February 20, 2008

CLOSED MEETING NOTICE

Organization:	U.S. Department of the Air Force
Date:	February 26, 2008, 2:00 p.m. – 3:00 p.m.
Location:	U.S. Nuclear Regulatory Commission Executive Boulevard Building, Room 3B18 6003 Executive Boulevard Rockville, Maryland 20852
Purpose:	To discuss USAF's alternative plans for the shipment of radioisotope thermoelectric generators to a Department of Energy disposal facility.
Participants:	<u>NRC/NMSS</u> Robert Nelson Nancy Osgood Jessica Glenny <u>NRC/Region IV</u> Rachel Browder <u>USAF.</u> Mark Mays Col Donna Rogers Joy Powell Mark Talbert Maj Clint Abell
Meeting Category:	This meeting is closed to the public due to the discussion of security-related SUNSI material.
Contact:	Jessica Glenny, 301-492-3285, JXG6@nrc.gov
Docket Nos.	71-5862 & 71-4888
TAC No.:	L24177
Enclosure:	Meeting Agenda

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Contact:	Jessica Glenny, 301-492-3285, JXG6@nrc.gov
Docket Nos.	71-5862 & 71-4888
TAC No.:	L24177
Enclosure:	Meeting Agenda

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DATE:	2/15/2008		2/13/2008		2/20/2008	

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OFFICIAL RECORD COPY

Agenda
February 26, 2008, 2:00 p.m. – 3:00 p.m.
Department of the Air Force

2:00 p.m.	General Meeting Information and Introductions
2:05 p.m.	RTG Background Discussion
2:10 p.m.	Discussion of Current Shipment Plan
2:30 p.m.	Disposal Plan Development and Timeline
3:00 p.m.	Meeting Adjourned

DEPARTMENT OF THE AIR FORCE
AIR FORCE TECHNICAL APPLICATIONS CENTER

13 December 2006

MEMORANDUM FOR AFMOA/SGPR

FROM: AFTAC/SE
1030 South Highway A1A
Patrick AFB Florida 32925-3002

SUBJECT: Renewal of Certificate of Compliance No. 4888 for Sentinel – 25A, LCG-25A; Sentinel-25B, LCG-25B; Sentinel 25-C, LCG-25C; Sentinel-25C3, 25D, 25E, and 25F Packages Radioisotope Thermoelectric Generators, USAF Permit No. FL-00409-01/00AFP, Docket No. 030-00409

1. The Certificate of Compliance (CoC) for the subject Radioisotope Thermoelectric Generator (RTG) is due to expire 31 January 2007. Please use the attached documents to renew the CoC with the Nuclear Regulatory Commission. No changes are required.

2. Please contact me at DSN 854-3870 or (321) 494-3870 if you desire additional information. Thank you for your assistance.

JOY M. POWELL, Civilian, DAF
Command Radiation Safety Officer

Attached
NRC CoC (8 pages)

NMSS01

NRC FORM 618 (8-2000) 10 CFR 71		CERTIFICATE OF COMPLIANCE FOR RADIOACTIVE MATERIAL PACKAGES		U.S. NUCLEAR REGULATORY COMMISSION
1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE / PAGES
4888	12	71-4888	USA/4888/B( )	1 OF 5

2. PREAMBLE

a. This certificate is issued to certify that the package (packaging and contents) described in Item 5 below meets the applicable safety standards set forth in Title 10, Code of Federal Regulations, Part 71, "Packaging and Transportation of Radioactive Material."

b. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. THIS CERTIFICATE IS ISSUED ON THE BASIS OF A SAFETY ANALYSIS REPORT OF THE PACKAGE DESIGN OR APPLICATION

a. ISSUED TO *(Name and Address)*

Department of the Air Force
Air Force Technical Application Center/CC
1030 S. HWY A1A
Patrick AFB, FL 32925-3002

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION

Teledyne Energy Systems applications dated April 26, 1985 and August 19, 1986, as supplemented

4. CONDITIONS

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

5.

(a) Packaging

(1) Model No.: Sentinel-25A, LCG-25A; Sentinel-25B, LCG-25B
Sentinel-25C, LCG-25C; Sentinel-25C3, -25D, -25E, -25F

(2) Description

The packages are thermoelectric generators. The major components include the main housing, tungsten shield, housing flange, and electrical connectors. The approximate dimensions and weights for the various Model Nos. are as follows:

Model No.	Dimensions (inches)	Weight (lbs.)
Sentinel-25A, LCG-25A	25 OD x 25	3000
Sentinel-25B, LCG-25B	25 OD x 25	3300
Sentinel-25C, LCG-25C	24 OD x 32	2000
Sentinel-25C3	24 OD x 32	1300
Sentinel-25D	25 OD x 27	3300
Sentinel-25E	25 OD x 34	4200
Sentinel-25F	25 OD x 32	1400

5. (a) Packaging (continued)

(3) Drawings

The packagings are constructed in accordance with the following Drawing Nos.:

Model No.	Drawing Nos.
All Models	Isotopes, Inc. Drawing Nos.: 001-20000, Rev. E 001-20001, Rev. F 001-20002, Rev. F 001-20003, Sht. 1, Rev. B 001-80003
Sentinel-25A, LCG-25A	Martin Company Drawing Nos.: N0013100, Rev. A N0013108, Rev. D 001-40000, Rev. A Isotopes, Inc. Drawing Nos.: 001-10000, Rev. B 001-70024, Rev. C 001-70025, Sht. 1, Rev. D 001-70033, Shts. 1 & 2, Rev. A 001-70036 001-80005
Sentinel-25B, LCG-25B	Martin Company Drawing Nos.: N0013200, Rev. C 001-40012 Isotopes, Inc. Drawing Nos.: 001-70024, Rev. C 001-70025, Sht. 1, Rev. D 001-70033, Shts. 1 & 2, Rev. A 001-70036 001-80005
Sentinel-25C, LCG-25C	Martin Company Drawing Nos.: 001-40004, Rev. A 001-70010 001-70012, Rev. B 001-80004 Isotopes, Inc. Drawing Nos.: 001C10000, Sht. 1 Rev. D, & Sht. 3 001-70009, Rev. D

Model No. (continued)	Drawing Nos. (continued)
Sentinel-25C3	Isotopes, Inc. Drawing Nos.: 001C10000 Shts. 1 & 2, Rev. D 001-70009, Rev. D 001-70057, Rev. D 001-70060, Rev. C 001-40019, Rev. B
Sentinel-25D	Martin Company Drawing No. 001-80004 Isotopes, Inc. Drawing Nos.: 001D10000 Shts. 1 & 2, Rev. C 001-70036 001-70033 Shts. 1 & 2, Rev. A 001-70025 Sht. 1, Rev. D 001-70024, Rev. C 001-40015, Rev. C 001-40006, Rev. B
Sentinel-25E	Isotopes, Inc. Drawing Nos.: 001E10000, Shts. 1 & 2, Rev. E, & Sht. 3 001-70039, Rev. C 001-70025, Sht. 1, Rev. D & Sht. 2 001-70024, Rev. C 001-40017, Shts. 1 & 2, Rev. D 001-40006, Rev. B
Sentinel-25F	Isotopes, Inc. Drawing Nos.: 001F10000, Shts. 1 & 2, Rev. H* 001-70070, Rev. C 001-70060, Rev. C 001-70009, Rev. D 001-40025, Rev. A

*As modified by Figure 1 of the April 26, 1985, application.

(b) Contents

(1) Type and form of material

(i) Strontium 90 titanate doubly encapsulated in a Hastelloy or Uniloy fuel capsule which meet the requirements of special form radioactive material; or

(ii) Model No. Sentinel-25F may have, strontium fluoride doubly encapsulated in Hastelloy or Uniloy fuel capsule, with a Hastelloy C-276 liner which meets the requirements of special form radioactive material.

(2) The maximum quantity of material per package

125,000 curies

6. A barrier (permitting the free circulation of air) must be provided with sufficient separation distance to ensure that the requirement of 10 CFR 71.43 (g) will be met.

7. Eye-bolts shall be removed or covered during transportation to prevent their use as tie-down devices of packages.

8. In addition to the requirements of Subpart G of 10 CFR Part 71, each package shall be operated, prepared for shipment and maintained in accordance with the following Operating Procedures and Maintenance Programs:

Model No.	Operating Procedures	Maintenance Program
Sentinel-25A, LCG-25A	Appendix E of TES-3206, as revised	Appendix F of TES-3206, as revised
Sentinel-25B, LCG-25B	Appendix E of TES-3209, as revised	Appendix F of TES-3209, as revised
Sentinel-25C, LCG-25C	Appendix E of TES-3210, as revised	Appendix F of TES-3210, as revised
Sentinel-25C3	Appendix E of TES-3211, as revised	Appendix F of TES-3211, as revised
Sentinel-25D	Appendix E of TES-3212, as revised	Appendix F of TES-3212, as revised
Sentinel-25E	Appendix E of TES-3213, as revised	Appendix F of TES-3213, as revised
Sentinel-25F	Chapter VIII of TES-3202, as revised	Chapter IX of TES-3202, as revised

9. The packages authorized by this certificate are hereby approved for use under the general license provisions of 10 CFR 71.12.

10. Expiration date: January 31, 2007

REFERENCES

Teledyne Energy Systems applications dated April 26, 1985; and August 19, 1986.

Teledyne supplements dated: November 3, 1986; September 17 and December 2, 1991.

Department of the Air Force supplement dated: November 12, 1993; December 11, 1996; January 15, 2002.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

E. William Brach

E. William Brach, Director
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Date: January 29, 2002

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

NOV 20 2006

Mr. David L. Pugh, Capt., USAF, BSC
Health Physicist
Department of the Air Force
110 Luke Avenue, Room 405
Bolling Air Force Base
Washington, DC 20032-7050

SUBJECT: NOTICE OF EXPIRATION OF CERTIFICATE OF COMPLIANCE NO. 4888

Dear Mr. Pugh:

This refers to Certificate of Compliance No. 4888 which has an expiration date of January 31, 2007.

To ensure continued use of the packaging, you should submit an application for renewal of the certificate at least 30 days prior to the expiration date. The sections on operating procedures, acceptance tests, and maintenance programs should be reviewed to assure they are complete and current. If revisions are necessary, the revised sections should be submitted with the application for renewal. Note that the certificate of compliance may be conditioned to specifically cite the operating procedures, acceptance testing, and maintenance programs.

This notice of expiration should not be construed that such notice will be provided in the future. Also, please let us know if you do not intend to request renewal of the certificate.

Sincerely,

Robert A. Nelson, Chief
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-4888

[redacted]

BACKGROUND

ON

BURNT MOUNTAIN RTG's

The Air Force operates an unattended science observatory at Burnt Mountain, Alaska, a remote area about 60 miles north of the Arctic Circle, 50 miles from the closest village and 56 miles from the nearest airport. The data collection and communications equipment at the station were powered by 10 nuclear batteries, called radioisotope thermoelectric generators (RTGs). Each RTG is fueled with 1.2 - 3.9 pounds of strontium-90 (Sr-90). In the late summer of 1992, a tundra fire around the site damaged some data cables but left everything else intact. The fire raised public concern about the safety of using a radioactive material as the station's power source. In 2000, a hybrid power system composed of batteries charged by solar panels and diesel fuel replaced the RTGs as the observatory power source. The Air Force is currently planning a course of action for removing the RTGs and transporting them to a DOE facility for disposal.

Location
- 67°25'N 144°36'W, approximately 62 miles north of the Arctic Circle.
- 1100 ft. difference in elevation between highest and lowest sensor sight.
- Discontinuous permafrost exists.

Access/Transportation
- There are no roads to Burnt Mountain
- Personnel and materials are flown in from Eielson AFB or Fort Wainright via helicopter.
- Fort Yukon is nearest village, having a population of approximately 600 people.
  - -- Fort Yukon has an unimproved airstrip capable of daily flights.
  - -- Bulk supplies are delivered to Ft Yukon residents via barge on Yukon River 3 times a year.

RTGs (Sentinel Model)
- 4 variants of Sentinel Model at site - 25A, 25E, 25F and 100F
- Installed in early 1970's and 1980's
- Encapsulated fuel cell, thermoelectric converter, biological shielding, and outer housing.
- Contains between 1.2 and 3.9 pounds of Sr-90 fuel.
  - -- Produces heat via radioactive decay, not through fission or fusion.
  - -- Half-life of 28 years.
  - -- Sr-90 fuel in the form of hockey puck-sized disks of strontium titanate ($SrTiO_3$).
    - --- Solid material selected for strength, fire-resistance, and low water solubility.
- Attached to a non-removable steel pallet
- Certified for shipment by vessel, rail, motor vehicle or cargo-only aircraft with no additional packaging required – certification expires 1 October 2008.
- May be handled by forklift or overhead hoist crane.

Table 1 Specifications for RTGs at Burnt Mountain

Site	RTG Serial #	RTG Model #	Present Output	Total Output	Site Demand	Replacement Date
BM01	8	Sentinel 25E	10.4 watts	25.2 watts	9.0 watts	June 2018
	17	Sentinel 25E	14.8 watts			
BM02	9	Sentinel 25E	9.8 watts	24.2 watts	9.0 watts	January 2018
	20	Sentinel 25E	14.4 watts			
BM03	1	Sentinel 100F	42.3 watts	52.7 watts	26.2 watts	March 2009
	14	Sentinel 25F	10.4 watts			
BM04	10	Sentinel 25E	9.5 watts	24.6 watts	9.0 watts	June 2019
	18	Sentinel 25E	15.1 watts			
BM05	4	Sentinel 25A	6.7 watts	21.3 watts	9.0 watts	August 2012
	19	Sentinel 25E	14.6 watts			

Source U.S. Congress, 1994

Table 2 Characteristics of the RTGs at Burnt Mountain

Physical Attributes	Sentinel 25A	Sentinel 25E	Sentinel 25F	Sentinel 100F
Initial Activity, Ci	94,000	105,000-109,000	108,000	329,000
Date of Initial Activity	1968	1969-71	1970	1972
Activity in April 1994, Ci*	50,000	56,000-61,000	60,000	189,000
Activity as of February 1 2006, Ci	38,400	43,400-47,500	46,500	145,600
Housing Material	Cast Iron	Steel	Aluminum	Aluminum
Weight, lbs (kg)	3,000 (1364)	4,170 (1895)	1,400 (636)	2,720 (1236)
Dimensions, height x diameter, inches (m)	35 x 26 (0.89 x 0.66)	42 x 26 (1.07 x 0.66)	36 x 20 (0.91 x 0.51)	46 x 28 (1.17 x 0.71)
Volume, ft^3 (m^3)	10.75 (0.304)	12.90 (0.366)	6.54 (0.186)	16.39 (0.463)
Weight with attached steel pallet, lbs (kg)	3285 (1493)	4455 (2025)	1685 (748)	3113 (1415)
Dimensions on the pallet, length x width x height, inches (m)	51 x 44 x 43 (1.30 x 1.12 x 1.09)	51 x 44 x 50 (1.30 x 1.12 x 1.27)	51 x 43 x 47 (1.30 x 1.09 x 1.19)	56 x 44 x 57 (1.42 x 1.12 x 1.45)

Source Sandia National Laboratories/New Mexico February 2006
* Draft Environmental Assessment February 1998

USAF
Radioisotope Thermoelectric Generators

RTG Overview

- **10 RTG's Licensed to USAF**
- **Located above arctic circle at Burnt Mountain, Alaska**
- **Remote location – 50 miles from nearest village (Ft Yukon)**
- **Installed in 70's/80's to power science observatory**
- **Initial total activity of Sr-90 ~ 1 million curies**
- **Current total activity (2006) ~ 545,000 curies**
- **Limited Relief from increased controls – 11 May 2006**

~~Security Related Information~~
~~Withhold From Public Disclosure IAW 10 CFR 2.390~~

RTG Disposal

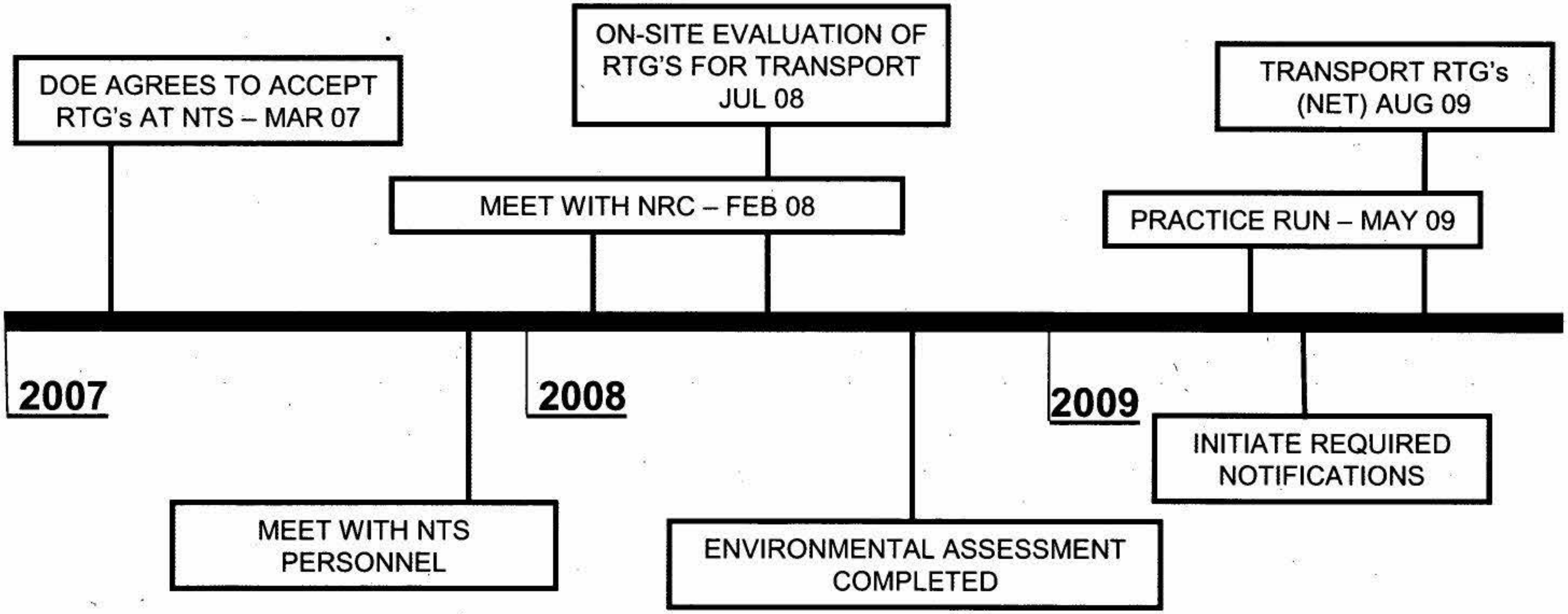
- **DoE has agreed to accept for disposal - March 2007**
  - **Greater than Class C radioactive waste**
- **RTG's will be transferred to Nevada Test Site**
- **Sandia National Labs mediating transfer of RTG's**
  - **AF responsible for transport of RTG's to NTS**
  - **Transferring possession/ownership to Sandia**
    - **Does not occur until RTG's reach NTS property**
  - **NTS accepts RTG's from Sandia**
- **Transport to occur no earlier than August 2009**
  - **Helo support currently deployed to Iraq**
  - **Environmental Assessment**
  - **Transportation Plan**
  - **Transferring possession/ownership**
  - **Security of RTG's during transport**
  - **Logistics at NTS**

RTG Transport

- NEPA compliance - Environmental Assessment
- All-Terrain Forklift used to load RTG's on to Chinook Helicopter
  - Two RTG's per flight
- Chinook Helicopter from BM to Ft Yukon
  - Secure at Ft Yukon
- C-130/C-17 cargo aircraft from Ft Yukon to Eielson AFB
  - Secure at Eielson AFB
- Option 1 Eielson AFB to NTS
  - C-130/C-17 cargo aircraft from Eielson AFB to NTS
    - Transport from NTS flightline to NTS disposal site
    - Sandia National Labs involvement
- Option 2 Eielson AFB to NTS – via Creech AFB
  - C-130/C-17 cargo aircraft from Eielson AFB to Creech AFB
    - Contract commercial carrier to NTS disposal site by public highway
    - Or transport through Creech AFB in to NTS

Security Related Information
Withhold From Public Disclosure IAW 10 CFR 2.390

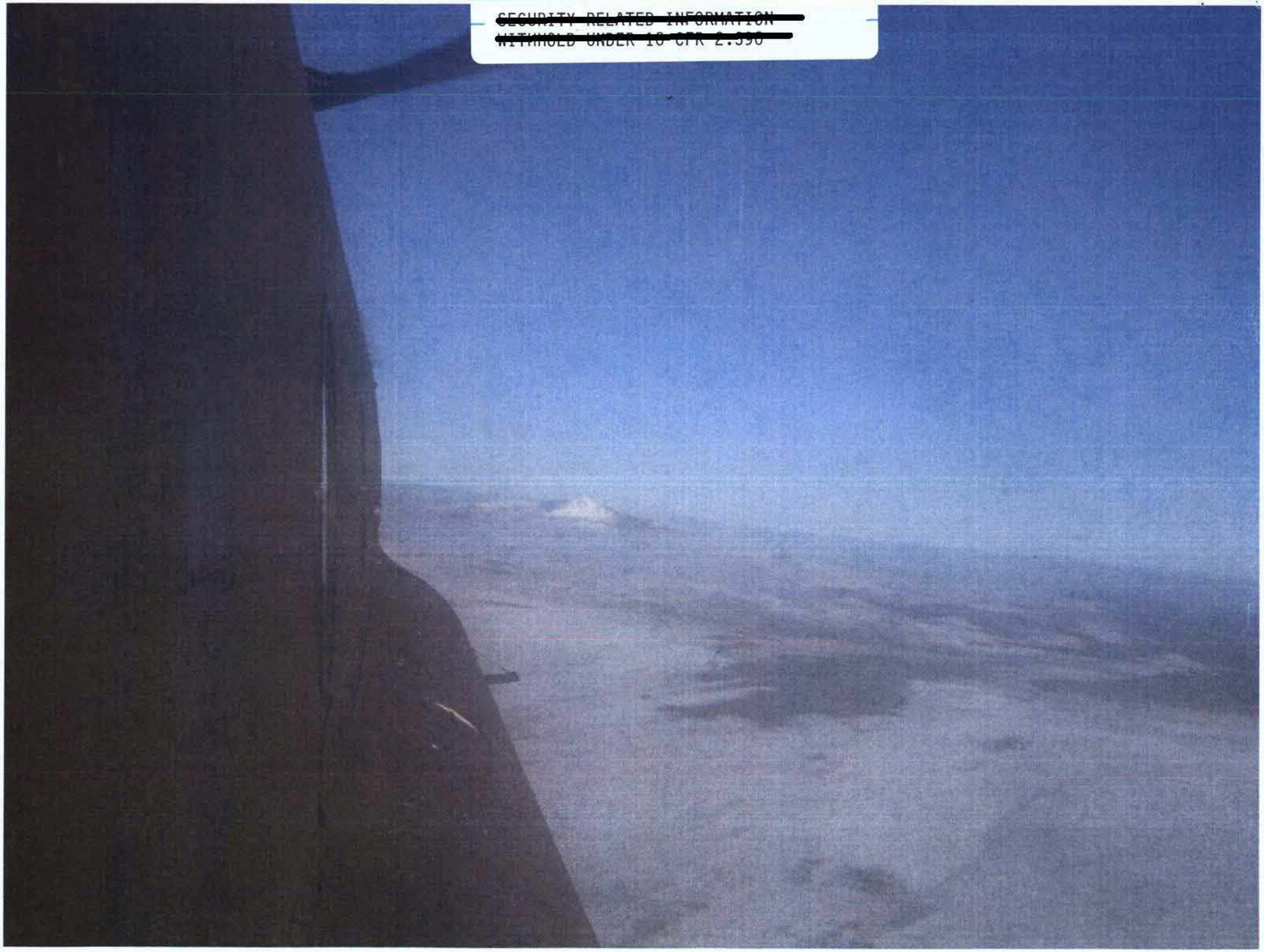
RTG Removal Timeline



Certificates of Compliance

- Two Certificates of Compliance
  - CoC No. 4888 – 9 RTG's, Type B Package USA/4888/B( )
    - Sentinel 25A, 25E, 25F
  - CoC No. 5862 – 1 RTG, Type B Package USA/5862/B( )
    - Sentinel 100F
- Expiration 1 October 2008
- Not Renewable

