801642
SAMPLE VOLUME D 0 71 LITERS D432568582 E605 P146-16801642
TRITIUM D 1 08 UC P L D432568582 E605 P146-16801642
236PU SPIKE RECOVERYD 91 3 PER CENT 293187417 E605 Q097-16803666
239PU ALPHA SPEC D 0 00 293187417 E605 Q097-16803666
DATE COUNTED 8066 D 293187417 E605 Q097-16803666
SAMPLE VOLUME D 1 12 LITERS 293187417 E605 Q097-16803666
SYSTEMIC BODY BURDEND 0 00 293187417 E605 Q097-16803666
TRITIUM D289 39 NC PER L 293187417 E605 Q097-16803666
DATE COLLECTED 24JANM D226384667 E605 E605-16800285
DATE COUNTED 8033 M D226384667 E605 E605-16800285
GROSS ALPHA M NDA D226384667 E605 E605-16800285
DATE COLLECTED 24JANM D310286447 E605 E605-16800286
DATE COUNTED 8033 M D310286447 E605 E605-16800286
GROSS ALPHA M NDA D310286447 E605 E605-16800286
DATE COLLECTED 24JANM D138266195 E605 E605-16800287
DATE COUNTED 8033 M D138266195 E605 E605-16800287
GROSS ALPHA M NDA D138266195 E605 E605-16800287

```

Figure A- 1 USAF RHL Electronic Data Record

Table A- 1. Sample code interpretation.

Code	Meaning
A	Water
D	Urine
J	Soil
L	Air Sample
M	Swipe or Nasal Swab

Columns 22 through 27 contain the analytical result with Column 25 containing a implied decimal point that produces a numerical format of XXX.XX. Columns 28 through 33 contain the estimated error for the result and contain an implied decimal point in Column 31.

Columns 35 through 45 contain the units for the result. Table A-2 provides an interpretation of the coding for units field interpretation.

**Table A- 2. Interpretation of units field.**

l	liter
pc	picocurie
fc	femtocurie
uc	microcurie
nc	nanocurie
p	per
swip	swipe
spl	sample
m3	cubic meter
NDA	No Detectable Activity (This is not strictly a unit, but was apparently placed in this field to avoid computer interpretation problems if present in a field requiring a number.)

Column 46 contains a letter sometimes, usually a 'D' whose meaning is undetermined.

Columns 47 through 55 contain the Social Security Account Number, Air Force Service Number or other alphanumeric person (generally for citizens of foreign countries) or site identifier. These must be cross-referenced to documentation created at the time the sample was collected to identify a specific person or place.

Column 56 is blank.

Columns 57 through 60 contain a code for the base where the exposure occurred if different from the base responsible for the sampling program. This field was developed to provide a common search term for all samples and results pertaining to a specific monitoring program, incident, etc., such as Operation Crested Ice. Code E605 means Thule AB.

Columns 61 through 67 are blank.

Columns 68 through 71 contain the code for the base that collected the sample and was presumably responsible for the records. For situations like Operation Crested Ice this entry represents the base of permanent assignment of personnel.

Column 72 contains a dash (-) to indicate that the record is a result record.

These criteria for interpretation of the electronic records were applied to convert the records into a Microsoft Excel spreadsheet for further manipulation and analysis. The results of those analyses are described in Section A.3 below.

### **A.2.3. Reports**

Additional information in the form of correspondence and written reports can provide details of the accident and the response effort, as well as insight into the approach to evaluating possible

health and safety issues associated with the response effort. Several documents provided key information about those factors and formed the foundation for the pertinent analysis required of this effort. Documents that provided those kinds of key information included:

- A special edition of the publication *USAF Nuclear Safety* that was published in 1970 by the Directorate of Nuclear Surety, Air Force Inspection and Safety Center, and devoted entirely to the circumstances, outcome, response, monitoring, and cleanup efforts associated with Operation Crested Ice.
- *Final Health Physics Report on Project Crested Ice* by John Taschner of the USAF Radiological Health Laboratory, and Lars Botter-Jensen of the Danish Atomic Energy Commission, dated September 14, 1968, that presented a summary of the on-site health physics activities during the disposal phase (April 1, 1968 through September 13, 1968).
- Other reports and documentation of the support to the incident.

### **A.3. DATA EVALUATION FOR DOSE ASSESSMENT**

#### **A.3.1. Data Evaluation**

The AFIERA data set was converted to three Microsoft Excel spreadsheets. One of those contained urine samples (coded "D"), one contained air sample results (coded "L"), and the other contained swipes and nasal swabs (coded "M"). The original data set also contained samples coded as water samples, soil samples, and other types. Those were not processed further for this effort.