~~SECURITY RELATED INFORMATION~~
~~WITHHOLD UNDER 10 CFR 2.390~~



~~SECURITY RELATED INFORMATION~~
~~WITHHOLD UNDER 10 CFR 2.390~~

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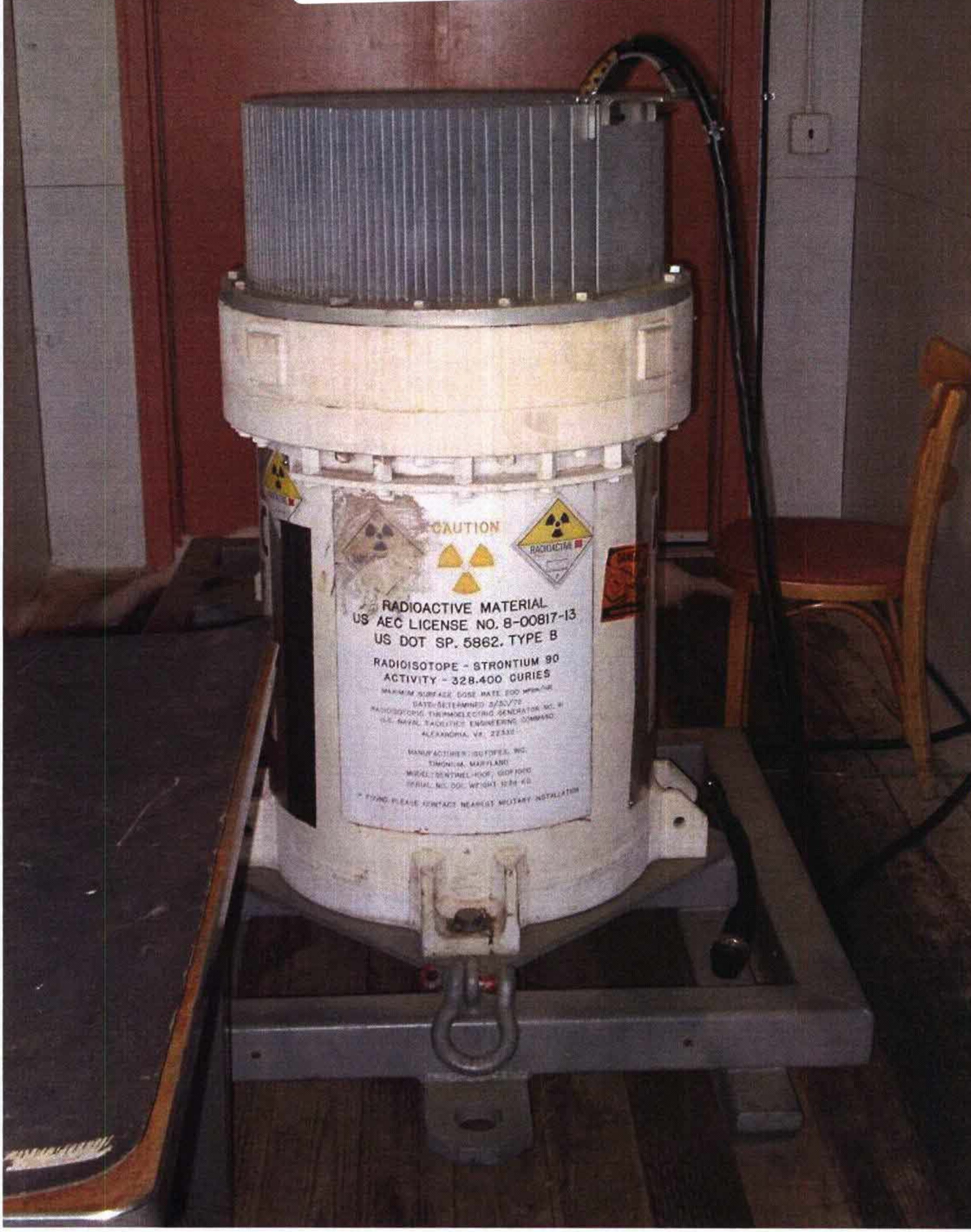

NRC FORM 618
(8-85)
10 CFR 71

U.S. NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. PACKAGE IDENTIFICATION NUMBER	d. PAGE NUMBER	e. TOTAL NUMBER PAGES
5862	7	USA/5862/B( )	1	2

2. PREAMBLE

a. This certificate is issued to certify that the packaging and contents described in Item 5 below, meets the applicable safety standards set forth in Title 10, Code of Federal Regulations, Part 71, "Packaging and Transportation of Radioactive Material."

b. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. THIS CERTIFICATE IS ISSUED ON THE BASIS OF A SAFETY ANALYSIS REPORT OF THE PACKAGE DESIGN OR APPLICATION

a. ISSUED TO *(Name and Address)*

Department of the Air Force
HQ ATAC/SEG
1030 S. Highway A1A
Patrick AFB, FL 32925-3002

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Teledyne Energy Systems application dated June 26, 1985, as supplemented.

c. DOCKET NUMBER 71-5862

4. CONDITIONS

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

5.

(a) Packaging

(1) Model No.: Sentinel-100F

(2) Description

The package, a thermoelectric generator, is 45.5 inches in height with a base diameter of 24.5 inches (excluding mounting pads), and weighs approximately 2,600 pounds. The components include a Tungsten biological shield (10.705" X 13.837" OD) which is within the aluminum (6061) outer protective housing. Four 6061-T6 mounting pads at the base of the aluminum housing provide the shipping pallet attachment points.

(3) Drawings

The packaging is constructed in accordance with the following Isotopes, Inc. Drawing Nos.:

010F10000 Sheets 1-3 (Rev. C), Generator Assembly Sentinel 100F
010-20000 Sheets 1-2 (Rev. B), Fuel Capsule Assembly
010-70003 (Rev. A) Shield Body
010-70004 Shield Plug
001-90064 Sheets 1-2 (Rev. A), Shipping Crate Sentinel RTG
001-90039 Sheets 1-2 (Rev. J), Sheet 3 (Rev. H), and Sheet 4, Pallet Assembly

5. (b) Contents

(1) Type and form of material

Strontium-90 titanate doubly encapsulated in a stainless steel liner and Hastelloy or Uniloy HC capsule which meets the requirements of special form radioactive material.

(2) Maximum quantity of material per package

370,000 curies.

6. Fabrication of additional packagings is not authorized.

7. In addition to the requirements of Subpart G of 10 CFR Part 71:

(a) The package shall be prepared for shipment and operated in accordance with the Operating Procedures in the supplement dated August 30, 1985.

(b) The package must be maintained in accordance with the Maintenance Program in the supplement dated August 30, 1985.

8. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12.

9. Expiration date: September 30, 2000.

REFERENCES

Teledyne Energy Systems application dated June 26, 1985.

Teledyne supplements dated: August 30, 1985; and July 26, 1990.

Department of the Air Force supplements dated: November 12, 1993; and August 15, 1995.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

William D. Travers

William D. Travers, Director
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Date: OCT 0 3 1995

U.S. NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE		PAGES
4888	12	71-4888	USA/4888/B( )	1	OF	5

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3. THIS CERTIFICATE IS ISSUED ON THE BASIS OF A SAFETY ANALYSIS REPORT OF THE PACKAGE DESIGN OR APPLICATION

a. ISSUED TO *(Name and Address)*

Department of the Air Force
Air Force Technical Application Center/CC
1030 S. HWY A1A
Patrick AFB, FL 32925-3002

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION

Teledyne Energy Systems applications dated April 26, 1985 and August 19, 1986, as supplemented

4. CONDITIONS

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

5.

(a) Packaging

(1) Model No.: Sentinel-25A, LCG-25A; Sentinel-25B, LCG-25B
Sentinel-25C, LCG-25C; Sentinel-25C3, -25D, -25E, -25F

(2) Description

The packages are thermoelectric generators. The major components include the main housing, tungsten shield, housing flange, and electrical connectors. The approximate dimensions and weights for the various Model Nos. are as follows:

Model No.	Dimensions (inches)	Weight (lbs.)
Sentinel-25A, LCG-25A	25 OD x 25	3000
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Sentinel-25C3	24 OD x 32	1300
Sentinel-25D	25 OD x 27	3300
Sentinel-25E	25 OD x 34	4200
Sentinel-25F	25 OD x 32	1400

5. (a) Packaging (continued)

(3) Drawings

The packagings are constructed in accordance with the following Drawing Nos.:

Model No.	Drawing Nos.
All Models	Isotopes, Inc. Drawing Nos.: 001-20000, Rev. E 001-20001, Rev. F 001-20002, Rev. F 001-20003, Sht. 1, Rev. B 001-80003
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Sentinel-25B, LCG-25B	Martin Company Drawing Nos.: N0013200, Rev. C 001-40012 Isotopes, Inc. Drawing Nos.: 001-70024, Rev. C 001-70025, Sht. 1, Rev. D 001-70033, Shts. 1 & 2, Rev. A 001-70036 001-80005
Sentinel-25C, LCG-25C	Martin Company Drawing Nos.: 001-40004, Rev. A 001-70010 001-70012, Rev. B 001-80004 Isotopes, Inc. Drawing Nos.: 001C10000, Sht. 1 Rev. D, & Sht. 3 001-70009, Rev. D

Model No. (continued)	Drawing Nos. (continued)
Sentinel-25C3	Isotopes, Inc. Drawing Nos.: 001C10000 Shts. 1 & 2, Rev. D 001-70009, Rev. D 001-70057, Rev. D 001-70060, Rev. C 001-40019, Rev. B
Sentinel-25D	Martin Company Drawing No. 001-80004 Isotopes, Inc. Drawing Nos.: 001D10000 Shts. 1 & 2, Rev. C 001-70036 001-70033 Shts. 1 & 2, Rev. A 001-70025 Sht. 1, Rev. D 001-70024, Rev. C 001-40015, Rev. C 001-40006, Rev. B
Sentinel-25E	Isotopes, Inc. Drawing Nos.: 001E10000, Shts. 1 & 2, Rev. E, & Sht. 3 001-70039, Rev. C 001-70025, Sht. 1, Rev. D & Sht. 2 001-70024, Rev. C 001-40017, Shts. 1 & 2, Rev. D 001-40006, Rev. B
Sentinel-25F	Isotopes, Inc. Drawing Nos.: 001F10000, Shts. 1 & 2, Rev. H* 001-70070, Rev. C 001-70060, Rev. C 001-70009, Rev. D 001-40025, Rev. A

*As modified by Figure 1 of the April 26, 1985, application.

(b) Contents

(1) Type and form of material

(i) Strontium 90 titanate doubly encapsulated in a Hastelloy or Uniloy fuel capsule which meet the requirements of special form radioactive material; or

(ii) Model No. Sentinel-25F may have, strontium fluoride doubly encapsulated in Hastelloy or Uniloy fuel capsule, with a Hastelloy C-276 liner which meets the requirements of special form radioactive material.

(2) The maximum quantity of material per package

125,000 curies

6. A barrier (permitting the free circulation of air) must be provided with sufficient separation distance to ensure that the requirement of 10 CFR 71.43 (g) will be met.

7. Eye-bolts shall be removed or covered during transportation to prevent their use as tie-down devices of packages.

8. In addition to the requirements of Subpart G of 10 CFR Part 71, each package shall be operated, prepared for shipment and maintained in accordance with the following Operating Procedures and Maintenance Programs:

Model No.	Operating Procedures	Maintenance Program
Sentinel-25A, LCG-25A	Appendix E of TES-3206, as revised	Appendix F of TES-3206, as revised
Sentinel-25B, LCG-25B	Appendix E of TES-3209, as revised	Appendix F of TES-3209, as revised
Sentinel-25C, LCG-25C	Appendix E of TES-3210, as revised	Appendix F of TES-3210, as revised
Sentinel-25C3	Appendix E of TES-3211, as revised	Appendix F of TES-3211, as revised
Sentinel-25D	Appendix E of TES-3212, as revised	Appendix F of TES-3212, as revised
Sentinel-25E	Appendix E of TES-3213, as revised	Appendix F of TES-3213, as revised
Sentinel-25F	Chapter VIII of TES-3202, as revised	Chapter IX of TES-3202, as revised

9. The packages authorized by this certificate are hereby approved for use under the general license provisions of 10 CFR 71.12.

10. Expiration date: January 31, 2007

REFERENCES

Teledyne Energy Systems applications dated April 26, 1985; and August 19, 1986.

Teledyne supplements dated: November 3, 1986; September 17 and December 2, 1991.

Department of the Air Force supplement dated: November 12, 1993; December 11, 1996; January 15, 2002.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

E. William Brach, Director
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Date: January 29, 2002

DEPARTMENT OF THE AIR FORCE
AIR FORCE TECHNICAL APPLICATIONS CENTER

FINDING OF NO SIGNIFICANT IMPACT

Environmental Assessment for the Non-routine Transportation of Radioisotope Thermoelectric Generators

AGENCY: United States Air Force, Air Force Technical Applications Center (AFTAC)

ACTION: Finding of No Significant Impact (FONSI)

DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES:

The U.S. Air Force proposes to transport ten (10) Radioisotope Thermoelectric Generators (RTGs) from Burnt Mountain, Alaska (AK) to the Nevada National Security Site (NNSS) in southern Nevada for further disposition. Three alternative actions were selected for analysis.

- **Alternative 1:** The 10 RTGs would be transported from Burnt Mountain to Fort Yukon, AK by CH-47 Chinook Helicopters, from Fort Yukon to Eielson Air Force Base (AFB), AK by C-130 Hercules, from Eielson AFB to Creech AFB, Nevada (NV) by C-17 aircraft, and from Creech AFB to the NNSS by truck.
- **Alternative 2, the Preferred Alternative:** The 10 RTGs would be transported from Burnt Mountain, AK to Eielson Air Force Base (AFB), AK by CH-47F Chinook Helicopters, from Eielson AFB to Creech AFB, Nevada (NV) by C-17 aircraft, and from Creech AFB to the NNSS by truck.
- **No-Action Alternative:** The 10 RTGs would remain in place at Burnt Mountain, AK.

SUMMARY OF ENVIRONMENTAL CONSEQUENCES:

The Environmental Assessment (EA) provides an analysis of the potential environmental consequences resulting from implementing the action alternatives. Nine categories were thoroughly analyzed to identify potential impacts. According to the analysis in this EA, no significant human health or environmental impacts are anticipated for any of the alternatives under routine incident-free operating conditions. There is the potential for radiological release and exposure to humans and the environment in the event of an aircraft accident. However, the probabilities of an aircraft accident resulting in a release of radiological material are extremely small: 1 in 385,000 for Alternative 1; and 1 in 192,000 for Alternative 2. Therefore, radiological impacts to specific resources are not described further.

The following summarizes and highlights the results of the analysis by categories that initial evaluation indicated could be effected by the action alternatives under routine incident-free operating conditions.

Climate and Air Quality. Minor, temporary impacts to air quality would result under routine incident-free operating conditions.

Biological Resources. Under routine incident-free operating conditions, there would be minor, temporary impacts to wildlife and vegetation at Burnt Mountain, but no impacts at the other sites.

Environmental Justice and Socioeconomics. There would be no impacts under routine incident-free operations.

Geology and Soils. There would be minor, temporary impacts to soils at Burnt Mountain and no impacts to geology and soils at the other sites under routine incident-free operations.

Health and Safety. Under routine incident-free operations, up to 58 or 48 personnel would be involved in the transport and temporary staging of the RTGs for Alternative 1 and 2, respectively. There would be no impact to the public.

Water Resources. There would be no impacts to water resources under routine incident-free operations.

Land Use. There would be no impacts to land use under routine incident-free operations.

Noise. There would be temporary, minor increases in noise levels under routine incident-free operations.

Radiological Consequences. Under routine incident-free operations there would be minimal radiological impacts to workers from ground or air operations.

CONCLUSIONS:

On the basis of the findings of the EA, no significant human health or environmental impacts are anticipated for any of the alternatives under routine incident-free operating conditions. There is the potential for radiological release and exposure to humans and the environment in the event of an aircraft accident. However, the probabilities of an aircraft accident resulting in a release of radiological material are extremely small, 1 in 385,000 for Alternative 1 and 1 in 192,000 for Alternative 2. Therefore, issuance of a Finding of No Significant Impact is warranted, and preparation of an Environmental Impact Statement pursuant to the National Environmental Policy Act of 1969 (Public Law 91-190) is not required for this action.

CHRISTOPHER A. WORLEY, Colonel, USAF
Commander

30 Jan 15
Date

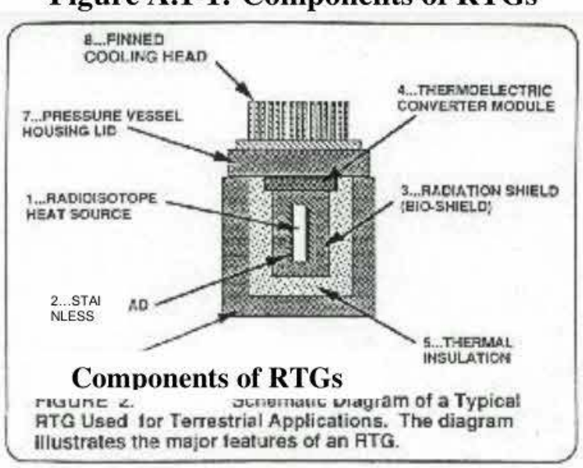
APPENDIX A
STRONTIUM-90 RADIOISOTOPE THERMOELECTRIC GENERATORS

This appendix provides a basic description of radioisotope thermoelectric generators (RTGs) as well as more specific information on strontium-90 (Sr-90) RTGs; their operation, energy production, application, and use in the U.S.; and relevant regulatory requirements.

A.1 Description of RTGs

RTGs use heat generated by decay of radioactive isotopes to produce electrical power. They are used as a power supply where frequent maintenance, refueling, or battery recharging or replacement is expensive or impossible. RTGs have various designs, but all contain a "sealed source," which means the radioactive materials are sealed in a capsule although the radiation is not. RTGs also contain thermocouples that convert the heat into electricity; a radiation shield made of tungsten or depleted uranium; a stainless-steel cooling radiator assembly surrounding the sealed source and thermocouple array; and a vessel to contain the device. Other components such as an insulation system or a power conditioner may also be present. Figure A.1-1 shows typical components in an RTG unit.

Figure A.1-1: Components of RTGs



Source: USAF, 1999

RTGs use radioactive elements (i.e. radioisotopes) as fuels. These fuels generate heat from radioactive decay to produce electricity. Radioisotopes used in RTGs include Sr-90, plutonium-238, polonium-210, cesium-144, and curium-242.

A.2 Sr-90 RTGs

The radioactive heat source used to power the RTGs addressed in this Environmental Assessment is Sr-90, which is a beta emitter. The RTGs contain radiation shields, which absorb beta radiation emitted by Sr-90 to reduce personnel radiation exposure to levels

that are as low as reasonably achievable. Sr-90 has a half-life of 28 years, which means RTG radioactivity from Sr-90 is reduced by roughly 50 percent every 28 years. Thus, only 0.1 percent of the original radioactivity of the RTGs would remain in 290 years. Sr-90, often in the form of strontium titanate ($SrTiO_3$), is one of the most common radioisotopes used in RTGs. Strontium titanate was selected because of its fire and shock resistance properties and low solubility in water. This low solubility is an important feature in keeping strontium out of biological systems.

The radioactive decay product of Sr-90 is yttrium-90, which has a half-life of approximately 64 hours. Because the half-life of Sr-90 is much greater than yttrium-90, the two radionuclides are said to be in secular equilibrium and are considered to be inseparable for health protection purposes. Both Sr-90 and yttrium-90 emit beta radiation. Because the maximum beta radiation energy from yttrium-90 (2.28 million electron volts) is higher than the beta radiation from Sr-90 (0.546 million electron volts), the yttrium-90 radiation is more penetrating. Energy from yttrium-90 beta particles travels approximately 10 meters (m) (400 inches [in.]) in air (Schleien, 1992). Sr-90 beta radiation travels approximately 2 m (80 in.) in air.

Sr-90 RTGs have been manufactured by several different companies and have several different designs since the late 1940s/early 1950s. For their size, RTGs do not generate much energy. Typically, only about 5 percent of the heat from the Sr-90 is converted to electric power by the thermocouples. When the composite alloy metal in the thermocouple is heated, it creates a small current generating about 500 watts of electricity (enough to light about five 100-watt light bulbs) in the average RTG. However, as a power source, they are reliable, virtually maintenance free, and capable of withstanding harsh environmental conditions.

Figure A.2-1: Burnt Mountain RTG

The Sr-90 RTGs owned by the U.S. Air Force (USAF) at Burnt Mountain are approximately 61 centimeters (cm) (2 feet [ft]) in diameter by 91 cm (3 ft) in height (about the size of a garbage can). Because of their housing and extensive shielding, these units weigh from 1 to 2 tons each. They range in weight from 635 to 1,905 kilograms (kg) (1,400 to 4,200 pounds [lb]) and in size from 63.5 to 71 cm (25 to 28 in.) in diameter and from 63.5 to 117 cm (25 to 46 in.) in height (U.S. Congress, June 1994). See Figure A.2-1 for a picture of a Burnt Mountain RTG.

A.2.1 Radiation Exposure

According to the U.S. Congress' Office of Technology Assessment, the main source of environmental risk associated with the Burnt Mountain RTGs is the Sr-90 radioactive sources. The Sr-90 RTGs at Burnt Mountain contain between 0.5 to 1.8 kg (1.2 to 3.9 lb) of the radioactive material Sr-90 as the heat source. Nine of the units originally contained 53,500 curies of radioactive material each, and the tenth unit contains 164,000 curies (U.S. Congress, 1994). Table A.2-1 presents regulatory limits, average exposure rates, and range of exposure rates associated with radiation from the Burnt Mountain RTGs.

Table A.2-1: Summary of Radiation Survey Data for Burnt Mountain RTGs, 2013

Location	Regulatory Limit	Average Exposure Rate[1]	Range of Exposure Rates
Outside entrance gate	2 mrem/hr[2] 100 mrem/yr	0.034 mrem/hr 297 mrem/yr	0.016–0.045 mrem/hr 140-394 mrem/yr
Work area (outside inner cage)	5,000 mrem/yr[3]	0.431 mrem/hr 3776 mrem/yr	0.303–0.700 mrem/hr
1 m from RTG end	10 mrem/hr[4]	1.56 mrem/hr	0.704–4.1 mrem/hr
RTG contact dose	NA	21.2 mrem/hr	17.0–39.5 mrem/hr

Source: CFR & AFTAC, 2013

mrem/hr = Millirem per hour
mrem/yr = Millirem per year
NA = Not applicable

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[1] These are the uncorrected exposure rates measured with an ADM 300 Survey Instrument.

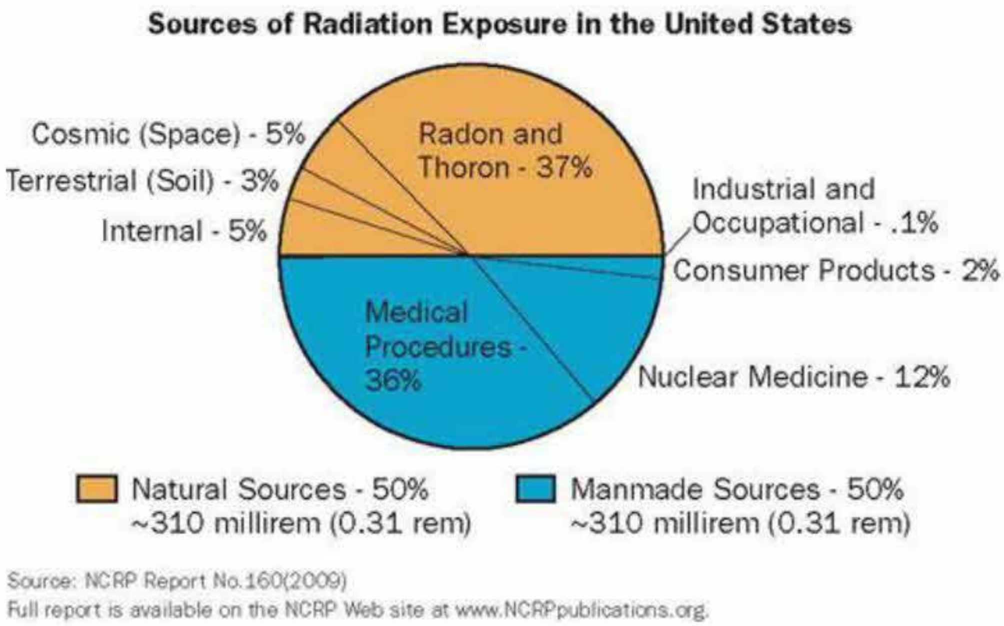
[2] Dose limits for members of the public are given in 10 *Code of Federal Regulations* (CFR) Part 20.1301. These regulations limit the total effective dose equivalent to individual members of the public to less than 100 millirem in a year. In addition, these regulations limit the dose rate in unrestricted areas to less than 2 millirem in any one hour. It is not anticipated a member of the public would continuously occupy the outside entrance gate to the RTGs at Burnt Mountain for more than 5 days (24 hours a day) in any given year. Therefore, currently, a member of the public is not expected to receive a dose equivalent greater than 100 millirem in a year (5 days × 24 hr/day × 0.034 millirem/hr = 4.08 millirem).

[3] The U.S. Nuclear Regulatory Commission (NRC) sets annual dose limits for occupationally exposed workers in 10 CFR Part 20.1201. However, NRC does not establish hourly exposure limits for occupationally exposed workers. Based on the average exposure for workers outside the inner cage (assuming 24 hours per day, 365 days per year), no worker would exceed the regulatory limit of 5,000 mrem/yr. If a worker outside the inner cage worked in the location of the highest activity, that person would receive 6,132 mrem/yr, thus exceeding the regulatory limit. No workers are remotely close to spending this amount of time in proximity to the RTGs. Generally, workers are in close proximity to the RTGs only during limited maintenance activities. Personnel performing maintenance and survey activities on the Burnt Mountain RTGs are monitored for exposure to radiation. None of these personnel has received a measurable exposure during these activities (Talbert, 2014).

[4] The RTGs in use at Burnt Mountain are designed to have a dose rate of less than 10 mrem/hr at 1 m to meet transportation requirements.

NRC regulations define three sets of radiation dose limits. For normal conditions, 10 CFR Part 20 Subpart D provides a radiation dose limit of 100 mrem/yr above background for individual members of the public (10 CFR Part 20.1301). Normal background radiation doses per year are about 620 millirem (NCRP, 2009) Figure A.2-2 shows sources of radiation exposures in the U.S. For routine operations for any worker, NRC regulations set a dose limit of 5,000 mrem/yr (10 CFR Part 20.1201).

Figure A.2-2



For accident conditions, NRC requires immediate notification for accidents that may cause a dose of 25 rem (25,000 millirem) or more to the whole body of any individual (10 CFR Part 2202). The U.S. Department of Energy (DOE) sets forth a guideline for the maximum calculated dose to off-site individuals in DOE Order 6430.1A, *General Design Criteria*. This Order requires doses do not exceed 25 rem (25,000 millirem) to the whole body per accident. The calculated dose includes exposure to internally deposited and external sources of radioactive materials. The USAF radiation protection requirements are detailed in AFI-48-148.

The radiation dose rate at contact for 9 of 10 Air Force RTGs is approximately 20 mrem/hr. The remaining RTG at Burnt Mountain has a contact dose rate of about 40 mrem/hr. If a person were in contact with the smaller RTGs at Burnt Mountain for 10 minutes, his/her dose would be less than 4 millirem to the whole body. By comparison, a chest x-ray gives about 10 millirem per examination (DOE, 2012). Table A.2-2 sets forth other common sources of radiation for dose comparisons with the RTGs.

Table A.2-2: Common Sources of Radiation

Source of Radiation	**Dose (mrem/yr)**
Cosmic Radiation (high-energy gamma radiation originating in outer space and filtered through the earth's atmosphere) – At sea level	26
Average Natural Background in the U.S.	310
Food and water, average	30
Medical Treatment • Chest x-ray • Dental x-ray • Mammogram	 10 1.5 30
Consumer Goods • Cigarettes (1 pack a day) • Gas lantern mantle • Natural gas heating and cooking • Air travel (every 2006 miles): 1 millirem • Road construction material • Porcelain dentures • Watching TV • Smoke detector	 15 - 20 <1 9 1 4 <1 1 <1

Source: DOE, 2012; NRC, 2012

A.2.2 Container Durability

NRC has certified the 10 RTGs as Type B containers. To qualify as Type B containers, the RTGs must be able to survive severe accidents in addition to normal transportation handling and minor accidents. They must meet all the performance requirements of Type A packages as defined in 49 CFR Parts 173.24, 173.411, and 173.412, and also survive the hypothetical accident conditions defined by the NRC in 10 CFR Part 71.73:

- A free drop of 9 m (30 ft) onto a flat, unyielding horizontal surface, striking the surface in a position that would be expected to produce maximum damage.
- Impact by 1-by-1-m (40-by-40-in.), 500-kg (1,100-lb) steel plate dropped from 9 m (30 ft) in a horizontal position onto the Type B package positioned on a flat, unyielding horizontal surface such that maximum damage would be expected to occur.
- A free drop of 1 m (40 in.) in a position expected to produce maximum damage onto a vertical steel spike 15 cm (6 in.) in diameter and at least 20 cm (8 in.) long.
- A fully engulfing fire of at least 800 degrees Celsius (^oC) (1475 degrees Fahrenheit [^oF]) for 30 minutes.
- Immersion in 15 m (50 ft) of water, or, under a water pressure of 150 kilopascal (21.7 pounds per square inch).

These 10 RTGs from Burnt Mountain all had NRC Certificates of Compliance (CoCs). The NRC issued two CoCs for the Sr-90 RTGs located at Burnt Mountain (No. 4888 and No. 5862) certifying the packaging and contents meet the applicable safety standards in 10 CFR Part 71. These NRC CoCs expired in 2011. Subsequently, DOE issued CoCs to the USAF certifying the units as Type B packages in August 2014 (DOE, 2014), and an Exemption to the transport restriction in August 2014 (DOE, 2014).

A.2.3 History and Application of Sr-90 RTGs

Based on the best information available, the current inventory shows approximately 100 Sr-90 RTGs have been manufactured in the U.S. Of these, DOE has information on 45 RTGs are within the U.S. These Sr-90 RTGs were located in 7 states: Alaska, California, New Mexico, Tennessee, Texas, Virginia, and Washington. Table A.2-3 shows the current known storage locations.

Table A.2-3: Current Sr-90 RTG Locations

Site	RTG Custodian	Number of RTGs
Albuquerque, NM	U.S. Department of Energy: Sandia National Laboratories	1 – disposed at NNSS
Burnt Mountain, AK	U.S. Air Force	10
Houston, TX	Nuclear Sources & Services, Inc.	4 – disposed at NNSS
La Jolla, CA	General Atomics	2 – disposed at NNSS
Oak Ridge, TN	U.S. Department of Energy: Oak Ridge National Laboratory	6 (5– disposed at NNSS) 1 still at ORNL
Richland, WA	U.S. Department of Energy: Richland	2 – disposed at Hanford
Yorktown, VA	U.S. Navy	20 (18 – disposed at NNSS) 2 – still in service
Total		**45**

Source: (INL, 2014)

From 1961 to present, these RTGs have been used for underwater, terrestrial, and space power applications. In their 40 years of existence, no RTG has ever leaked or been breached deliberately or accidentally despite the very harsh environments in which the RTGs have been deployed. Many of these RTGs have exceeded their useful lifespan and are being stored in buildings or, less frequently, on outside platforms.

The 10 Sr-90 RTGs at Burnt Mountain Seismic Array Observatory were used as remote power sources for seismic monitoring and data communications equipment under the U.S. Atomic Energy Detection System, which is a worldwide system of sensors to detect nuclear explosions underground, underwater, and in the atmosphere and space. This system is in place to verify international compliance with nuclear weapons testing treaties. The Observatory is critical to the verification of nuclear test ban treaties and has been in operation since 1973. Because of its remote siting and national security mission,

USAF initially determined the RTGs would provide the optimum power generation technology to meet its needs. However, due to the decline in power output the USAF has now replaced the RTGs with an alternative power supply.

References

10 CFR PART 20, "Standards for Protection against Radiation."

10 CFR Part 71, "Packaging and Transportation of Radioactive Material."

49 CFR 173, "Shippers—General Requirements for Shipments and Packagings."

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USAF (U.S. Air Force). 1999. *Environmental Assessment for the Burnt Mountain Seismic Array Power Supply*, 354 CES/CEVP. June.

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APPENDIX B

PACKAGING AND TRANSPORATION REQUIREMENTS

B.1 Transportation Regulations

Transportation actions are regulated by DOT. These actions are covered under DOT regulations as follows:

- 49 CFR 171.1(e) (*Code of Federal Regulations*, 2013) says:
    - (e) *Requirements of other Federal agencies.* Each facility at which pre-transportation or transportation functions are performed in accordance with the HMR may be subject to applicable standards and regulations of other Federal agencies.
- 49 CFR 171.1(d)(5), says:
    - (d) *Functions not subject to the requirements of the HMR.* The following are examples of activities to which the HMR do not apply:
        - (5) Transportation of a hazardous material in a motor vehicle, aircraft, or vessel operated by a Federal, state, or local government employee solely for noncommercial Federal, state, or local government purposes.
- AFMAN 24-204 (USAF, 2012) says:
    - AFMAN 24-204 governs the transport of hazardous material when entered into the Defense Transportation System (DTS) as cargo on military controlled fixed and rotary wing aircraft according to Defense Transportation Regulation (DTR) 4500.9R.
- The IAEA Safety Standards No. TS-R-1 (IAEA, 2009) says:
    - These Regulations apply to the transport of radioactive material by all modes on land, water or in the air, including transport which is incidental to the use of the radioactive material. Transport comprises all operations and conditions associated with and involved in the movement of radioactive material; these include the design, manufacture, maintenance and repair of packaging, and the preparation, consigning, loading, carriage including in-transit storage, unloading and receipt at the final destination of loads of radioactive material and packages.
    - A graded approach is applied to the performance standards in these Regulations characterized by three general severity levels:
        - (a) routine conditions of transport (incident free);
        - (b) normal conditions of transport (minor mishaps);
        - (c) accident conditions of transport.

B.2 Packaging Regulations

Packaging actions are regulated by NRC. These actions are covered under NRC regulations as follows:

- 10 CFR Part 71
    - NRC must approve any package used for shipping nuclear material before shipment. If the package meets NRC requirements, the NRC issues a Radioactive Material Package Certificate of Compliance (CoC) to the organization requesting approval of a package. Organizations are authorized to ship radioactive material

in a package approved for use under the general licensing provisions of 10 CFR Part 71.
- Before any shipment can occur, the shipper is required to review the package certificate of compliance (CoC) to determine if any testing or maintenance is required. The shipper must also meet the DOT's requirements for shipment of the nuclear material including route selection, vehicle condition and placarding, driver training, package marking, labeling, and other shipping documentation.

- 49 CFR Part 173.413, Requirements for Type B packages
    - Except as provided in § 173.416, each Type B(U) or Type B(M) package must be designed and constructed to meet the applicable requirements specified in 10 CFR Part 71.
- 49 CFR Part 173.416, Authorized Type B packages
    - Each of the following packages is authorized for shipment of quantities exceeding A_1 or A_2, as appropriate:
        - (a) Any Type B(U) or Type B(M) packaging that meets the applicable requirements of 10 CFR part 71 and has been approved by the U.S. Nuclear Regulatory Commission may be shipped pursuant to 10 CFR Part 173.471.
        - (b) Any Type B(U) or B(M) packaging that meets the applicable requirements in "IAEA Regulations for the Safe Transport of Radioactive Material, No. TS-R-1" and for which the foreign Competent Authority Certificate has been revalidated by DOT pursuant to 10 CFR Part 173.473. These packagings are authorized only for export and import shipments.
        - (c) Continued use of an existing Type B packaging constructed to DOT Specification 6M, 20WC, or 21 WC is authorized until October 1, 2008, if it conforms in all aspects to the requirements of this subchapter in effect on October 1, 2003.

B.3 Packaging and Transportation Compliance

The U.S. Department of Energy, Oak Ridge Office (DOE/ORO) training material for advanced radioactive materials packaging and transportation compliance (DOE, Office of Science, 2013) says the following:

- The A_1 and A_2 values are used in the regulations as a normalized measurement of the radiological risk for all radionuclides. Their uses go beyond the activity limits for Type A packages in determining when Type B packages must be used. Other uses involving large multiples of A_1 or A_2 or different fractions of A_1 or A_2 include:

    - Ensuring special routing of packages with large quantities.
    - Determining the total activity in packages and conveyances.
    - Designating the limits for packages excepted from most requirements.
    - Designating the specific activity of a contaminated material and associated packaging.

- The derivation of the A_1 and A_2 values in the IAEA regulations is based on a series of dosimetric models (i.e., the Q System).
- The limiting value for A_1 results from the worst-case assumptions of external direct γ radiation levels from an unshielded source at a certain distance. Generally, the A_1 value for a radionuclide is the quantity of that radionuclide which will result in a dose rate of 0.1 Sv/hr (10 rem/hr) at a distance of 1 meter.
- The A_2 value, however, is based on the applicability of the most conservative worst-case value for five different scenarios, which include the A_1 scenario plus external β radiation to skin, inhalation, ingestion, and external γ radiation from immersion in a gaseous cloud of material released from a breached package.
- As a result of an arbitrary limitation established by the IAEA, no radionuclides have been assigned A_1 or A_2 values greater than 40 TBq (1080 Ci). However, based on their LSA and low toxicity, some radionuclides were assigned <u>unlimited</u> A_1 and A_2 values.
- The A_1/A_2 values have a direct relationship to radiation protection principles. The values are established based on potential exposures. The values in the 1985 IAEA regulations were derived using a dosimetric model intended to limit an individual's exposure due to a damaged package to the allowed annual dose limit for a radiation worker (5 rem). This was considered acceptable as a once-in-a-lifetime exposure for members of the public inadvertently exposed near an accident scene involving a Type A package. This dosimetric model, called the Q System, was an improvement over an earlier system that divided nuclides into transport groups based on toxicity. The revised Q System that is the basis for the A_1/A_2 values in the current domestic regulations no longer links to the annual dose limit for radiation workers; however, the 5 rem reference dose has been retained.

B.4 Packaging Certifications

The 10 RTGs from Burnt Mountain originally had NRC CoCs. The NRC issued two COCs for the RTGs (No. 4888 and No. 5862) certifying the packaging and contents meet the applicable safety standards in 10 CFR Part 71. The RTGs were certified for shipment (via vessels, cargo-only aircraft, motor vehicles, and rail cars) as a Type B package. The RTGs have been inspected and deemed to be in original condition. However, they must remain attached to the steel pallets (or equivalent) originally provided with the generators. RTGs must have unrestricted airflow around the generators. The original CoCs expired and extensions were requested and granted by the NRC two separate times. The last extensions of the CoCs expired in 2011.

The *Atomic Energy Act of 1954*, as amended, gives DOE broad authorities to regulate all aspects of activities involving radioactive materials undertaken by DOE or on its behalf, including transportation. DOE manages a program for certification of fissile and Type B packagings that conforms with DOT and NRC requirements. This is administered through the DOE Office of Packaging and Transportation (P&T). DOE P&T issued two CoCs for storage only of the 10

RTGs in 2013. DOE P&T has issued an exemption for the transportation of the 10 RTGs from Alaska to Nevada.

References

10 CFR 71, "Packaging and Transportation of Radioactive Material."

42 U.S.C., 2011 et seq., *Atomic Energy Act of 1954*.

49 CFR 171.1. "Applicability of Hazardous Materials Regulations (HMR) to Persons and Functions."

49 CFR 173.413, "Requirements for Type B Packages."

49 CFR 173.416, "Authorized Type B Packages."

DOE, Office of Science (U.S. Department of Energy, Oak Ridge Office Office of Science). 2013. *Radioactive Materials Packaging and Transportation Primer,* Chapter 3, p. 16.

IAEA (International Atomic Energy Agency). 2009. *Regulations for the Safe Transport of Radioactive Material*, IAEA Safety Standards No. TS-R-1, 2009 edition. pp. 2-3.

USAF (U.S. Department of the Air Force), 2012. *Preparing Hazardous Materials for Military Air Shipments*, Air Force Manual 24-204, 3 December. p. 5.

Sr^{90} Sealed Source Transport Hazard Analysis and Safety Evaluation

In Support of

Environmental Assessment (EA) for the Air Transportation of the USAF Radioisotope Thermoelectric Generators (RTG) from Burnt Mountain, Alaska to the National Nuclear Security Site Mercury, Nevada.

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August 2014

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1. Introduction

This assessment constitutes a semi-quantitative risk analysis in support of the Environmental Assessment (EA) for the Air Transportation of USAF Radioisotope Thermoelectric Generators (RTG) from Burnt Mountain, Alaska to the Nevada National Security Site Mercury (NNSS), Nevada. The assessment does not include the ground transport from the landing location in NNSS). As discussed in the associated EA, the ground transport from Creech AFB to NNSS is covered under a separate DOE Environmental Assessment.

This hazard assessment evaluates the additional risk during transport from the radioactive materials. It does not evaluate the other risks associated with the transport as these risks are considered mundane when considered with all of the other transport, shipping and aircraft flights happening on a daily basis. Except as discussed, this assessment only assesses the health, safety and environmental risks as a result of the transport. Except where mentioned in the text the economic impacts and associated risks are not evaluated in this document.

1.1. Radioisotope Thermoelectric Generator Description

Ten RTG units are currently stored by the U.S. Air Force RTGs at Burnt Mountain (BM), Alaska. The USAF operates an unattended seismic observatory at BM, a remote area approximately 60 miles north of the Arctic Circle; 50 miles from the closest village and the nearest airport. Access to the site is limited to helicopters only as no roads exist in the area. The data collection and communications equipment at the station was previously powered by the 10 RTG's until a hybrid power station was installed in 2000.

Data for the RTG units, which are model Sentinel-100F, 25A, 25E, and 25F RTGs, is provided in Table 1.

Table 1: Summary Data for U.S. Air Force RTG

Model	Serial Number	Year	Current Activity[1] (Ci)	Estimated Current Exposure Rate (on contact – mR/h)	Weight (lbs)
Sentinel – 100F	RTG1	1972	122,922	39.5	2720
Sentinel – 25A	RTG4	1966	32,021	19	3000
Sentinel – 25E	RTG10	1968	36,809	17	4170
Sentinel – 25E	RTG17	1968	40,018	21	4170
Sentinel – 25E	RTG18	1968	38,993	17	4170
Sentinel – 25E	RTG19	1971	38,700	18	4170
Sentinel – 25E	RTG20	1971	38,663	17	4170
Sentinel – 25E	RTG8	1971	36,566	20	4170
Sentinel – 25E	RTG9	1971	37,643	19	4170
Sentinel – 25F	RTG14	1970	39,155	24	1400

1.1.1. **Source Material**

Strontium-90 is a radioactive isotope of strontium produced by nuclear fission. It decays by beta decay and has a half-life of 28.8 years. In the RTG units the strontium-90 is coupled to thermocouples which are then connected to a heat sink. The heat released from the decay of the radioactive material is transferred through the thermocouple and generates an electric current. The power from the RTG was used to power seismic monitors and ancillary equipment at the site.