The spreadsheets were separately evaluated for data content relevant to performing dose evaluations. Parameters including exposure dates, sample collection dates, and results were considered critical. Although the nasal swabs were considered as screening samples only, the nature and content of the records could serve as confirmation of statements made in the original incident reports. Dates that nasal swabs were collected especially indicate when an individual was present at Thule and an approximate time of exposure.

Table A-3 summarizes the data for nasal swabs, swipes and urine. The results are also categorized for the total sample records, for samples from United States personnel, and for samples from citizens of foreign countries (Danish citizens at Thule). Records were assigned to the categories based on the entry in the Social Security Number field. Entries with the characters 001 or higher in the leftmost three positions were assumed as US citizens. Entries with 000 in the leftmost three characters that were assumed initially to be non-US citizens; however, following a research effort to match names with SSNs, some of those numbers were apparently assigned to U.S. personnel. Perhaps this was done when an Air Force Service Number of Social Security Number were not immediately available in the field. For urine samples, 10 samples were analyzed using gross alpha and 526 samples were analyzed using alpha spectrometry. All of those analysis records pertain to United States personnel. Furthermore, none of the urine sample records contains exposure date information and only the 10 samples analyzed by gross alpha have sample collection date information. Fortunately, counting date information is available for all but a few of these samples. It may be possible to correlate counting dates with sample

numbers and nasal swab collection dates to estimate an approximate exposure period for some participants. However, this approach will provide a rather rough estimate.

The nasal swab records indicate that 9312 records are available for samples from individuals that were analyzed for  $^{239}\text{Pu}$ . These records contain entries in the Social Security Number field, indicating that they were collected from people. It is not clear that these samples were analyzed by alpha spectrometry. We suspect they were analyzed using a gross counting technique because the lowest value report is 2 picocuries per sample - a value more consistent with a gross counting technique. Furthermore, 8223 of the samples contained an entry for the date the sample was collected. Those could be used, if correlated to the Social Security Number entry, to develop a rough estimate of the period of exposure.