The strontium is in the form of $SrTiO_3$, which is an insoluble form of Sr-90. The fuel is packaged as a compressed, sintered solid inside the RTG unit. The radioactive components of the fuel, Sr-90 and its daughter product, Yttrium-90 (Y-90), pose an internal and external radiation hazard (beta particles and gamma photons) when uncontained or improperly shielded. However, internal confinement and shielding provided by the source packaging significantly reduces exposures to beta radiation and photons. The source material only poses a radiation hazard to the public when it is released from its packaging and

[1] As of 1 January 2013

dispersed. Due to the robust packaging requirements, this type of release should only occur under extreme accident conditions.

The strontium fuel was pelletized and encased in stainless steel by WEST in Richland, Washington (Teledyne 2011). The purpose of this stainless steel encasement was not so much containment but rather to minimize the possibility of contamination of the fuel capsule and ancillary equipment. The fuel pellets were loaded into a double encapsulation of Hastelloy C-276 or Uniloy UC and then electron beam welded. The strontium-90 fuel was in the form of a titanate ($SrTiO_3$). This fuel form was chosen due to its chemical compatibility with nickel-based super alloys (Hastelloy C-276), ease of manufacturing, and it's very low water solubility. All ten Sentinel RTGs at the Burnt Mountain array are loaded with the same type of fuel. The SrF_2 form discussed in the RTG design documents was not an allowable form under Teledyne's radioactive materials license until after 1978 and thus was not used in the units located at Burnt Mountain.

1.1.2. RTG Design and Packaging

The 10 RTGs are comprised of four models, Sentinel models 25A, 25E, 25F and 100F. The first RTG unit was installed at the site in 1973. An additional nine were installed in 1985 to support upgraded power requirements. The Sentinel model 25 RTGs were designed in the mid-1960s. Several variants were developed culminating in 1969/1970 with the F-series model 25F. The entire Sentinel product line was developed by Teledyne.

Most of the Sentinel 25 RTGs built were initially delivered to Naval Facilities Engineering Command (NAVFAC). NAVFAC returned the units to Teledyne and these units were then transferred to AFTAC in early 1984 and then transported to Burnt Mountain to power the seismic array. The only exception to this is the Sentinel 25A, which was initially delivered to GeoTech in Galveston, Texas before being transferred to Burnt Mountain (Teledyne 2011).

The Sentinel 25A specifications are detailed in Attachment 8, TES-3206, "Safety Evaluation for a Twenty-Five Watt Strontium 90 Low Cost Generator Model LCG-25A" dated April 15, 1965. From the center out, the generator consists of the heat source contained in a cylindrical Hastelloy-C capsule which is surrounded by a tungsten alloy shield. The shield is encased in thermal insulation. The unit is then encased in a cast iron shell. The thermoelectric module is attached to an aluminum lid positioned directly over the Sr-90 fuel block. Fins are located on the lid and are used to dissipate any waste heat. The total weight of the unit is 3000 pounds with the bulk of the weight (2550 pounds) consisting of the cast iron shell.

Figure 1: Sentinel model 25A RTG

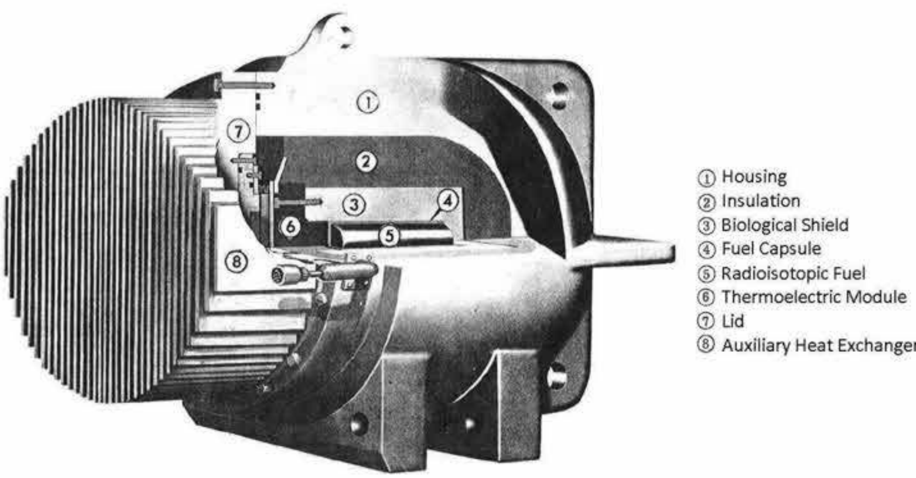

Figure 2: Cross section of model Sentinel 25A RTG

The design and testing criteria of the 25A RTG unit is found on page IV-1 of TES-3206. It complies with the requirements of the Interstate Commerce Commission

(ICC) and the Atomic Energy Commission (AEC) which both existed at the time of its original manufacture. TES-3206 details the design criteria for the unit. As mentioned above, the unit was certified as a type B package by the NRC until February, 2011.

The Sentinel 25E specifications are detailed in Attachment 9, TES-3213, "Resubmittal of Prior Applications and Supplements for Approval to Transport the Sentinel 25E Radioisotope Thermoelectric Generator as a Type B Package" dated December 1991. The Sentinel 25E is a modification of the model 25D which was a design modification of the original model 25A. TES-3213 specifies the sentinel RTG packages were designed to meet the requirements of 10 CFR 71.

Figure 3: Model 25E RTG

The design of the 25E units is very similar to the 25A unit with some modifications. The 25E was designed for undersea use and thus had significant upgrades in the packaging to withstand pressures at depth. The housing of the 25E unit is made from carbon steel as opposed to cast iron. The thickness of the lid was increased and the size of the housing bolts was increased. The outside shape of the package was changed slightly as well. The model 25E RTG were designed to comply with the Type B package requirements and testing as outlined in 10 CFR 71. The model 25E was certified as a type B package by the NRC until February 2011.

The Sentinel model 25F RTG unit specifications are detailed in Attachment 10, TES- 3202 “Resubmittal of Prior Applications and Supplements for Approval to Transport the Sentinel-25F Radisotope Thermoelectric Generator and New

Information to Support the Type B ( ) Designation" dated December 1991. The model 25F is a modification of the model 25C3 design.

The biggest difference between the model 25A and E models and the 25F model is the 25F model uses an aluminum housing as opposed to steel or cast iron. This significantly reduces the weight of the unit and reduces the size of the unit so it can be used in smaller spaces. Modifications were made to the 25C3 unit design to improve the mounting brackets and to reduce the external radiation levels around the unit. The mounting brackets were simplified so no shims are required when the unit is attached to the pallet. The housing of the unit was modified. The housing was made from a single forge piece of aluminum rather than two welded half sections. The fuel of the 25F unit is in titanate form and is encapsulated in Hastelloy C, Hastelloy C-276 or Uniloy HC. The fuel is completely surrounded by a tungsten biological shield. The space between the housing and shield is filled with thermal insulation. The housing of the unit is made with 6061 aluminum and is filled with argon gas to increase the thermal efficiency. The complete weight of the generator is 1397 pounds.

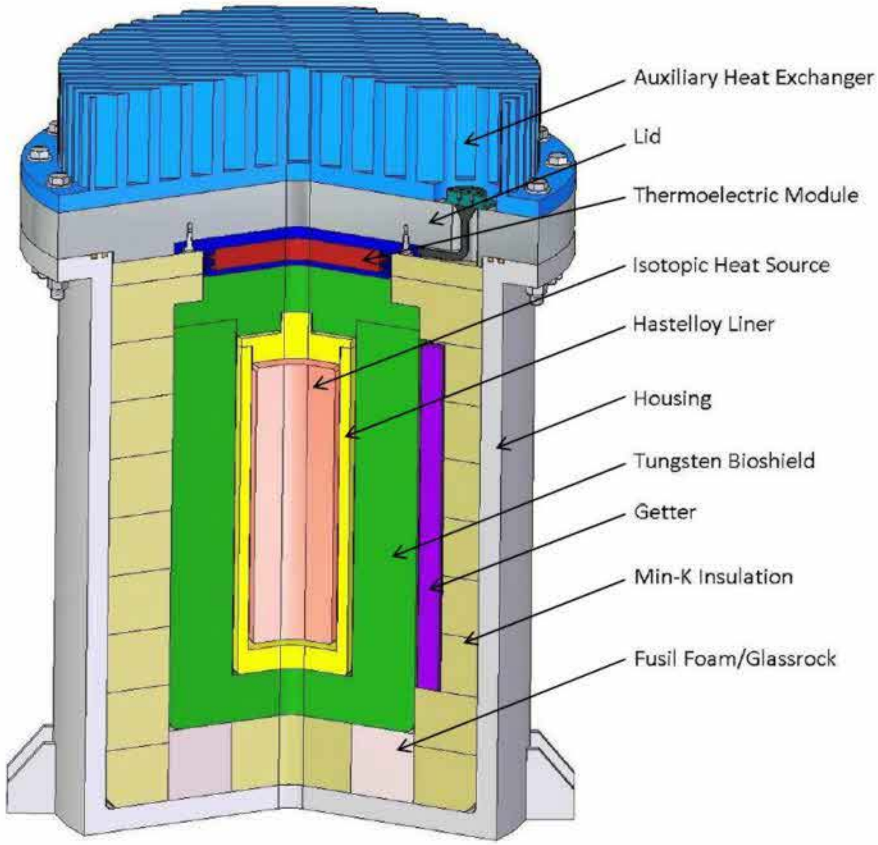

Figure 4: Cross section of model Sentinel 25F RTG unit

The Sentinel 100F is for practical purposes a larger version of the Sentinel 25F. Similar to the 25F, the 100F has an aluminum housing. The sentinel 100F is larger than the 25F and has two additional internal components, a load plate designed to distribute the load of the tungsten biological shield and Inconel retaining ring placed on the upper side of the tungsten shield. The two components help distribute the load and assist in keeping the biological shield assembly in place. Details of the design and structural evaluation of the 100F model is included as Attachment 11, “Structural and Thermal Evaluation of Sentinel 100F”, INSD-3080 published in August 1985.

Figure 5: Sentinel Model 100F RTG

The unit was originally loaded with 328,400 Curies of strontium orthotitanate. The fueling was performed by Union Carbide, Nuclear Division at ORNL. After initial testing the 100F generator was delivered to NAVFAC.

The RTG units were previously certified by the NRC as type B packages. Under DOT requirements, the RTG's must be shipped in a type B container because of the quantity of the radioactive material. The NRC certification of the container has expired. For reasons beyond the scope of this document, the NRC will no

longer certify the containers. DOE personnel have reviewed the design specifications of the units and have performed an on a site assessment of the physical condition of the units and have come to the determination the units can be certified as a Type B package by the DOE. For the proposed shipment, the RTG's have been issued a Certificate of Compliance (CoC) by the DOE certifying the units as Type B packages for non-transport. Initially the certificate will not allow for transport of the units. DOE has issued an exemption to the transport restriction.

2. Purpose and Need

The purpose of this study is an assessment of the radiological risks associated with the transport of the 10 RTG's from Burnt Mountain Alaska to the NNSS in Mercury, Nevada. The RTG units no longer provide enough power to adequately power the site and have been replaced by alternative power source. The power from the RTG units is currently only used to power the RTG remote monitoring system. The intent is to transfer all ten RTG units to the DOE for ultimate disposition. Multiple exposure scenarios were evaluated including incident free transport and accident/incident scenarios resulting in public exposures.

The RTG units are located at a remote site in Alaska only accessible by rotary wing aircraft. The proposed action is removal of the RTG units from Burnt Mountain using helicopter airlift to an airstrip in Alaska. The units will then be transported by fixed winged aircraft to an airstrip in Nevada near the DOE facility. Lastly, the units will be transported by truck to their final destination in NNSS.

The alternative action is to leave the RTG units in place. The risks from this course of action are no impact. The units are located in a very remote location of Alaska and only require minimal maintenance by personnel. The primary reason to transfer the RTG units from Burnt Mountain is concerns about their security and the potential of forest fires in the area damaging the units.

3. Hazard Analysis Methodology

Risk is defined as the combination of two factors: the probability of occurrence and the severity of effect. The probability of incident is further subdivided into the probability of an incident occurring and the probability a particular incident occurs. The product of the two factors is thus probability of a particular incident occurring. For example, the probability of a truck accident that releases radioactive material would be the product of a truck accident multiplied with the probability of the accident being severe enough to release radioactive material. Because of the overall low incidence of accidents involving radioactive materials involving sources of this type, some of the probability factors are not well known.

In some cases these probabilities were estimated using professional judgment but in all cases a reasonable conservative estimate is assumed. Thus this risk estimate should be considered an upper bound estimate of the risks involved in the transport.

Quantitative risk assessments were made when feasible. When quantitative estimate were not possible qualitative assessments were made based upon peer reviewed reports, assessments and professional judgment. Unless otherwise noted, reasonable conservative approximations were employed. The result of this study is a semi-quantitative risk assessment for transport of the U.S. Air Force RTG units.

This document only assesses the risks of the radiological material in the RTG units. The other risks from the transport are not assessed. Fatalities as a direct result of vehicle accidents, health and environmental risks from the exhaust of vehicles, fuel spills and other such impacts are not assessed as they are considered routine to cargo transport occurring on a routine basis across the country. When only evaluated as a transport of cargo, such risks are negligible when considered with the multitude of similar transports occurring across the country daily. Such risks are very well defined and regulated by federal, state and local transportation requirements. For these reasons, these risks are considered routine and are not evaluated in this document.

3.1. **Probability of Occurrence**

Risk is assessed for both routine incident free transportation and potential accidents. For incident free transport, the fractional probability of occurrence is assumed to be 1.0. For non-incident free transport the probability of occurrence is based upon historical accident statistics when available. The probability of the occurrence of a particular accident occurring is difficult to assess. Two accident worst case accident scenarios are considered.

The accident assessment consists of two components: (1) an accident risk assessment to determine the likelihood of an accident occurring during transport; and (2) an accident consequence assessment that considers the radiological consequences to a population group from severe transportation related accidents postulated to result in the largest releases of radioactive material.

3.2. **Impact Assessment**

Two types of radiation impacts are considered, the acute effects from high dose short duration exposures resulting in immediate health effects and long term chronic effects from long term radiation exposures. Acute impacts are measured

in the number of fatalities from radiation exposure. Long term effects are expressed as the excess number of fatal cancers in the exposed populations. These effects combined with the probability of occurrence are a measure of the risk associated with the transport. Impacts are calculated considering the upper bound dose for the maximally exposed individual (MEI). Impacts are calculated for both workers and crew involved in the transport and for any members of the general public that may be exposed as a result of the transport.

Radiological impacts are calculated in terms of dose and associated health effects in the exposed populations. The radiation dose calculated is the total effective dose equivalent (TEDE), as specified in 10 CFR Part 20 ("Standards for Protection against Radiation"), which is the sum of the effective dose equivalent (EDE) from exposure to external radiation and the 50-year committed effective dose equivalent (CEDE) (International Commission on Radiological Protection [ICRP], 1977) from exposure to internal radiation. Doses of radiation are typically calculated in units of rem (roentgen-equivalent man) or millirem (mrem, 1 rem = 1,000 mrem) for individuals and in units of person-rem for collective populations. Federal regulations require individual members of the public not be exposed to more than 100 mrem/yr from licensed operations (10 CFR 20.1201). Transportation workers involved in the shipment of radioactive materials, as well as other individuals, such as shipment inspectors, will be monitored by a dosimetry program if it is expected they may be exposed to radiation in excess of 100 mrem/yr. In all cases, doses will be maintained ALARA and at a level well below the 5 rem annual limit for radiation workers (10 CFR 20.1201).

The goal of this assessment is to provide estimates of the radiation dose to workers and members of the public, which are then converted to estimates of health effects for each identified risk. The health effect end point used is radiation-induced latent cancer fatalities (LCFs), which are estimated by multiplying the dose (person-rem) by health risk conversion factors. These factors relate the radiation dose to the potential number of expected LCFs based on comprehensive studies of people historically exposed to radiation, such as the Japanese atomic bomb survivors. The factors most commonly used in recent assessments are 0.0004 LCF/person-rem of exposure for workers and 0.0005 LCF/person-rem of exposure for members of the general public (ICRP, 1991). The latter factor is slightly higher because some individuals in the public, such as infants, are more sensitive to radiation than the average worker. These factors imply if a population of workers receive a total dose of 2,500 person-rem, on average, one additional LCF will occur among the workers. Similarly, if the general public receives a total dose of 2,000 person-rem, on average, one additional LCF will occur.

3.3. Description of Methodology

The methodology for this assessment is based upon several sources. Large radiation sources are primarily transported by the Department of Energy and thus they provide the most comprehensive methodologies, documentation and technical evaluations. The NRC has some additional guidance for the transport of spent fuel casks. This additional guidance was incorporated as well. Some of the primary documents referenced include:

- "Recommendation for Analyzing Accidents Under National Environmental Policy Act", US Department of Energy, 2002
- "A Resource Handbook on DOE Transportation Risk Assessment", US Department of Energy, July 2002
- "Recommendations for the Supplement Analysis Process", US Department of Energy, July 2005
- "NUREG 2125, Spent Fuel Cask Transport Risk Assessment", NRC, May 2012

Additional details of the methodology and references are included in each relevant section.

The largest risk for the transport is assumed to be a severe aircraft accident in route. To assess this risk, multiple modes and routes of transport were evaluated. These risks will be used as one factor in selecting the route and the mode of transport of the units. Using recent road and aircraft accident data, the accident probability for each was calculated for either road or air transport. In all, a total of 1095 possible routes were evaluated.

Although the most severe consequences would occur from an accident, the highest probability of occurrence is from an incident free transport. Members of the public and federal employees and military members may be exposed to radiation as a result of the transport. This assessment makes quantitative estimates of these exposures. Based upon the estimated exposures additional risk is calculated using the most recent risk factors for radiation exposures. Temporary storage in route may be required in the event of delays due to weather or other factors such as aircraft maintenance issues. Any risks associated with the storage of the RTG during transport were evaluated. These risks are calculated for two population groups. The first is occupationally exposed individuals who are directly involved in the transport of the units. These individuals are the pilots, cargo handling crew, drivers, security and health and safety personnel who will participate. The second group is members of the public who are incidentally exposed as a result of the transport.

Both incident-free and accident scenarios are evaluated. For the incident free routine transport, an upper bound collective dose estimate is determined for the personnel transporting the units by air. Radiation dose rates are determined using recent survey measurements of the RTG units. Conservative transport routes and dose rates for crew members are assumed. These dose rates are used to determine a collective person dose which is then used to estimate the additional LCF probability for the air transport.

For the accident scenarios, recent aircraft accident data is used to estimate the probability of an incident during transport. In the event of a catastrophic aircraft accident it is possible the containment of the RTG packaging would be breached and radioactive material would be released. The analysis of the airborne release from aircraft accidents was evaluated using Hazard Prediction and Assessment Capability (HPAC) Version 5.0. Total Effective Dose Equivalent (TEDE) was calculated due to inhalation of airborne material and external exposure to the material. These represent the major portion of the dose an individual would receive as a result of an aircraft accident. HPAC parameters were all set to maximize the calculated dose and produce a conservative and bounding radiological consequence to the public.

The following assumptions were applied to the analysis:

- Although the RTG are not currently certified as Type B packages, they meet all the design criteria of a Type B package and thus can be expected to meet the Type B package criteria in terms puncture, fire and accident resistance.

- The RTG may be temporarily stored during transport but any such storage will be short in duration (less than 2 weeks).

- No additional shielding is provided by other items within the vicinity of the RTGs during storage and transport.

- The RTG will be transported by ground with each transport vehicle transporting 5 RTG at a time. By air, the RTG will be transported as follows: CH-47 2 per aircraft, C-130 5 per aircraft, C-17 10 per aircraft.

4. Air Transport Risk Assessment

As a baseline for this assessment it is assumed the RTG units will be transported using one of the two following routes:

ROUTE #1

- From Burnt Mountain by US Army CH-47F Chinook helicopters to Fort Yukon, AK. Each helicopter will carry two RTG units.
- From Fort Yukon the units will be transported using C-130 Hercules aircraft to Eielson AFB, AK. Each C-130 aircraft can transport five RTG units.
- From Eielson the units will be transported using C-17 Globemaster III to Creech AFB, NV. The C-17 can accommodate ten RTG units.
- After Creech AFB the units will be transported by ground.

ROUTE #2

- From Burnt Mountain by US Army CH-47F Chinook helicopters to Eielson AFB, AK. Each helicopter will carry two RTG units.
- From Eielson the units will be transported using C-17 Globemaster III to Creech AFB, NV. The C-17 can accommodate ten RTG units.
- After Creech AFB the units will be transported by ground.

The above transport scenarios are used as a baseline. These two routes of transport are the most viable routes of transport at this time based on cost, available facilities, permission of local authorities, fuel and other factors. Additional transport scenarios were evaluated but not to the same detail as the two routes presented here. For two scenarios, specific probabilities and risk values were calculated. For details on the risks associated with each route see the included Appendices.

4.1. Impacts to the Global Commons

4.1.1. Incident-Free Transport

Transporting the sealed sources from Alaska would result in only minor incremental non-radiological impacts. The only anticipated impacts would be the emission of exhaust from the combustion of aircraft fuel. The flight would be one of more than 30,000 daily air flights by commercial and air cargo airlines that occur over the United States (NATCA 2010). Because there would be no release of radioactivity under incident-free transport, there would be no radiological impacts on the global commons.

4.1.2. **Transportation Accident**

The analysis of the potential environmental impacts of an accident over the global commons assumes the loss of the RTG packages to an aircraft accident over water. The analysis further assumes that through either acute or long-term processes, the entire contents of the packages would be released into the ocean. Impacts to marine life from such an accident would be similar to those discussed in the other analyses involving transport over the global commons (DOE 1994a, 2005). These analyses concluded there could be some loss of marine life directly exposed to radioactive material. Yet because of the large volumes of water involved, mixing mechanisms, existing background radiation concentrations, and radiation-resistance of aquatic biota, the radiological impact of an accident would be localized (DOE 1994a, 2005). An accident involving an aircraft carrying the sealed sources from Alaska resulting in a crash in the ocean was assumed to result in a release of all of the radioactive materials. The release could be immediate, but the packaging and containerization of the radioactive material would make a gradual failure and release more likely (IAEA 1993). Whether immediate or gradual, this assessment assumes the release would result in the loss of marine organisms near the released material.

In the event of an accident over land the RTG units would be recoverable. The only impact would be if the RTG were breached as a result of the impact. There could be impacts to local wild life in the immediate vicinity but long term effects would be minimal as any release would be mitigated.

4.2. **Incident-Free Air Transportation**

4.2.1. **Incident-Free Air Transport – Probability**

Incident free transport assumes the RTG units are transported according to the transport plan with only minimal deviations. This is the most likely scenario. For this reason the assumed probability for incident free transport is assumed to be unity.

4.2.2. **Incident-Free Air Transport - Ground Operations Impacts**

The air phase of the transport will require ground operations resulting in radiological exposures to personnel involved in the transport and potentially to members of the general public. Ground operations include:

- Removal of the RTGs from their storage location at Burnt Mountain
- Loading and unloading of the RTG units onto and off of aircraft

- Temporary staging of the RTG units during transport.

For route #1, the RTG units will be handled on four separate occasions. At Burnt Mountain the units will be removed from their current storage locations and loaded onto C-47 Helicopters. Upon arrival at Fort Yukon the units will be placed in a secured staging area awaiting transport to Eielson AFB. The units will then be loaded onto C-130 aircraft for transport to Eielson AFB. At Eielson AFB the RTG units will be placed in a secure remote area for staging. The units will then be loaded onto an aircraft and transported to Creech AFB. At Creech AFB the units will be removed from the aircraft and staged for a short period of time. They will then be loaded on trucks for transport to their final destination at the DOE facility. Temporary storage at each location may result due to delays of the transport aircraft or as a result inclement weather.

For route #2, the RTG units will be handled on three separate occasions. At Burnt Mountain the units will be removed from their current location and loaded onto C-47 Helicopters. Upon arrival at Eielson AFB, the RTG units will be placed in a secure remote area for staging. The units will then be loaded onto an aircraft and transported to Creech AFB. At Creech AFB the units will be removed from the aircraft and staged for a short period of time. They will then be loaded on trucks for transport to their final destination at the DOE facility.

The risk for the ground transport from Creech AFB to the DOE facility is not addressed in this assessment. The risk for that phase of the transport is considered routine transport and is covered in a separate NNSA EA. See the associated EA for additional details. The debarking, staging and loading of the RTG on the ground vehicles for transport to the site is evaluated in this document.

For safety and security reasons, members of the public will not be permitted access to the any temporary storage area or be allowed near the units during transport operations. Under incident-free transport conditions the dose to members of the public would be negligible from loading and staging operations during the air phase of the transport. Thus, the risk from the air phase ground operations, incident free transport of the RTG units to members of the public is deemed as no impact.

The doses from ground operations are summarized in Table 2 and Table 3. Details are included as Attachment 6.

Table 2: Radiation Doses from Route #1 Ground Operations during the Air Phase of Transport

Location	Operation	Number of Personnel	Dose Rate (mrem/h)	Exposure Time	Total Exposure (person-rem)
Burnt Mountain, AK	Removal and loading of RTG units	4	Dose at 1 meter for each unit	1 hours per unit	5.4×10^{-2}
Fort Yukon, AK Eielson AFB, AK	Unloading and Loading of RTG units	4	1.5	4 hours (2 hours at each location)	2.4×10^{-2}
Fort Yukon, AK Eielson AFB, AK Creech AFB, NV	Staging of RTG Units (Security)	2	0.04	360 hours (5 days at each site)	2.9×10^{-2}
Creech AFB, NV	Unloading and Loading on Ground Vehicles	4	1.5	4	2.4×10^{-2}
TOTAL					1.3×10^{-1}

For route #1 the total dose to personnel from the non-incident air transport ground operations is 1.3×10^{-1} person-rem. The total LCF probability from this portion of the transport is estimated to be 5.3×10^{-5} or 1 in 19,000 excess cancer fatalities for the personnel conducting the transport.

Table 3: Radiation Doses from Route #2 Ground Operations during the Air Phase of Transport

Location	Operation	Number of Personnel	Dose Rate (mrem/h)	Exposure Time	Total Exposure (person-rem)
Burnt Mountain, AK	Removal and loading of RTG units	4	Dose at 1 meter for each unit	1 hours per unit	5.4×10^{-2}
Eielson AFB, AK	Unloading and Loading of RTG units	4	1.5	2 hours	1.2×10^{-2}
Eielson AFB, AK Creech AFB, NV	Staging of RTG Units (Security)	2	0.04	240 hours (5 days at each site)	1.9×10^{-2}
Creech AFB, NV	Unloading and Loading on Ground Vehicles	4	1.5	4	2.4×10^{-2}
TOTAL					1.1×10^{-1}

For route #2 the total dose to personnel from the non-incident air transport ground operations is 1.1×10^{-1} person-rem. The total LCF probability from this portion of the transport is estimated to be 4.4×10^{-5} or 1 in 23,000 excess cancer fatalities for the personnel conducting the transport.

4.2.2.1. **Removal and Loading of the RTG units at Burnt Mountain**

It is assumed it will take 4 personnel up to 1 hour to remove each RTG unit and load them on the helicopter. Additional time may be required to remove the RTG units but it is assumed the personnel will only be required to operate in the immediate vicinity of the units for 1 hour. The extended time is due to the remoteness of the location and ruggedness of the terrain. It accounts for equipment problems or other unexpected delays. The dose rate from each unit was measured using an ion chamber during the annual radiation protection survey of the units. The dose rate at 1 meter for 4 personnel for 1 hour at each unit results in a total estimated dose of 5.4×10^{-2} person-rem.

4.2.2.2. **Loading/Unloading and Staging of RTG Units at Fort Yukon**

It is estimated it will take 4 personnel 2 hours to remove the units from the aircraft, place the units in the staging location and then reload them on the aircraft and secure them for transport. It is assumed it will take 0.5 hours to remove and stage the units and 1.5 hours to inspect, load the units on the aircraft

and secure them in place for transport. The average external dose rate from the units at 1 meter was used to determine the dose during the transfer operations. From these operations the total worker dose would be approximately 2.4 x 10^{-2} person-rem.

During staging security will may be provided 24 hours a day by 2 personnel. Assuming they will be approximately 10 meters (33 feet) from the units, the dose rate was estimated to be 0.04 mrem/h. Assuming staging lasts 5 days, the total collective dose to personnel during staging would be 1.9 x 10^{-2} person-rem.

4.2.2.3. **Loading/Unloading and Staging of RTG Units at Eielson AFB**

It is estimated it will take 4 personnel 2 hours to remove the units from the aircraft, place the units in the staging location and then reload them on the aircraft and secure them for transport. It is assumed it will take 0.5 hours to remove and stage the units and 1.5 hours to inspect, load the units on the aircraft and secure them in place for transport. The average external dose rate from the units at 1 meter was used to determine the dose during the transfer operations. From these operations the total worker dose would be approximately 2.4 x 10^{-2} person-rem.

During staging security may be provided 24 hours a day by 2 personnel. Assuming they will be approximately 10 meters (33 feet) from the units, the dose rate was estimated to be 0.04 mrem/h. Assuming staging lasts 5 days, the total collective dose to personnel during staging would be 1.0 x 10^{-2} person-rem.

4.2.2.4. **Loading/Unloading and Staging of RTG Units at Creech AFB**

Once the RTG units arrive at Creech AFB they will be unloaded from the aircraft and placed into the staging location for at least 24 hours. They will then be loaded onto trucks for transport to the DOE site. The risk assessment of the ground transport of the units is addressed in a separate section of this document. The risk from the loading and unloading is addressed here. It is assumed it will take 4 personnel 1 hours to unload the units and place them in the staging location. It is assumed the units will be stage up to 5 days at the location. It is estimated it will take 4 personnel 3 hours to load them onto trucks for transport. An average dose rate at 1 meter of 1.5 mrem/h was used as a conservative estimate for the dose rate. The total dose from this operation would be 2.4 x 10^{-2} person rem.

During staging security may be provided 24 hours a day by 2 personnel. Assuming they will be approximately 10 meters (33 feet) from the units, the dose rate was estimated to be 0.04 mrem/h. Assuming staging lasts 5 days, the total collective dose to personnel during staging would be 1.0 x 10^{-2} person-rem.

4.2.3. Incident Free Air Transport - Air Operations Impacts

The phase when the units have been loaded onto the aircraft for transport until the process of unloading the units is termed air operations. During this phase occupational workers (flight crew) have the potential to be exposed to radiation from the units. Members of the public will be far enough away exposures will be negligible. Thus there is no impact to members of the public from air operations.

For this assessment the baseline transport routes were assumed as the nominal risk. The following assumptions were made:

- The flight time of each aircraft was determined by dividing the flight distance by the block aircraft speed. An additional 60 minutes was added to account for taxing, flight routing or other delays.
- The RTG were loaded in the configurations that resulted in the highest overall dose to the crew.
- Each aircraft will have 5 crew members, a pilot, copilot, 2 flight crew and 1 radiation protection monitor/observer.
- The dose to all crew members was assumed to be equal to the maximum dose to any crew member

Table 4: Baseline Route #1 Routing and Shipping Data Used for Crew Nominal Dose Estimate

Aircraft	RTG's per Aircraft	Distance of Travel	Time of Travel	Minimum Distance from Crew to RTG's
CH-47	2	61 miles Burnt Mountain to Fort Yukon	1.9 hours	10 feet
C-130	5	142 miles Fort Yukon to Eielson AFB	1.4 hours	15 feet
C-17	10	2332 miles Eielson AFB to Creech AFB	5.6 hours	15 feet

Table 5: Baseline Route #2 Routing and Shipping Data Used for Crew Nominal Dose Estimate

Aircraft	RTG's per Aircraft	Distance of Travel	Time of Travel	Minimum Distance from Crew to RTG's
CH-47	2	203 miles Burnt Mountain to Eielson AFB	3.1 hours	10 feet
C-17	10	2332 miles Fort Yukon to Creech AFB	5.6 hours	15 feet

The dose rate and total dose for each route #1 aircraft leg is listed in Table 6. The upper bound total person dose was estimated to be 3.0×10^{-2} person-rem. The upper bound latent cancer fatality risk was estimated at 1.2×10^{-5} or the probability of 1 in approximately 82,700 of an LCF among the crew as a result of the transport for route #1.

Table 6: Baseline Route #1 Upper Bound Radiation Doses and Probability of Latent Cancer Fatalities for Air Transport of RTG's

Aircraft	Maximum Dose Rate to Crew (rem/hr)	Total Dose to Crew (person-rem)	LCF
CH-47	5.0×10^{-4}	1.3×10^{-2}	5.4×10^{-6}
C-130	2.9×10^{-4}	3.4×10^{-3}	1.4×10^{-6}
C-17	4.7×10^{-4}	1.3×10^{-2}	5.3×10^{-6}
Total		3.0×10^{-2}	1.2×10^{-5}

The dose rate and total dose for each route #2 aircraft leg is listed in Table 7. The upper bound total person dose was estimated to be 3.5×10^{-2} person-rem. The upper bound latent cancer fatality risk was estimated at 1.4×10^{-5} or the probability of 1 in approximately 70,500 of an LCF among the crew as a result of the transport for route #2.

Table 7: Route #2 Upper Bound Radiation Doses and Probability of Latent Cancer Fatalities for Air Transport of RTG's

Aircraft	Maximum Dose Rate to Crew (rem/hr)	Total Dose to Crew (person-rem)	LCF
CH-47	5.0×10^{-4}	2.2×10^{-2}	8.9×10^{-6}
C-17	4.7×10^{-4}	1.3×10^{-2}	5.3×10^{-6}
Total		3.5×10^{-2}	1.4×10^{-5}

Details are included as Attachment 7.

4.3. Air Transport Accidents

4.3.1. **Probability of Air Transportation Accidents**

On an annual basis the Air Force Safety Center produces mishap statistics for all aircraft in the Air Force inventory. The Army produces similar numbers for Army Aircraft including the CH-47. These statistics are included as Attachment 4. An assessment was conducted and multiple potential routes for transferring the 10 RTG from Burnt Mountain to the DOE site in Nevada were identified. Additionally, multiple airframes have been identified for transport during various legs of the transport. These aircraft include the CH-47F Chinook helicopter, C-130 Hercules, C-5 Galaxy and the C-17 Globe Master.

There are multiple alternative routes possible from Burnt Mountain, AK to NNSS. Many of the routes involve consideration beyond the scope of this document. Factors include state and local approval, cargo handling facilities, aircraft maintenance availability and security. Because of these other factors, the goal of this document is not to identify a shipping route but only to assess the risk associated with the transport. A multitude of routes were considered even if not practical for other reasons. Combining all of the possible route combinations with the capable aircraft results in 876 possible route and aircraft combinations.

The probability of a mishap occurring is based upon the likelihood of an aircraft accident occurring factored with the probability the accident will be severe enough to result in the release of radioactive material. Not all mishaps would result in a breach of one or more RTG units. The AF categorizes aircraft accidents as Class A when there is more than $1 million in damages or a fatality occurs. It is likely any mishap would damage the RTG to such an extent that radioactive material is released would result in significant damage to the aircraft. Thus, the statistics for Class A mishaps are used to determine the risk of an aircraft accident is severe enough to have the potential to result in the breach of the source containment. Using the 2013 Air Force Safety Center aircraft mishap data for Class A aircraft accidents and data provided by the Army, the probability of an accident ranges from 1.2×10^{-3} to 4.4×10^{-4} for all of the possible routes considered. Attachments 1, 2, and 3 include details of the risks for each individual route and the exact parameters used to calculate the risk values. Many of these routes are not feasible for reasons beyond the scope of this document.

Table 8: Probability of Class A Flight Accident for Route #1

Route	Aircraft	Flight Miles / Sorties	Probability of Accident	Adjusted Probability of Accident with Release[2]
Burnt Mountain, AK → Fort Yukon, AK	CH-47	305 miles / 5 sorties	1.2×10^{-4}	1.2×10^{-6}
Fort Yukon, AK → Eielson AFB	C-130	284 miles / 2 sorties	2.2×10^{-6}	1.2×10^{-7}
Eielson AFB → Creech AFB	C-17	2332 miles / 1 sorties	2.7×10^{-5}	1.3×10^{-6}
Total			1.4×10^{-4}	2.6×10^{-6}

Table 9: Probability of Class A Flight Accident for Route #2

Route	Aircraft	Flight Miles / Sorties	Probability of Accident	Adjusted Probability of Accident with Release[3]
Burnt Mountain, AK → Fort Yukon, AK	CH-47	1015 miles / 5 sorties	3.8×10^{-4}	3.8×10^{-6}
Eielson AFB → Creech AFB	C-17	2332 miles / 1 sorties	2.7×10^{-5}	1.3×10^{-6}
Total			4.1×10^{-4}	5.2×10^{-6}

The risk from the helicopter portion of the transport dominates the probabilistic risk of an accident. This is a result of the increased accident probability for rotary wing aircraft.

Numerous accident scenarios are possible including an aircraft accident over a non-populated area, an aircraft accident over a high density population area, an aircraft accident over the ocean. For this assessment only a representative few were evaluated to assess the magnitude of the impacts. Worst case upper bound accidents were selected.

4.3.2. **Impact from Air Transportation Accidents**

The RTG packaging is very robust. An accident would have to place extreme stress on the package to result in a rupture that would release a significant

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[2] The risk of a release of radioactive material from an RTG breech is assumed to be 0.05 during a class A fixed wing aircraft accident and 0.01 for a class A rotary wing aircraft accident.

[3] The risk of a release of radioactive material from an RTG breech is assumed to be 0.05 during a class A fixed wing aircraft accident and 0.01 for a class A rotary wing aircraft accident.

amount of material. It is difficult to estimate the probability of this occurrence. Type B packages are designed to withstand potential accidents during transport. They are designed to withstand 2 drops from a height of 9 meters (50 km/h) onto an unyielding surface and to withstand an 800ºC fire for 30 minutes. Based upon other reports examined, the robustness of the RTG packaging, professional judgment and examination of the Type B package design requirements, it was estimated the probability of an RTG being breeched during a class A fixed wing aircraft accident was 0.05. For rotary wing aircraft speeds and altitudes are typically much lower likely resulting in a lower probability of severe RTG damage. Additionally, only 2 RTG units will be carried on each aircraft further reducing the probability. For rotary wing aircraft, a probability of 0.01 for release of material from an RTG was assumed.

As an upper bound risk assessment two accident scenarios were considered, the crash of a CH-47 at in an urban area and the crash of a C-17 in a dense urban area.

Accident Scenario #1: While on approach a CH-47 suffers a catastrophic failure and crashes in an urban area. The helicopter is assumed to be carrying 2 RTG units. With a probability of 0.01 that one of the two RTG units is severely damaged releasing radioactive material resulting in exposure of the surrounding population. The force of the crash and the subsequent fire results in airborne transport of the source material. For this accident scenario an additional factor of 0.4 is applied as well. This is due to the fact a majority of the transport route by helicopter is primarily over undeveloped wilderness. Based upon a Boeing study, approximately 36% of all aircraft accidents occur during final approach and landing (Boeing 2013).

Accident Scenario #2: While on approach a C-17 crashes into a nearby urban area. With a probability of 0.05 the crash is severe enough to breech 3 of the 10 RTG units the aircraft is carrying. Much of the route from Eielson is over unpopulated areas. However, both the landing and takeoff points are over urban centers, so no additional modifier is applied in this case.

The following assumptions were made regarding the accidents:

- The radiological impacts are independent of the type of aircraft except for the quantity of material transported and the speed of the aircraft on impact. The radiological impacts are a function of the plume heat energy, plume height, plume duration, the fraction of the radiological materials released to the environment as respirable particles, the population distribution surrounding the accident, the number of RTG units involved and meteorological conditions.

- Only acute hazards are assessed as they are deemed as the most impactful. Long term risks to the food supply, local wildlife, and long term exposure of the local populace is not considered. The risks are either considered small in relation to the short term exposure or would be mitigated by control measures and remediation of the material released.

Radiological impacts were calculated as follows:

- Population doses and risks were calculated for the population estimated to be within 80 kilometers (50 miles) of the accident site.

- Individual doses and risks were calculated for a maximally exposed individual (MEI), a hypothetical individual member of the public who would likely receive the maximum dose from an accident. Members of the public (including airport workers) could be near the crash location, hence a distance of 100 meters (330 feet) from the accident site was assumed.

- The impacts of an accident on the aircrew are not evaluated quantitatively. No adequate method exists for calculating meaningful consequences at or near the location where the accident might occur.

The analysis of the impact from these accidents were conducted using the Defense Threat Reduction Agency (DTRA) Hazard Prediction and Assessment Capability (HPAC) Version 5.0. Doses were calculated due to inhalation of airborne material and external exposure to the passing plume. These represent the major portion of the dose an individual would receive as a result of an aircraft accident. HPAC input parameters were all set to maximize the calculated dose and produce a conservative and bounding radiological consequence to the public.

The Sr-90 is in the form of strontium titanate. An aircraft fuel fire would not be expected to melt the strontium titanate. JP-8 burns at a temperature of 260-315 ºC (500 – 599 ºF) far below the melting point of strontium titanate which has a melting point of 2080 ºC (3776 ºF). Thus it is not expected an aircraft fuel fire would disperse respirable particles of strontium-90 because of its high melting point (American Elements 2010). The only viable release fraction would be as a result as impaction stress release or fracturing of the source during impact. HPAC uses experimental data from Department of Energy (DOE) on the dispersion of radiological sources dispersed using explosives. Although the HPAC data is not based on aircraft accidents, the energy released in a large aircraft accident is similar to that released during an explosive detonation. The DOE included data included experimental data on sealed sources. The RTGs are extremely robust sealed sources. They also meet the design requirements of a

Type B() package. The model used to estimate the release of material is for only a sealed source and does not account for the Type B() designation. Thus, to account for this, the amount of material potentially released in each RTG was reduced by a factor of 10. This is likely a very conservative estimate.

Exposure to radioactive materials typically has two exposure routes both internal and external. Sr-90 and Y-90 are both pure beta emitters. Betas may produce bremsstrahlung radiation when interacting with dense materials which can result in an external dose. In fact, this is the primary source of radiation exposure from an intact RTG unit. However in the event of an aircraft accident the external dose from bremsstrahlung will be trivial in comparison to the dose from internal inhalation of airborne respirable particles. The HPAC code models all of these exposures.

4.3.2.1. **Potential Impacts of Accident #1**

For accident scenario #1 a CH-47 crashes on approach in a nearby densely populated area. The CH-47 is carrying 2 RTG units. The force of the impact is sufficient to breach the RTG units and release radioactive materials. The HPAC code provided the following exposure groups based on population density and the quantity of material released. Total Effective Dose Equivalent (TEDE) was calculated for a 30 day period for the exposed population. It is assumed that any area where the populace would receive greater than 1 rem of dose over the next 30 days would be evacuated until the area was remediated.

Table 10: Collective Dose from Accident Scenario #1

Dose Range (rem)	Number Exposed	Total Dose (person-rem)
>100	15	NA
50 - 100	22	NA
10 - 50	47	NA
5 - 10	67	NA
1 - 5	182	182
0.5 - 1	318	159
0.1 - 0.5	1283	128.3
0.05 - 0.1	2342	117.1
0.01 - 0.05	12371	123.71
Total		710

Table 10 shows the collective dose for the potentially exposed population. The total population dose is then 710 rem. This results in an LCF of 0.35 or 1 in 2.8 chance of an excess cancer.

Population in the immediate area of the crash may receive a high radiation dose. However, it is likely anyone in the immediate vicinity would not survive the effects of the crash. Fatalities as a result of the crash including crew and population are not considered in this assessment as this assessment only includes additional risk as a result of potential exposure to radiological materials.

4.3.2.2. **Potential Impacts of Accident Scenario #2**

For accident scenario #1 a C-17 crashes on approach in a nearby densely populated area. The C-17 is carrying 10 RTG units. The force of the impact is sufficient to breach the RTG units and release radioactive materials. The HPAC code was used to calculate the dose for exposure groups based on population density and the quantity of material released. Total Effective Dose Equivalent (TEDE) was calculated for a 30 day period for the exposed population. It is assumed that any area were the populace would receive greater than 1 rem of dose over the next 30 days would be evacuated until the area was remediated.

Table 11: Collective Dose from Accident Scenario #2

Dose Range (rem)	Number Exposed	Total Dose (person-rem)
>100	128	NA
50 - 100	187	NA
10 - 50	482	NA
5 - 10	781	NA
1 - 5	2575	2575
0.5 - 1	4086	2043
0.1 - 0.5	18355	1835
0.05 - 0.1	33761	1688
0.01 - 0.05	105683	1056
Total		9198

Table 11 shows the collective dose for the potentially exposed population. The total population dose is 9198 rem. This results in an LCF of 4.6 or approximately 5 excess cancers in the exposed population.