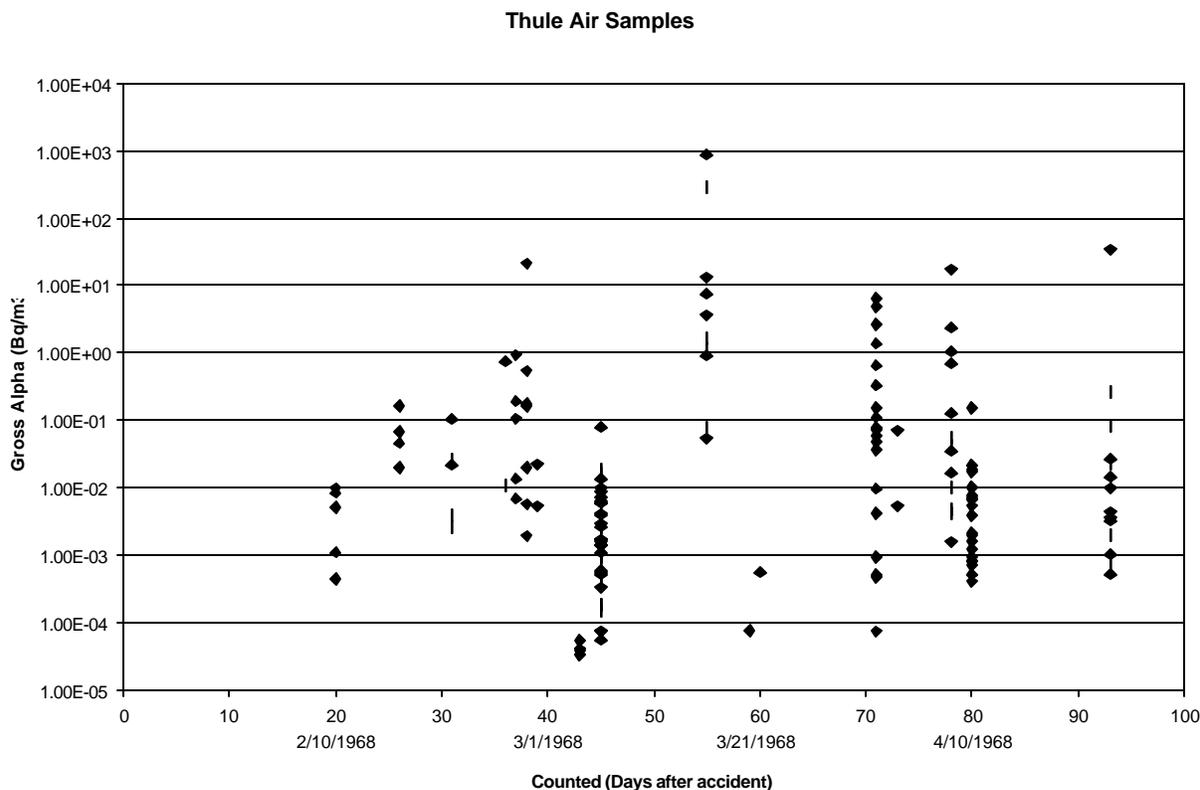
**Table A- 3. Sample records in IERA data set.**

	Total		U.S.		Foreign	
	#*	Range (pCi/sample)	#*	Range (pCi/sample)	#	Range (pCi/sample)
Urine						
Gross Alpha	10	0.3-1.3	10	0.3-1.3	0	-
$^{239}\text{Pu}$	526	NDA	526	NDA	0	-
Tritium	251	0.002-1.29 uCi/L	211	0.002-1.29 uCi/L	40	3-22 nCi/L
Date Collected	10	-	10	-	0	-
Total Samples						
Nasal Swabs						
Gross Alpha	5(1)	5-5	5(1)	5-5	0	-
$^{239}\text{Pu}$	9312(335)	2-208	8397	2-208	915	3-22
Tritium	97(1)	6-6	(89)	6-6	8	NDA
Date Collected	8223	-	7429	-	794	-
Total	9329	-	8414	-	915	-
Swipes						
Gross Alpha	5896(2186)	1-26,200	-	-	-	-
$^{239}\text{Pu}$	514(7)	4-162	-	-	-	-
Tritium	5235(2366)	1-22,300	-	-	-	-
Total	6425	-	-	-	-	-
Note: * The number in parentheses indicates the number of results with a result greater than the minimum detectable.						

The results for the gross alpha,  $^{239}\text{Pu}$  and tritium analyses for the nasal swabs confirm the conclusions that exposures to these radionuclides were not significant.

The air sample data set contained 169 results for samples collected during February through April 1968. Collection dates were available for only 21 of those records; but laboratory counting dates were recorded for all. Analysis of the 21 samples revealed that the collection date to counting date ranged from 11 to 19 days with an arithmetic mean of 14 days. The 169 results ranged in gross alpha activity concentration from  $8.89 \times 10^{-04}$  to  $2.38 \times 10^{-04}$  picocuries per cubic meter (pCi/m<sup>3</sup>) with a median value of  $2.05 \times 10^{-01}$  pCi/m<sup>3</sup>. Figure A-1 below illustrates the air sample results plotted against the days after the incident. Further analysis of those air sample results showed that the distribution was highly skewed. Table A-4 and Figure A-2 list and display the air concentration representing each 5 percent increment of the distribution. These

were found suitable for performing estimates of lower bound, upper bound, and median intake and committed effective dose equivalent.

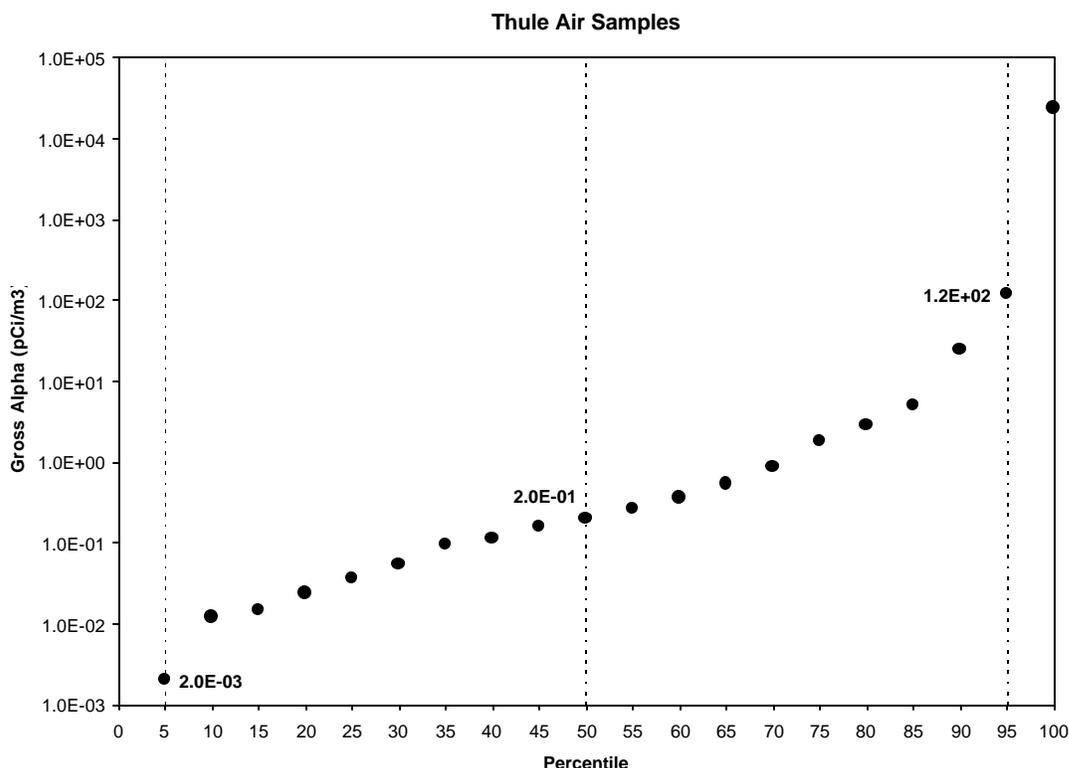


**Figure A- 1. Distribution of Thule air sample results.**

The data set contains one additional and significant data gap. Beside the Social Security Number field entries, there records contain no specific identifying information about the individuals test. That is, the records contain no names. Therefore, correlating the records with specific individuals will required additional searches, which included an effort to match names to SSNs and SSNs to names performed by the Locator Service of the Air Force Personnel Center.