Population in the immediate area of the crash may receive a high radiation dose. However, it is likely anyone in the immediate vicinity would not survive the effects of the crash. Fatalities as a result of the crash including crew and population are not considered in this assessment as this assessment only includes additional risk as a result of potential exposure to radiological materials.

4.3.3. **Uncertainty**

The assessment of RTG impacts has significant uncertainties. The probability of the RTG units being breached and the subsequent quantity of material released

being the most significant. It is difficult to assess these quantities. In this assessment professional judgment and values from other sources are used. It should be noted the other sources are only based upon professional judgment as well and not empirical data. There is likely significant uncertainty in these values.

The RTG units were designed as NRC Type B packages and can withstand significant stress before they would be breached. Additionally, they are designed to fail gracefully. If they were to breach they would only release a small fraction of material. The forces in an aircraft crash can be significant. The amount of energy released in an air crash is estimated to be on the order of 5×10^{11} J. This is the equivalent of 100 tons of TNT. Thus, the possibility of breach cannot be discounted.

There are many unknowns in this assessment and several best guess professional judgments were made. As stated, this assessment is a worst case estimate of the impacts of a severe aircraft crash. Judgments were always made on the side of caution.

4.3.4. **Discussion of Impacts**

The form of the material used in the RTG units significantly reduces the potential impacts from a release of material. The extremely high melting point of the ceramic Sr-90 significantly reduces the potential impacts. A fire from aircraft fuel would not be nearly hot enough to vaporize the Sr-90 and thus particles are only transported as a powder after fracturing as a result of the initial impact. Thus, the range of transport is limited in comparison to other materials with lower melting points. When evaluated in conjunction with the probability of an aircraft accident, the risk to the population is minimal.

In the event of a release a significant area would be contaminated with Sr-90. In the case of the C-17 accident this could include tens of square miles. Most of this area would need to be mitigated before it could be reoccupied. The cost of such mitigation and the economic impact would be significant. The evaluation of such impacts is beyond the scope of this document. The initial health consequences of such an accident would be dominated by the injuries and fatalities as a result of the crash. The release of the radioactive material would have relatively insignificant health consequences.

5. Analysis Summary

Table 12 summarizes the results of the risk analysis performed. For details of the methodology and results refer to the corresponding sections.

Table 12: Summary or RTG Transportation Risk

Risk to the Global Commons

Event	Probability of Occurrence	Impact of Occurrence	Notes
Incident-Free Air Transport of the RTG impact and risk to the global commons	1.0	No additional impact except that normally associated with air transport	
Aircraft accident risk to the global commons (at sea, populated areas refer to aircraft accidents below)	$2.6 \times 10^{-6} – 5.2 \times 10^{-6}$	Fatalities among local marine life No measureable long term effects	

Air Transport Risks Route #1

Event	Probability of Occurrence	Impact of Occurrence	Risk	Notes
Route #1 Burnt Mountain -> Fort Yukon -> Eielson AFB -> Creech AFB				
Incident-free air transport risk to occupational workers	1.0	6.5×10^{-5} LCF	6.5×10^{-5} LCF	5.3×10^{-5} LCF Ground Loading/Unloading 1.2×10^{-5} LCF Storage Aircraft Transport
Incident-free air transport risk to members of the general public	1.0	No Impact	No Impact	The assumption is made that members of the general public will not be exposed during air transport
Severe aircraft accident scenario #1 CH-47 accident during transport - Risk to occupational workers	1.2×10^{-6}	Fatal to all aircraft crew and passengers	No Impact[4]	It is assumed that any accident significant enough to result in a radiological release would be fatal to the aircrew
Severe aircraft accident scenario #1 CH-47 accident during transport - Risk to members of the general public	1.2×10^{-6}	0.35 LCF	4.2×10^{-7} LCF	
Severe aircraft accident scenario #2 C-17 accident during transport - Risk to occupational workers	1.3×10^{-6}	Fatal to all aircraft crew and passengers	No Impact[4]	It is assumed that any accident significant enough to result in a radiological release would be fatal to the aircrew
Severe aircraft accident scenario #1 C-17 accident during transport - Risk to members of the general public	1.3×10^{-6}	4.6 LCF	6.1×10^{-6} LCF	
TOTAL			**7.1×10^{-5} LCF**	

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4 Although an aircraft accident severe enough to breach the RTG units would be fatal to the aircrew and passengers, the fatalities would be a result of the accident itself and not a result of the radiological material being transported. For this reason the risk to the aircrew is considered routine and is not an additional risk as a result of transporting the RTG units and is not considered in this assessment.

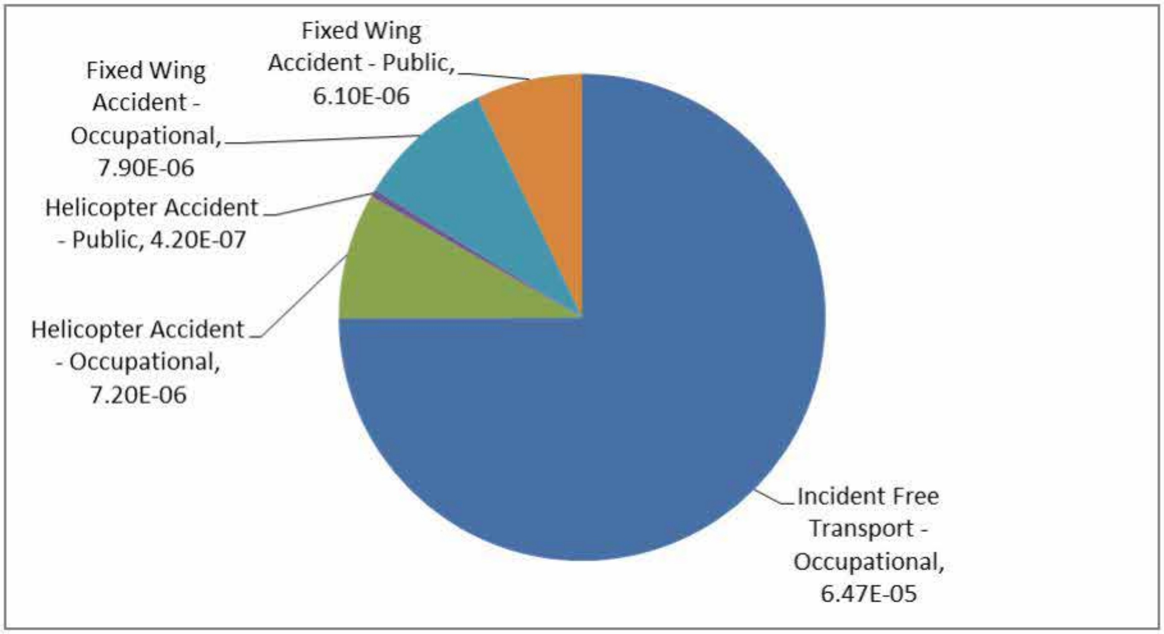

Figure 6: Relative Risks of Route #1

Air Transport Risks Route #2

Event	Probability of Occurrence	Impact of Occurrence	Risk	Notes
Route #2 Burnt Mountain -> Eielson AFB -> Creech AFB				
Incident-free air transport risk to occupational workers	1.0	5.8×10^{-5} LCF	5.8×10^{-5} LCF	4.4×10^{-5} LCF Ground Loading/Unloading 1.4×10^{-5} LCF Storage Aircraft Transport
Incident-free air transport risk to members of the general public	1.0	No Impact	No Impact	The assumption is made that members of the general public will not be exposed during air transport
Severe aircraft accident scenario #1 CH-47 accident during transport - Risk to occupational workers	3.8×10^{-6}	Fatal to all aircraft crew and passengers	No Impact[5]	It is assumed that any accident significant enough to result in a radiological release would be fatal to the aircrew
Severe aircraft accident scenario #1 CH-47 accident during transport - Risk to members of the general public	3.8×10^{-6}	0.35 LCF	1.3×10^{-6} LCF	
Severe aircraft accident scenario #2 C-17 accident during transport - Risk to occupational workers	1.3×10^{-6}	Fatal to all aircraft crew and passengers	No Impact[5]	It is assumed that any accident significant enough to result in a radiological release would be fatal to the aircrew
Severe aircraft accident scenario #1 C-17 accident during transport - Risk to members of the general public	1.3×10^{-6}	4.6 LCF	6.0×10^{-6} LCF	
Total			**6.5×10^{-5} LCF**	

[5] Although an aircraft accident severe enough to breach the RTG units would be fatal to the aircrew and passengers, the fatalities would be a result of the accident itself and not a result of the radiological material being transported. For this reason the risk to the aircrew is considered routine and is not an additional risk as a result of transporting the RTG units and is not considered in this assessment.

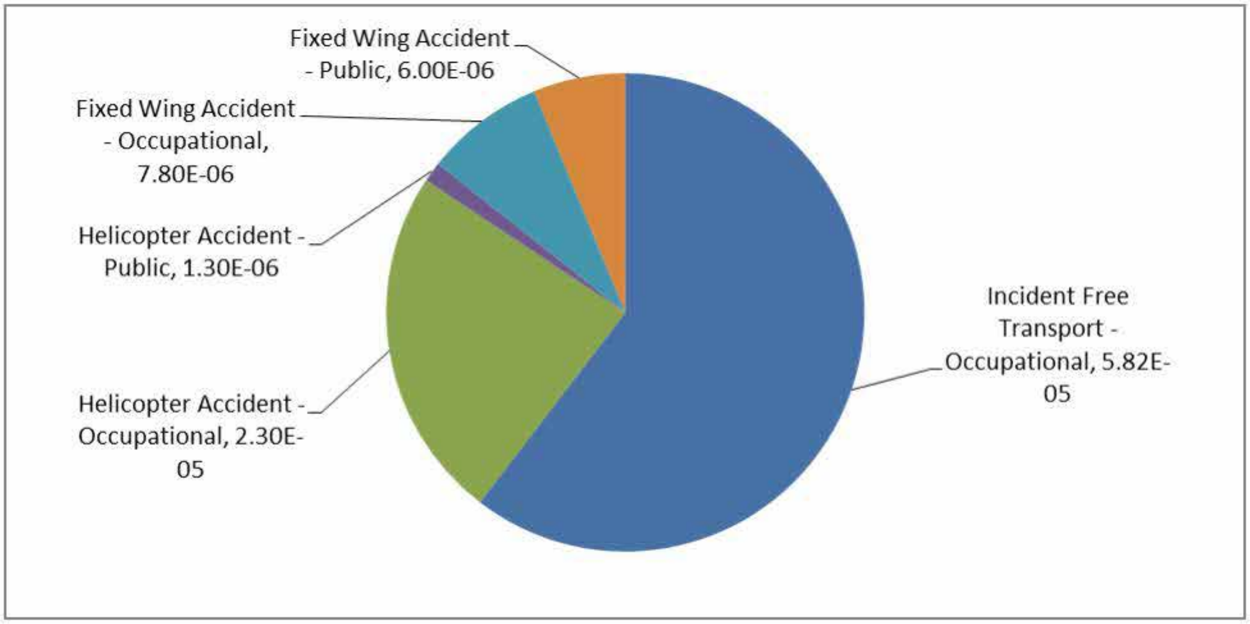

Figure 7: Relative Risks of Route #2

6. Results and Conclusions

The total risk of a fatality from transport of the RTG units for the two routes of transport considered was 7.1×10^{-5} for route one and 6.5×10^{-5} for route 2. This equates to a risk of about 1 in 10,000. The risk is a result of latent cancer fatalities. Considering the uncertainty associated with this assessment, the difference in risk between the two routes is negligible.

The most significant risk from radiological exposures as a result of RTG transport is the exposure of the occupational workers during incident free transport. Although, the impacts from an accident in route would be significant, the probability of such an accident occurring is very small resulting in a total risk smaller than the incident free transport. The potential economic impacts from such an accident could be severe and the transport plan for this operation should take this into consideration. Flight routes should avoid populated areas as much as practical.

Based on this assessment, the additional risks from radiological materials as a result of transport of the RTG units from Burnt Mountain, AK to the NNSA site are minimal.

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8. Attachments

1. Aircraft Fuel and Speed Data

2. Accident Probability for all Possible Routes

3. Routing Data

4. Accident Risk Statistics

5. Aircraft Accident Risk Assessment

6. Incident Free Ground Operations Dose Assessment

7. Incident Free Air Transport Dose Assessment

8. Safety Evaluation for a Twenty-Five Watt Strontium-90 Low Cost Generator Model LCG-25A, TES-3206, April 1965

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11. Structural and Thermal Evaluation of Sentinel 100F, INSD-3080, August 1985

~~Security-Related Information: Withhold Under 10 CFR 2.390~~

Environmental Assessment for the Non-routine Transportation of Radioisotope Thermoelectric Generators

January 2015

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RESPONSIBLE AGENCY: U.S. AIR FORCE (USAF)

TITLE: Environmental Assessment for the Non-routine Transportation of Radioisotope Thermoelectric Generators

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Abstract: This EA addresses the human health and environmental impacts of non-routine aspects of transporting ten (10) Radioisotope Thermoelectric Generators (RTGs) from Burnt Mountain, Alaska (AK), to the Nevada National Security Site (NNSS) in southern Nevada for further disposition. Three alternative actions were selected for analysis:

- **Alternative 1:** The 10 RTGs would be transported from Burnt Mountain, AK, to Fort Yukon, AK, by CH-47 Chinook helicopters; from Fort Yukon to Eielson Air Force Base (AFB), AK, by C-130 Hercules; from Eielson AFB to Creech AFB, Nevada (NV), by C-17 aircraft; and from Creech AFB to the NNSS by truck.
- **Alternative 2:** The 10 RTGs would be transported from Burnt Mountain, AK, to Eielson Air Force Base, AK, by CH-47F Chinook helicopters; from Eielson AFB to Creech AFB, NV, by C-17 aircraft; and from Creech AFB to the NNSS by truck.
- **No-Action Alternative:** The 10 RTGs would remain in place at Burnt Mountain, AK.

No significant human health or environmental impacts are anticipated for any of the alternatives under routine incident-free operating conditions. Although the probabilities of an aircraft accident are extremely small, should an accident occur, there is the potential for radiological release and exposure to humans and the environment.

Public Comments: This EA was not released for public comment pursuant to federal regulations. This EA contains non-releasable 10 CFR 2.390 information and Sensitive Unclassified Security-Related Information, which is generally not publicly available and encompasses a wide variety of categories, including detailed information surrounding radioactive material.

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ACRONYMS AND ABBREVIATIONS

ADOT & PF	Alaska Department of Transportation and Public Facilities
AEC	Atomic Energy Commission
AFB	Air Force Base
AFTAC	Air Force Technical Applications Center
AK	Alaska
amsl	Above mean sea level
ATV	All-terrain vehicle
BLM	Bureau of Land Management
ºC	Degree(s) Celsius
CAC	Combat Alert Center
CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
cm	Centimeter(s)
CoC	Certificate of Compliance
CoE	Certificate of Exemption
DAQEM	Department of Air Quality and Environmental Management
dB	Decibel(s)
dBA	Decibel(s), A-weighted
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ºF	Degree(s) Fahrenheit
FAA	Federal Aviation Administration
FNSB	Fairbanks North Star Borough
FONSI	Finding of No Significant Impact
ft	Foot (feet)
GHG	Greenhouse gas
HA	Hazard Analysis
ICC	International Code Council, Inc.
in.	Inch(es)
JBER	Joint Base Elmendorf-Richardson
km	Kilometer(s)
km^2	Square kilometer(s)
L_{dn}	Daylight noise level
LCF	Latent cancer fatality
LFE	Large Force Exercise
LLNL	Lawrence Livermore National Laboratory

LLW	Low-level waste
LRRS	Long Range Radar Site
m	Meter(s)
MEI	Maximally exposed individual
mi	Mile(s)
mi^2	Square mile(s)
MLLW	Mixed low-level waste
mph	Mile(s) per hour
mrem	Millirem
mrem/hr	Millirem per hour
mrem/yr	Millirem per year
NA	Not applicable
NEPA	*National Environmental Policy Act*
N-I	Navarro-Intera, LLC
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site
NNSS SWEIS	NNSS Site-Wide Environmental Impact Statement
NRC	U.S. Nuclear Regulatory Committee
NSTec	National Security Technologies, LLC
NV	Nevada
ORNL	Oak Ridge National Laboratory
PCB	Polychlorinated biphenyl
PLO	Public Land Order
$PM_{2.5}$	Particulate matter 2.5 microns or less
PM_{10}	Particulate matter 10 microns or less
P&T	Packaging and transportation
rad	Radiation absorbed dose
RDD	Radiological dispersal device
rem	Roentgen-equivalent man
RIC	Radioisotope Committee
RTG	Radioisotope thermoelectric generators
RWMC	Radioactive Waste Management Complex
SNL	Sandia National Laboratories
Sr-90	Strontium-90
$SrTiO_3$	Strontium titanate
SUNSI	Sensitive unclassified nonsafeguards information
TEDE	Total Effective Dose Equivalent
Teledyne	Teledyne Energy Systems, Inc.
TLD	Thermoluminescent dosimeter
U.S.C.	*United States Code*
US-95	U.S. Highway 95
USACE	U.S. Army Corps of Engineers

USAF	U.S. Air Force
USARAK	U.S. Army Alaska
USFS	U.S. Forest Service
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey

1.0 PURPOSE AND NEED

1.1 PURPOSE AND NEED

The purpose of the action alternatives described in this document is for the U.S. Air Force (USAF) to transport ten (10) strontium-90 (Sr-90) radioisotope thermoelectric generators (RTGs) from their current location at Burnt Mountain, Alaska (AK), to the Nevada National Security Site (NNSS) in southern Nevada (NV) for disposition (Figure 1-1). A study in 2011 by Teledyne Energy Systems, Inc. (Teledyne) determined the current output of the RTGs is insufficient to satisfy the USAF mission requirements (Teledyne, 2011). The RTGs are now considered excess materials, requiring transfer for temporary storage and disposition. The U.S. Department of Energy (DOE) has agreed to accept the RTGs at NNSS. The USAF is proposing the RTGs be removed from Alaska in the summer of 2015 because they are no longer used other than to provide power to monitor their own security.

DOE's acceptance of the RTGs is based on a 1987 Report to Congress (DOE, 1987) that states DOE would select a long-term storage location to accommodate up to 50 Sr-90 RTGs, as required under the *Low-Level Radioactive Waste Policy Amendments Act of 1985* (Public Law 99-240). The source material used to power the RTGs was initially derived from DOE radioactive material. The NNSS, formerly the Nevada Test Site, received the first shipment of RTGs on May 19, 2004. The NNSS has received an additional 5 shipments for a total of 30 RTGs (Geisinger, 2011).

IAW U.S. Nuclear Regulatory Commission's (NRC) security regulations, 10 *Code of Federal Regulations* (CFR) Part 37, requires much of the information regarding the RTGs to be categorized as sensitive unclassified non-safeguards information (SUNSI). SUNSI is generally not publicly available and encompasses a wide variety of categories, including detailed information surrounding certain categories of radioactive material. This document contains SUNSI and should be handled IAW NRC guidance.

This Environmental Assessment (EA) evaluated all alternatives and examined three reasonable alternatives in detail: two action alternatives and the No Action Alternative. The action alternatives, Alternatives 1 and 2, would meet the USAF's need to remove the RTGs from Burnt Mountain and return responsibility for the RTGs to DOE as specified under Public Law 99-240.

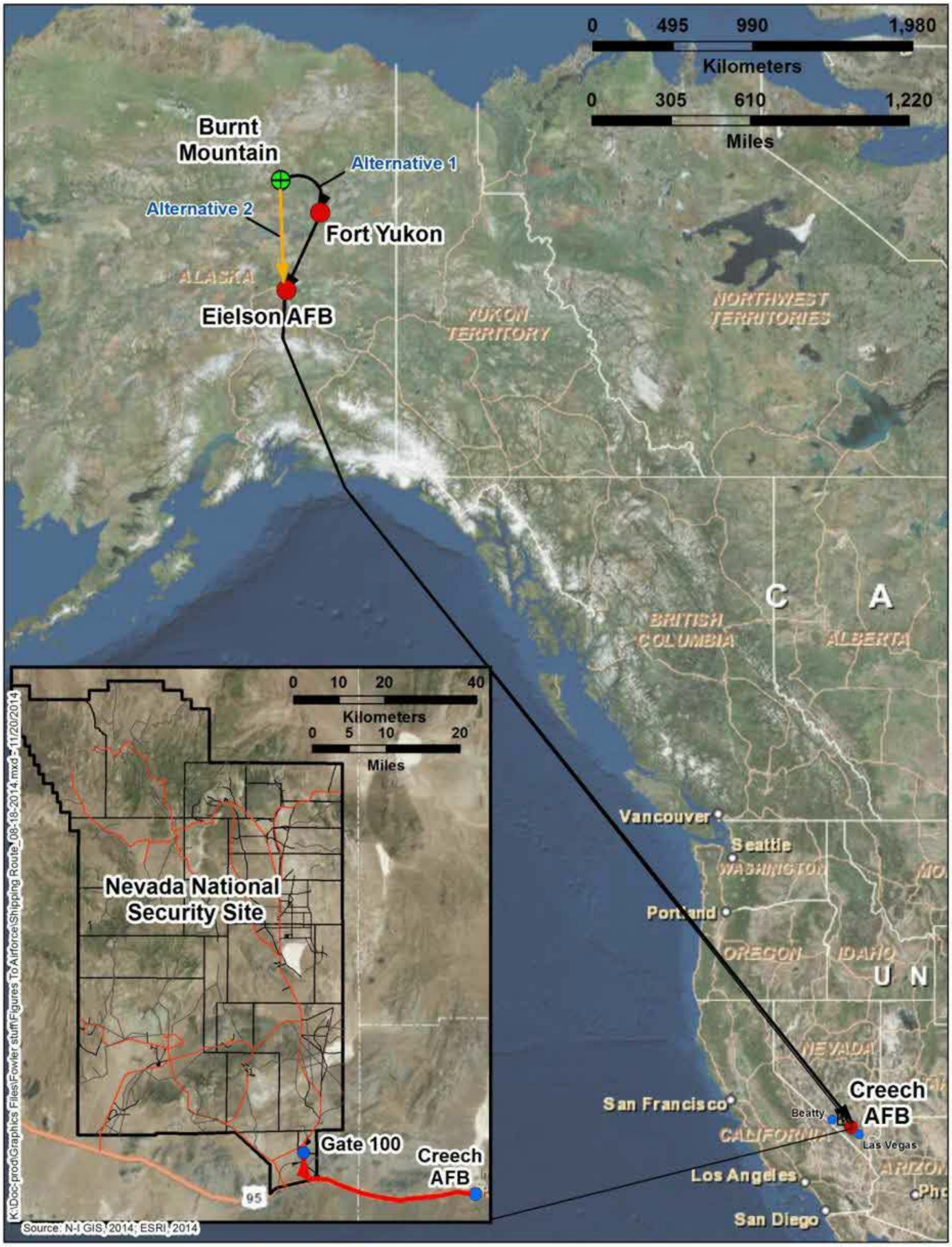

Figure 1-1
Alternative Routes from Burnt Mountain to NNSS

1.2 BACKGROUND

This section provides background information regarding the USAF's alternatives for the transport of 10 Sr-90 RTGs to the NNSS. The Air Force Technical Applications Center (AFTAC) is developing this EA in consideration of the *National Environmental Policy Act* (NEPA) *of 1969* (Public Law 91-190, 42 *United States Code* [U.S.C.], 4321–4347), the Council on Environmental Quality (CEQ) NEPA Regulations (40 CFR Parts 1500–1508) as amended, and USAF procedures set forth in 32 CFR Part 989. The purpose of this EA is to provide sufficient evidence and analysis to issue a Finding of No Significant Impact (FONSI) or to determine if an Environmental Impact Statement (EIS) is needed.

The USAF operates an unattended seismic observatory at Burnt Mountain, AK, in the Yukon River Valley. It is a remote area approximately 62 miles (mi) (100 kilometers [km]) north of the Arctic Circle; 50 mi (80 km) from the closest village and nearest airport. Access to the site is by helicopter only, as no roads exist in the area. The data collection and communications equipment at the observatory were powered by 10 RTGs until an alternate power station was installed in 2000. The USAF is the current custodian of the 10 RTGs, which were developed under the Atomic Energy Commission's (AEC) "Beneficial Uses of Radioactive Material" program. The RTGs use the heat from the decay of Sr-90 to generate electricity and are often used in remote locations. The RTGs at Burnt Mountain were used by AFTAC to generate the electricity to operate and maintain the Burnt Mountain Seismic Array, which was implemented to verify international compliance with nuclear weapons testing treaties. The 10 RTGs are located at the array system's five remote seismic sensor sites, identified as sites BM01, BM02, BM03, BM04, and BM05 (Figure 1-2). Each site contains a shed with two RTGs mounted on a forklift-compatible steel pallet (Figures 1-3 and 1-4).

A 35,000-acre (142-square-kilometer [km^2]) tundra fire caused damage to data cables at one of the five RTG storage sites at Burnt Mountain in 1992 (U.S. Congress, 1994). Although the fire burned to within 100 yards (91 meters [m]) of the RTG site, no damage occurred to the RTGs, and no release of radioactive materials resulted. However, local residents were alarmed to learn of the RTGs and speculated about the potential for nuclear contamination should the RTGs be damaged by fire or other mishap. The report states Alaska Senator Frank Murkowski requested the USAF conduct a site visit, public meetings at Fort Yukon, Arctic Village and Venetie, and an assessment of alternative power sources. In response to the request for an assessment, the USAF prepared a report titled *Power Assessment for the Burnt Mountain Seismic Array Observatory* (Lamp, 1994). Senator Murkowski and Senator Ted Stevens also requested the U.S. Congress Office of Technology Assessment conduct an independent review of power supply alternatives, which resulted in the report titled *Background Paper: Power Sources for Remote Arctic Applications* (U.S. Congress, 1994). These reports concluded that continued use of the RTGs entails low risk for the safety of maintenance workers, local populations, and the environment. The Congressional report stated "continued use of the RTGs is clearly the safest, most reliable,

economical approach to supplying electrical power to the Burnt Mountain Seismic Array Observatory." USAF officials subsequently recommended the RTGs continue to be used at Burnt Mountain to the end of their useful lives. The RTGs were used to supply electrical power to the seismic array until 2000, when an alternate power source was installed. The RTGs do not contribute to the operational mission of the array.

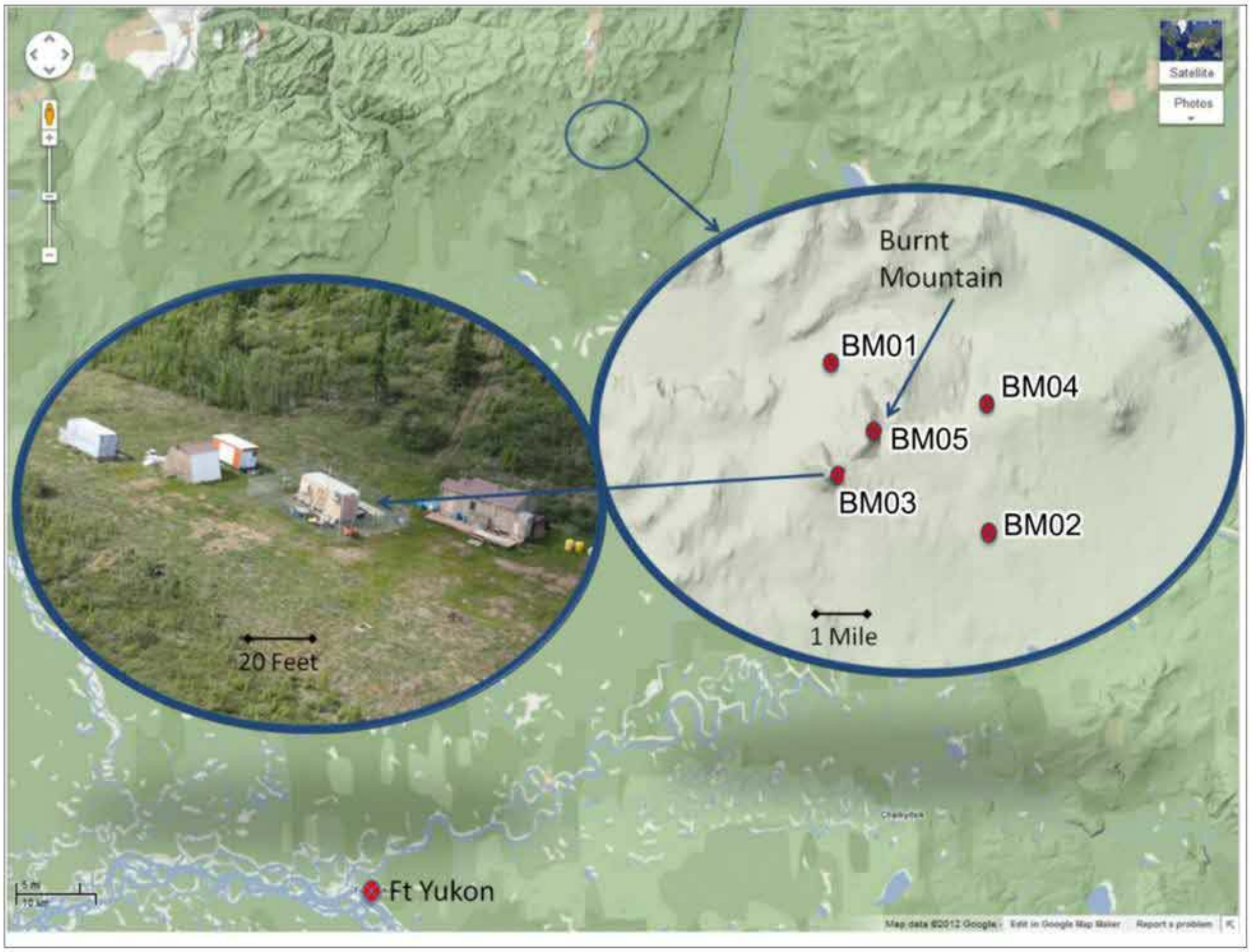

Figure 1-2
Location of Five RTG s in Alaska (Burnt Mountain Sites)

The RTGs are approximately 2 feet (ft) in diameter and 3 ft tall. These units weigh from 1 to 2 tons each, including their housing and extensive shielding. These units generated about 500 watts of electricity. As a power source, they are reliable, virtually maintenance free, and capable of withstanding the harsh environmental conditions of Alaska. A more detailed description of the RTGs is provided in Appendix A of this EA.

Figure 1-3
RTG Storage Shed and Fenced Area

The USAF, current holder of the 10 RTGs at Burnt Mountain, maintains the license issued by the NRC for possession and use. AFTAC possesses a USAF permit issued by the USAF Radioisotope Committee (RIC) to operate the RTG under the Air Force License. AFTAC is responsible for complying with both NRC and RIC requirements. The source material used to power the RTGs originated from the AEC, predecessor to the DOE. As such, DOE is the entity responsible for the ultimate disposition of the RTGs at the NNSS. The NNSS has agreed to accept the RTGs for further disposition.

Figure 1-4
Two RTGs on Metal Pallets

1.3 SCOPE OF THE EA

The scope of the EA includes the transport of 10 Sr-90 RTGs using rotary-winged aircraft and fixed-wing aircraft from Burnt Mountain, AK, to Creech Air Force Base (AFB), NV. At Creech AFB, the RTGs would be transferred to a flatbed truck for transport to the NNSS. Creech AFB is located in close proximity (approximately 20 mi) to the NNSS, minimizing transport via public highway. Sandia National Laboratories (SNL) would take ownership of the RTGs on behalf of DOE at Gate 100 of the NNSS. The transportation and disposition of radioactive material at the NNSS is evaluated in the *Final Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada,* which will be referred to as the NNSS Site-Wide Environmental Impact Statement (NNSS SWEIS) for the remainder of this document (DOE, 2013b).

This document provides a detailed assessment of the following reasonable alternatives:

- **Alternative 1:** The 10 RTGs would be transported from Burnt Mountain, AK, to the NNSS RWMC in southern Nevada for further disposition. The RTGs would be transported from Burnt Mountain to Fort Yukon, AK, by CH-47F Chinook helicopters; from Fort Yukon to Eielson AFB, AK, by C-130 Hercules; from Eielson AFB to Creech AFB, NV, by C-17 aircraft; and from Creech AFB to the NNSS by truck.
- **Alternative 2:** The 10 RTGs would be transported from Burnt Mountain, AK, to the NNSS RWMC in southern Nevada for further disposition. The RTGs would be transported from Burnt Mountain to Eielson AFB, AK, by CH-47F Chinook helicopters; from Eielson AFB to Creech AFB, NV, by C-17 aircraft; and from Creech AFB to the NNSS by truck.
- **No Action: Sr-90 RTGs Remain in Place**. Under the No Action Alternative, the 10 RTGs at Burnt Mountain would be left in place at Burnt Mountain.

1.4 PUBLIC INVOLVEMENT

This EA was not issued for public comment pursuant to federal regulations. This EA contains non-releasable 10 CFR § 2.390 information and Sensitive Unclassified Security-Related Information, which is not releasable to members of the public and encompasses a wide variety of categories, including detailed information concerning radioactive material.

2.0 DESCRIPTION OF ALTERNATIVES

The section describes two reasonable alternatives and the No Action Alternative evaluated in this EA. Alternatives considered but not carried forward for further analysis, and the relationship to other USAF/DOE actions and programs are also described in this section.

Application of the following evaluation criteria narrowed the transportation routes to be included in the action alternatives:

- Minimizing risk to personnel and the environment due to a remote and rugged location.
- Minimizing risk factors to the safe transport of the RTGs.
- Using U.S. Department of Defense (DoD) - or DOE-operated airfields to the maximum extent possible.
- Minimizing the length of transport over public highways.

The RTGs are currently stored at Burnt Mountain in storage sheds. During transport to the NNSS, the RTGs would be temporarily staged at various locations. Before removal and transport, the RTGs would be prepared for shipment in accordance with DoD and Federal guidelines. This means the RTGs would be packaged, marked, and labeled as required by law. The RTGs were previously certified by the NRC as Type B packages IAW 10 CFR Part 71. Under DoD and Federal guidelines, the RTGs must be shipped in a Type B container because of the quantity of the radioactive material. A Type B container is able to withstand tests simulating normal shipping conditions, is able to withstand severe accident conditions without releasing its contents, and provides shielding against radiation. The NRC certification of the container has expired. For reasons beyond the scope of this document, the NRC will no longer extend the certification of the containers. In 2011 Teledyne Energy Systems performed an engineering evaluation of the RTGs and determined the units are "in original transport condition". Additionally, in 2014 DOE performed a safety evaluation and concluded, "the packages meet the structural requirements of 10 CFR Part 71." The USAF will transport the RTGs in accordance with DoD and Federal transportation regulations. Included in this effort are temporary staging locations during transport.

2.1 ALTERNATIVE 1

The USAF's Alternative 1 would transport 10 RTGs from Burnt Mountain, AK, to the NNSS in southern Nevada for further disposition using the following transportation route and vehicles:

- From Burnt Mountain to the Fort Yukon Airfield, AK, using CH-47F Chinook helicopters.
- From the Fort Yukon Airfield, AK, to Eielson AFB, AK, using C-130 aircraft.

- From Eielson AFB, AK, to Creech AFB, NV, using a C-17 aircraft.
- From Creech AFB, NV, the NNSS using ground transportation.

Burnt Mountain to the Fort Yukon Airfield via CH-47F Chinook Helicopter

The USAF plans to use CH-47F Chinook helicopters and an all-terrain forklift to accomplish the move from Burnt Mountain to the state-owned public-use airfield in Fort Yukon, AK. The CH-47F is a twin-engine, tandem-rotor, heavy-lift helicopter (Figure 2-1). Helicopters are needed because of uneven terrain, lack of aircraft runways, and no access road to Burnt Mountain.

Figure 2-1
CH-47F Chinook Helicoptor

A CH-47F would transport a forklift to each RTG storage location at Burnt Mountain. Matting and plywood would be laid down as necessary depending on ground conditions at each site (Figure 2-2). Sites BM01 and BM04 are located in low-lying areas with very soft ground. Therefore, the matting and plywood are expected to be used at these sites. Radiation surveys would be conducted, and a portion of the fence would be removed to allow the forklift access to the storage shed. The forklift would be used to remove the RTGs from the shed, load them onto standard military transport (463L) pallets, and transport them to the helicopter. Once loaded on

the CH-47F, the RTGs would be secured for transport to the Fort Yukon Airfield. The matting and plywood would be removed from the site.

Figure 2-2
Matting Used To Protect Ground and Provide a Stable Forklift Surface

Sheds and fencing would remain at each site. They would be used for onsite storage. The area surrounding the Burnt Mountain storage sites would continue to be used for the mission.

While one CH-47F is transporting two RTGs to Fort Yukon, a second CH-47F would take the forklift to the next RTG storage location at Burnt Mountain to repeat the loading process the following day. The CH-47F can only accommodate two RTGs at a time (weight restrictions). The distance to Fort Yukon is 61 mi (98 km) south, and the flying time is 30 minutes. The CH-47Fs must repeat this flight pattern to Fort Yukon four more times, amounting to a total of about 610 mi (982 km) over a 5-day period, depending on weather; the RTGs would be on board the helicopter for a total of 305 mi (491 km).

Transport of the RTGs from Burnt Mountain to Fort Yukon will be dependent upon external factors such as weather or aircraft availability due to world events. Required personnel (security personnel, flight crew, forklift and all-terrain vehicle [ATV] drivers, and radiation protection monitor) would conduct the activities at Burnt Mountain.

Upon arrival at Fort Yukon, the RTGs would be unloaded from the CH-47F and transported to an existing, already disturbed, fenced area near the Fort Yukon Airfield for temporary staging (Figure 2-3). It is expected the RTGs would be staged for up to 7 days until they can be loaded onto the C-130 for transport to Eielson AFB. However, depending on weather conditions, they may remain secured by USAF Security Forces on site until weather conditions permit their removal. The USAF Security Forces would provide 2-man, 24-hour security for the staging location.

Fort Yukon to Eielson AFB via C-130 Hercules Aircraft

The USAF plans to use a C-130 aircraft to move the RTGs from Fort Yukon to Eielson AFB, AK. The C-130 Hercules is a 4-engine turboprop military transport aircraft originally designed to operate from austere locations (Figure 2-4). It is a highly versatile aircraft, operated by the USAF in transport; tanker; gunship; special operations; and command, control, and communication interface variants. The C-130 can accommodate only five RTGs at a time during flight; thus, this would require two trips. The C-130 would fly 142 mi (228 km) in a 60-minute time frame. The C-130 must repeat this flight pattern a second time for the remaining five RTGs, for a total flight distance of 568 mi (912 km). The RTGs would be on board for a total distance of 284 mi (456 km).

Figure 2-3
Fort Yukon Airfield Staging Area

Figure 2-4
C-130 Hercules

Upon arrival at Eielson AFB, the RTGs would be unloaded from the C-130 and transported to the Combat Alert Center (CAC) for temporary staging (Figure 2-5). It is expected the RTGs would be staged for up to four days until they can be loaded onto the C-17 for transport to Creech AFB. However, depending on weather conditions, they may remain at the CAC for up to 10 days. The USAF Security Forces would provide 2-man, 24-hour security for the staging location. Approximately 20 personnel at Eielson AFB would be involved with the transport and staging of the RTGs.

Eielson AFB to Creech AFB via C-17 Aircraft

The USAF plans to transport the RTGs on a C-17 aircraft from Eielson AFB to Creech AFB on a flight path avoiding transport over Canada. The high-wing, 4-engine, T-tailed, multiservice C-17 can carry large equipment, supplies, and troops directly to small airfields in harsh terrain anywhere in the world, day or night (Figure 2-6). The massive, sturdy, long-haul aircraft tackles distance and heavy, oversized payloads in unpredictable conditions. The C-17 has delivered cargo in every worldwide operation since the 1990s and is the backbone of the USAF's airlifter fleet. The C-17 can accommodate all 10 RTGs, so only one trip would be required. The distance to Creech AFB is approximately 2,332 mi (3,753 km).

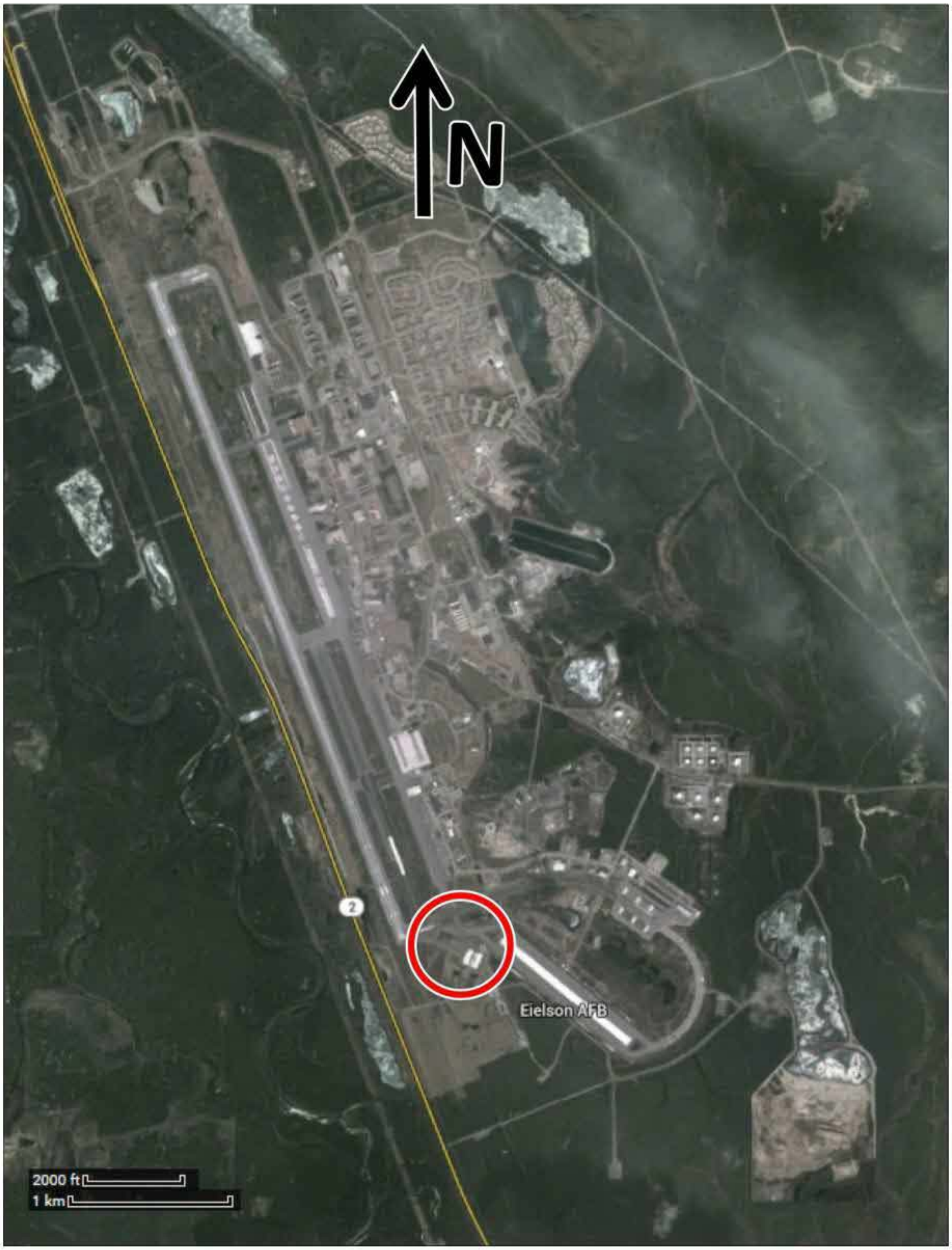

Figure 2-5
Eielson AFB Staging Area
Note: Red circle is the CAC.

Figure 2-6
C-17

Upon arrival at Creech AFB, the RTGs would be unloaded from the C-17 and transported to a hangar north of the runway for temporary staging, indicated by the red circle. (Figure 2-7). The RTGs would be staged in the hangar for 24 to 48 hours until they can be loaded onto a truck for transport to the NNSS. The USAF Security Forces would provide 2-man, 24-hour security for the staging site. Up to 20 personnel at Creech AFB would be involved with the transport and staging of the RTGs.

Creech AFB to NNSS via Truck

The RTGs would be loaded onto a flatbed truck to be transported to the NNSS. The truck would be operated by USAF drivers. Creech AFB was selected as the site to transfer the RTGs from aircraft to truck because of its close proximity to the NNSS, which minimizes transport via public highway. The truck would exit Creech AFB and travel on U.S. Highway 95 (US-95) for approximately 20 mi (32 km), exiting US-95 onto Mercury Highway, a paved federal road, and entering the NNSS through Gate 100 (Figure 2-8).