**Table A- 4. Distribution of air sample results in percentiles.**

Percentile	pCi/m3	Percentile	pCi/m3
5	2.000E-03	55	2.674E-01
10	1.200E-02	60	3.610E-01
15	1.500E-02	65	5.392E-01
20	2.380E-02	70	8.642E-01
25	3.700E-02	75	1.820E+00
30	5.400E-02	80	2.848E+00
35	9.440E-02	85	5.120E+00
40	1.120E-01	90	2.498E+01
45	1.594E-01	95	1.184E+02
50	2.010E-01	100	2.380E+04



**Figure A- 2. Distribution of air sample results.**

#### **A.4. SUMMARY OF THE DATA EVALUATION**

The available data set for the Thule accident (Operation Crested Ice) was successfully interpreted and evaluated for use in estimating doses to participants using modern internal dosimetry techniques. The data set generally confirms conclusions made during the accident that significant exposures did not occur. Unfortunately, the data set contains data gaps that will seriously limit the quality of the estimates that can be performed. These data gaps include:

- Lack of identifying information for individuals; i.e. the records contain Social Security Number information but do not contain names.
- Lack of exposure date information for specific individuals.
- Lack of dates that samples were received at RHL.
- Sample collection information for only 10 urine sample records.

Efforts have already been started to correlate as many Social Security Numbers as possible using Air Force locator systems. Other efforts may be needed to obtain similar information for the members of other services and agencies. In addition, more intensive searches of available information may be warranted because we have preliminary information that many of the results were reported daily by RHL to the site using electronic messages.

**APPENDIX B**  
**DATABASE DATA STRUCTURE**

## APPENDIX B DATABASE STRUCTURE

### APPENDIX B.1 INCIDENT DATA

Incident description report (links to scanned images)  
Monitoring / follow-up reports with group (vs. individual) analysis / conclusions  
Bibliography of additional reports  
File Plan #  
Individuals involved  
Standard database reports available

### APPENDIX B.2 INDIVIDUAL DATA

Name  
Rank (current / retirement)  
Contact Info (address, phone, e-mail, etc.)  
AF ID#  
SSN (include privacy act wording when displayed)  
Sex  
Date of Birth  
Incidents  
    Incident link  
    Radionuclide(s)  
    Start / End Exposure date  
    Incident Base  
    Assigned Base  
    Bioassay Samples  
        Sample number  
        Sample date  
        Sample type  
        Sample volume & units  
        Collection Period  
        Sample collected by (name, org)  
        Sample Link (to scanned images)  
        Contaminated w/ remarks  
        Analysis  
            Radionuclide  
            Laboratory Name / Address  
            Lab receipt date  
            Analysis method  
            Analysis date  
            Sample result & units  
            Uncertainty & units  
            Uncertainty type  
            Multiple analyses of sample?

Analysis report links (to scanned data)

Dose modeling

Model used (name, version, version date, author)

Model parameters

Radionuclide(s)

Statistical method

Exposure duration assumption

Samples included (link to bioassay sample data)

Estimated intake & units

Organ CDE's & units

50 year CEDE & units

Interpretation of model results (narrative)

Correspondence

Letters to/ from individuals (links to scanned images)

Log of inquiries / correspondence / reports

Standard database reports available

Generic memo (several varieties of these)

Standardized memo