Figure 2-7
Creech AFB Staging Area
Note: Red circle is the temporary staging location.

AS stated in paragraph 1.3 above, SNL would take ownership of the RTGs on behalf of DOE at Gate 100 of the NNSS. The transportation and disposition of radioactive material at the NNSS is evaluated in the NNSS SWEIS.

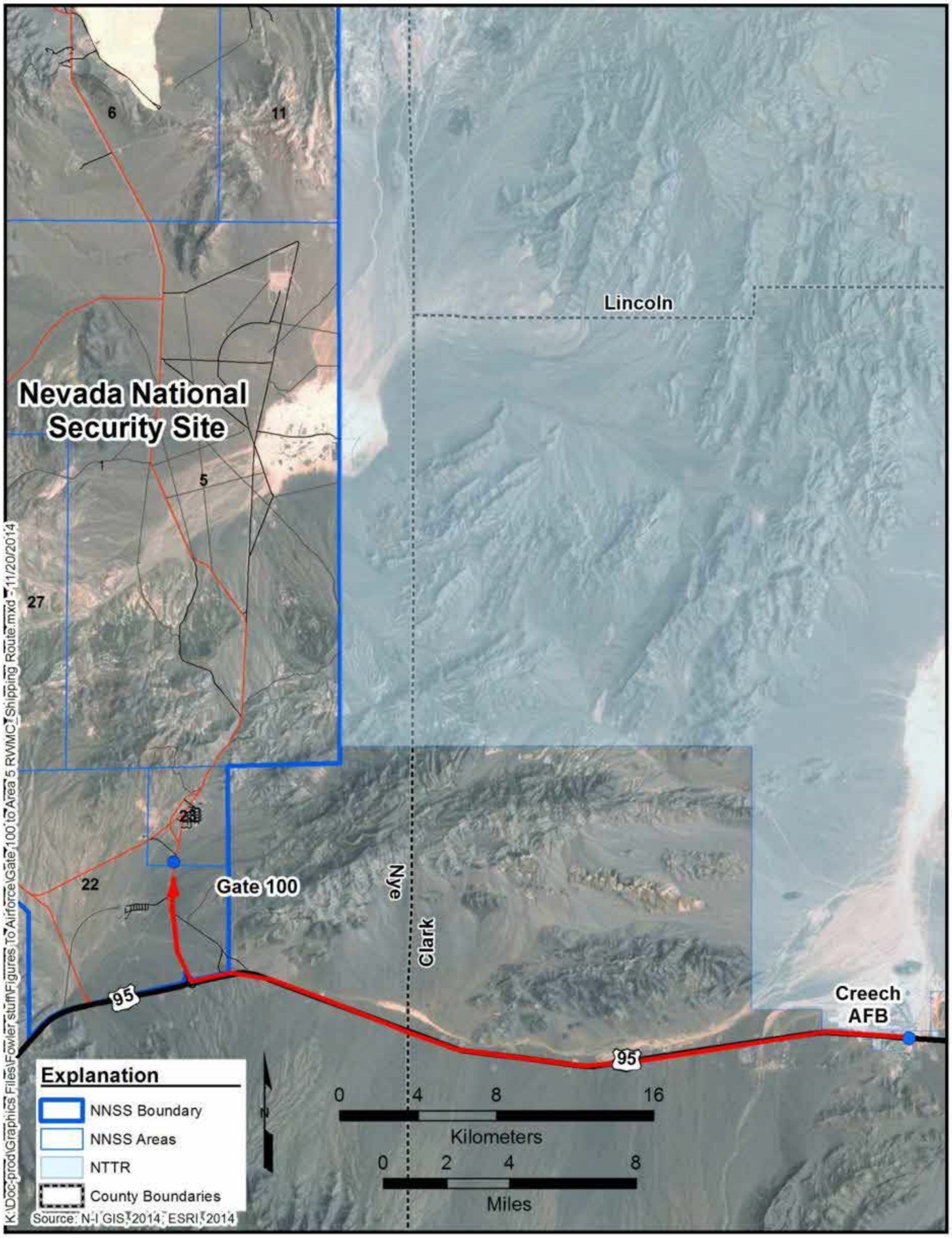

Figure 2-8
NNSS Gate 100

2.2 ALTERNATIVE 2

Alternative 2, which is the Preferred Alternative, would be the same as Alternative 1 except the RTGs would be transported directly from Burnt Mountain to Eielson AFB using CH-47F helicopters (Figure 1-1). Alternative 2 is the Preferred Alternative because this route would (1) bypass Fort Yukon, which is not federal property; (2) decrease the number of take-offs and landings; (3) decrease the number of times the RTGs are transferred between aircraft and staging sites; (4) decrease the number of personnel handling the RTGs; and (5) eliminate the use of the C-130 and its flight crew. The CH-47F Chinook helicopter has a greater range than the previous version of the helicopter (CH-47D), so no refueling would be required between Burnt Mountain and Eielson AFB, given the weight of the RTGs and travel distance. Additionally, the CH-47F has increased capability and is fully instrument-flight-rules capable.

The CH-47F can accommodate only two RTGs at a time (weight restrictions), so this would require five CH-47 roundtrip flights. The distance between Burnt Mountain and Eielson AFB is approximately 200 mi (322 km) with an approximate flying time of 1.5 hours. The CH-47F would repeat this flight pattern four more times, amounting to a total of about 2,000 mi (3,219 km) over a 5-day period, depending on weather. The RTGs would be on board the CH-47F helicopter for a total of 1,000 mi (1,609 km).

2.3 NO ACTION ALTERNATIVE

Under the No Action Alternative, the RTGs would remain in place at Burnt Mountain, providing power for their own security. They would not be providing power for the seismic monitoring and data communications equipment, which was the original mission of the RTGs at Burnt Mountain. The alternate power source, Centralized Diesel Hybrid Power, now provides power for the seismic monitoring and communications equipment. The Centralized Diesel Hybrid Power uses lead/acid storage batteries charged by either a photo-voltaic system or a diesel generator to power for the array. The power is generated at a central location and distributed to the individual sensor sites. The *Environmental Assessment for the Burnt Mountain Seismic Array Power Supply* (USAF, 1999) evaluated the potential impacts of the Centralized Diesel Hybrid Power. RTG maintenance would be accomplished during routine maintenance trips (one per year) to Burnt Mountain. Unscheduled maintenance trips specifically required for the RTGs would be conducted when needed and have typically occurred approximately one time per year. (Holdsworth, 2014). Maintenance crews would be transported to the RTG storage sites in a CH-47F helicopter. ATVs would continue to be used for traveling between remote terminal locations.

Under the No Action Alternative, multiple monitoring systems would continue to be used to monitor the RTGs for integrity and intruders. The monitoring equipment meeting NRC requirements is already in place; thus, there would be no additional costs, other than those for

routine maintenance and inspection of the RTGs. Typically, two workers would conduct the routine maintenance and inspection activities. As part of the routine annual maintenance, a 225-ft (69-m) radius around the RTG storage units would be cleared, if necessary.

2.4 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM FURTHER ANALYSIS

A NEPA review specifies the purpose and need for an action, describes the action the federal agency proposes to meet that purpose and need, and identifies reasonable alternatives. A potential alternative might be eliminated from detailed consideration for many reasons including, but not limited to, if the alternative (1) does not meet the purpose and need for the project, (2) would take too long to implement, (3) would be prohibitively expensive, or (4) would be highly speculative in nature and thus is considered unreasonable. This section identifies the alternatives that were eliminated from further consideration and provides a brief explanation of the reasons for elimination. The alternatives considered but eliminated are as follows:

- Reuse or Recycling of the RTGs
- Upgrade of the RTGs for Continued Use
- Alternate Routes for Transport of RTGs

2.4.1 REUSE OR RECYCLING OF THE RTGS

Possible options for reuse or recycling of Sr-90 RTGs identified and subsequently dismissed are return to the manufacturer, deployment in current or new applications, and disassembly of the RTGs and reuse of the Sr-90 in other applications.

Return to the Manufacturer. When Sr-90 RTGs were first developed in the 1960s, five or six companies were actively producing RTGs (e.g., Teledyne, 3M, and General Electric). However, Sr-90 RTGs are no longer manufactured. Therefore, the manufacturers have no use for the RTGs.

Deployment in Current or New Applications. Private corporations and government agencies have tried through the years to find reuse or recycling applications for Sr-90 RTGs that have been placed in storage after their initial application.

- Nuclear Sources & Services, Inc., in Houston, Texas took possession of Sr-90 RTGs in 1977 with the intention of either transferring them to another party or disposing of them as waste. Neither option has become available.
- The Hanford Site in southeastern Washington currently has Sr-90 RTGs stored as waste. Hanford has had no success with efforts to find a party interested in reapplication of the RTGs and has not received any inquiries about reuse or recycling of the RTGs.

- The Oak Ridge National Laboratory (ORNL) has made several attempts in the past to transfer the RTGs offsite for final disposition but has been unsuccessful. Recently, efforts have been renewed to ship these RTGs to NNSS for disposition.
- SNL has received no inquiries about reuse or recycling of the Sr-90 RTG under their supervision since December 1978. SNL has expended considerable effort to identify potential reuse, recycling, or disposal opportunities, with no success.

Although Sr-90 RTGs are extremely reliable and virtually maintenance-free, they are also the most expensive of RTGs manufactured in terms of initial investment. In addition, they are bulky and heavy compared to RTGs powered by other nuclear sources currently in use, making Sr-90 RTGs undesirable for applications such as space exploration.

Disassembly of the RTGs and Reuse of Sr-90. The 225-B Waste Encapsulation and Storage Facility at the Hanford Site currently provides storage and monitoring of cesium and Sr-90 capsules. The facility operated from 1974 to 1985 to encapsulate cesium-137 and strontium separated from high-level radioactive waste to reduce heat generation in the nearby tanks where these wastes were stored. The activity also provided an opportunity to explore beneficial uses of the separated radionuclides. Few other uses have been identified for the Sr-90 capsules remaining in storage.

2.4.2 UPGRADE OF THE RTGS FOR CONTINUED USE

In July 2011 Teledyne inspected all 10 RTGs at Burnt Mountain to determine their current condition and determine if they were suitable for an onsite upgrade. All 10 RTGs were found to be in good condition and still producing power. However, because the radioisotope heat source is now generating only about 35 percent of the original heat, the current output power of the RTGs is insufficient to satisfy mission requirements. Upgrading the RTGs with improved thermoelectric couples would result in a 200 to 300 percent increase in the output power. Upgrading alone would not meet the current power requirements with the increased power demand due to the security monitoring. The addition of a battery pack would be required for the peak power needed when the security devices are operating. Current projections indicate that upgrading the RTGs and including a battery pack would extend the useful lifespan and produce sufficient power to meet the mission requirements for an additional 17 to 20 years (Teledyne, 2011). However, the upgrade including the addition of a battery pack would cost about $3 million and require ongoing security monitoring efforts (AFTAC, 2012). In comparison, maintaining the RTGs in their current configuration over the 20 year span would cost approximately $100,000 and require ongoing security monitoring efforts, and transporting the RTGs to the NNSS for disposition would cost approximately $1.0 million (AFTAC, 2012).

2.4.3 ALTERNATE ROUTES FOR TRANSPORT OF THE RTGS

The following alternate transport routes were considered. Figure 2-9 shows the locations of staging sites along transport routes:

Joint Base Elmendorf-Richardson (JBER) via Fort Yukon. The 10 RTGs would be removed from Burnt Mountain by CH-47Fs and taken to Fort Yukon. At Fort Yukon, the 10 RTGs would be loaded onto two C-130 aircraft and transported to JBER. This route is similar to Alternative 1; however, the transport distance from Fort Yukon to JBER is well over twice the distance from Fort Yukon to Eielson AFB. Also, Detachment 460, who is responsible for operation and upkeep of the Burnt Mountain RTGs, is based out of Eielson AFB. Therefore, routing the RTGs through JBER would require additional personnel involvement and coordination compared to routing them through Eielson AFB.

Fort Wainwright direct from Burnt Mountain. The 10 RTGs would be removed from Burnt Mountain by CH-47s and taken to Fort Wainwright. This route bypasses Fort Yukon and is similar to Alternative 2; however, Detachment 460, who is responsible for operation and upkeep of the Burnt Mountain RTGs, is based out of Eielson AFB. Therefore, routing the RTGs through Fort Wainwright would require additional personnel involvement and coordination compared to routing them through Eielson AFB.

The following transportation routes were considered even less desirable than those described above:

- With respect to the transport of the RTGs from Burnt Mountain to Eielson AFB, the USAF considered the **Circle-Hot Springs Airfield** located in Central, AK, as a transfer point instead of Fort Yukon, AK. Circle is not equipped to provide logistical support or staging facilities. Factors such as weather delays, support equipment requirements, personnel lodging and security would require additional logics preparations and resources, as well as extend the length of time required to complete the RTG removal and transportation effort. Furthermore, transport from Circle-Hot Springs to Eielson AFB failed to minimize transport by public highway and would include traveling approximately 3 hours over 120 mi (193 km) on unimproved dirt roads susceptible to sudden environmental changes and mudslides due to rain softened surfaces often leading to road closures (Daigle, 2011).

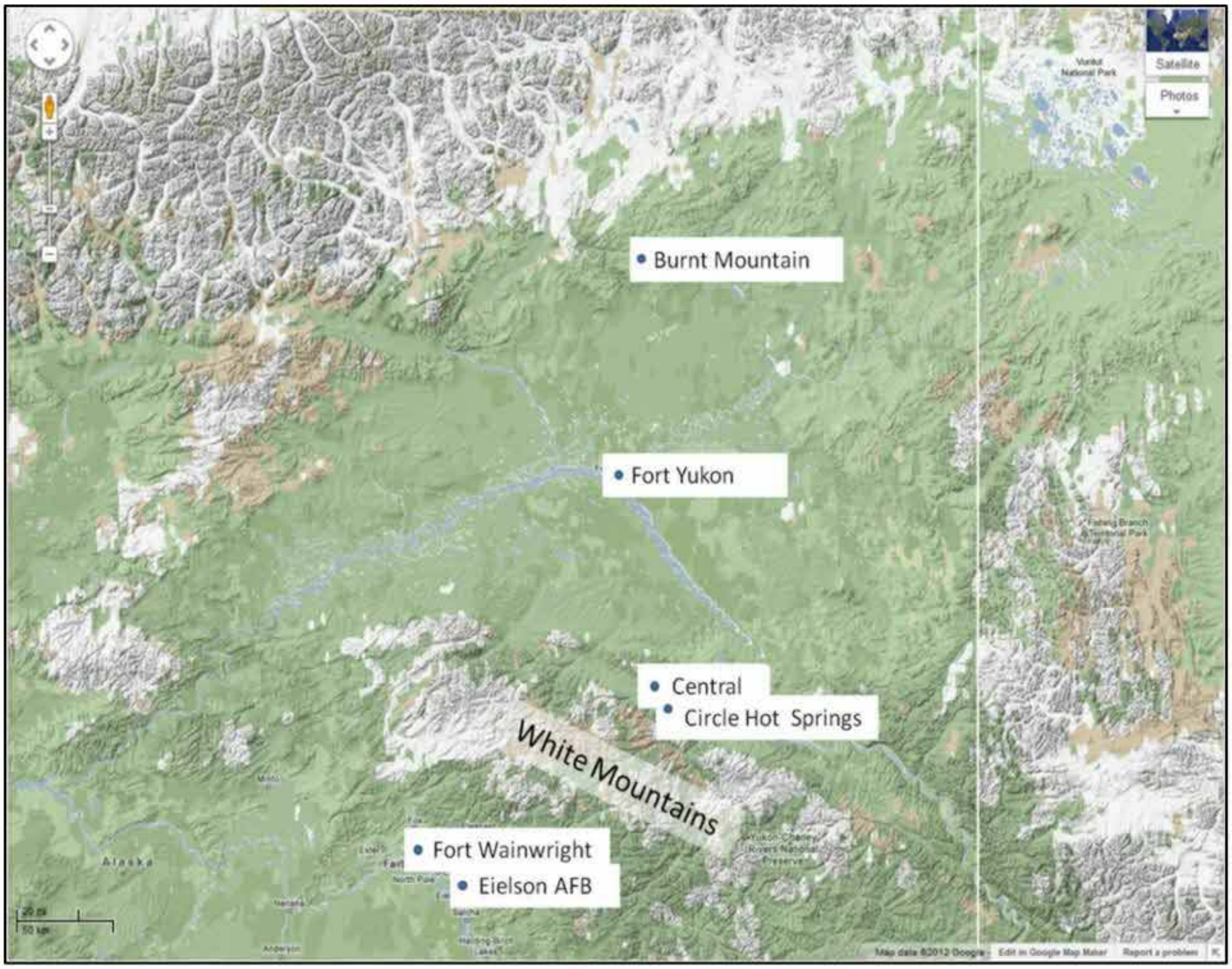

Figure 2-9
Alternate Staging Sites Considered but Eliminated

- **Transfer RTGs via Water.** The Yukon River is navigable from the Canadian border to the Bering Sea and is a major transportation corridor in the Alaskan interior. However, the river cannot be entered by ocean-going vessels because of limited depths. Additionally, few communities have improved barge or boat landings. Traditional docks and loading equipment are almost non-existent. Fort Yukon has a barge off-loading area but no dock. Barges off-load using equipment carried on the barge. Operations are weather- and tide-dependent, making this unpredictable and risky. River operations are water-level dependent, requiring tremendous experience and skill to read the river, evaluate risks, and negotiate a constantly moving current. Varying water levels and occasional groundings that lead to lost days add to the challenges of river operations (ADOT & PF, 2004).

Airfields considered in Nevada. A number of airfields are located in relatively close proximity to the NNSS. Nellis AFB, is located in northeast Las Vegas approximately 90 mi (145 km) from the NNSS. Nellis AFB was eliminated from consideration because it would increase the truck-transport distance by approximately 70 mi (113 km). The Tonopah Test Range Airfield, owned and operated by the USAF, was eliminated because it would increase the truck-transport distance to 166 mi (267 km). The Beatty Airport, Lida Junction Airport in Goldfield, and Tonopah Airport were eliminated because they are public airports and because of their distances from the NNSS, which are 59 mi (95 km), 125 mi (201 km), and 159 mi (256 km), respectively.

The following airfields and helipads on the NNSS were considered but eliminated:

- Pahute Airstrip, which was eliminated because it is not suitable for fixed-wing aircraft
- Yucca Airstrip, which was eliminated because it is not suitable for fixed-wing aircraft and facility management would not approve its use
- Desert Rock Airfield, which was eliminated because facility management would not approve its use
- Area 6 Control Facility Airstrip, was deemed unsafe by Aviation Safety
- Area 6 Art Hangar, was deemed unsafe by Aviation Safety
- Area 25 Reactor Control Point Airstrip, was deemed unsafe by Aviation Safety
- Area 23 Mercury Airstrip, was deemed unsafe by Aviation Safety

2.5 RELATIONSHIP TO OTHER USAF ACTIONS AND PROGRAMS

There are no USAF actions or programs duplicating the action alternatives considered in this EA. The 10 Sr-90 RTGs at Burnt Mountain are the only RTGs under the USAF care (SNL, 2000), and there are no efforts under way that would conflict with or duplicate the two action alternatives. Actions that may be related are described in the following paragraphs.

Public Law 99-240 states DOE would select a long-term storage location to accommodate up to 50 Sr-90 RTGs, as required under the *Low-Level Radioactive Waste Policy Amendments Act of 1985.*

- The *Energy Policy Act of 2005* contains requirements related to the safe disposal of LLW.
- On May 19, 2004, DOE accepted the first shipment of RTGs at the NNSS for disposal. Since this date, NNSS has received a total of six shipments of RTGs for disposal, five from Lawrence Livermore National Laboratory (LLNL), and one from SNL. All were Sr-90 type RTGs (Geisinger, 2011).

- Efforts are currently under way to ship one Sr-90 RTG located at the DOE's ORNL. Unlike the Burnt Mountain RTGs, the ORNL RTG was never certified as a Type B package and requires additional actions to be shipped as a compliant package (Fuhrman, 2005).

2.6 COMPARISON OF IMPACTS

Table 2-1 provides a summary of potential impacts from the alternatives analyzed.

Table 2-1

Summary of Potential Impacts from the Alternatives Analyzed

	Alternative 1		Alternative 2		No Action Alternative	
	Routine Incident-free Operating Conditions	**Accidents**	**Routine Incident-free Operating Conditions**	**Accidents**	**Routine Incident-free Operating Conditions**	**Accidents**
Probability of Aircraft Accident	Not applicable.	1.4×10^{-4} (about 1 in 7,150).	Not applicable.	4.1×10^{-4} (about 1 in 2,450).	Not applicable.	Not applicable.
Probability of Radiological Release from Aircraft Accident	Not applicable.	2.6×10^{-6} (about 1 in 385,000).	Not applicable.	5.2×10^{-6} (about 1 in 192,000).	Not applicable.	Not applicable.
Air Quality	Temporary, minor impacts.	An airborne release and respirable release of Sr-90 material may occur in the unlikely event of an aircraft accident.	• Temporary, minor impacts. • No impact at Fort Yukon.	• An airborne release and respirable release of Sr-90 material may occur in the unlikely event of an aircraft accident. • No impact at Fort Yukon.	No impacts.	Not applicable.
Biological Resources	• Temporary, minor impacts to wildlife and vegetation at Burnt Mountain. • No impacts to wildlife and vegetation at the staging sites. • No impacts to Special Status Species at Burnt Mountain, Fort Yukon, Eielson AFB, or Creech AFB. • Minimal impacts to the threatened desert tortoise may occur at the NNSS.	• There would be an increase in radiation exposure to biological resources in the unlikely event of an aircraft accident. • Biological resources may be affected by severe hazards associated with an aircraft accident such as fires and fuel spills. • Should an aircraft accident occur over the ocean resulting in a radiological release, there would be a loss of marine organisms near the released material.	• Temporary, minor impacts to wildlife and vegetation at Burnt Mountain. • No impacts to wildlife and vegetation at the staging sites. • No impacts to Special Status Species at Burnt Mountain, Fort Yukon, Eielson AFB, or Creech AFB. • Minimal impacts to the threatened desert tortoise may occur at the NNSS.	• There would be an increase in radiation exposure to biological resources in the unlikely event of an aircraft accident. • Biological resources may be affected by severe hazards associated with an aircraft accident such as fires and fuel spills. • Should an aircraft accident occur over the ocean resulting in a radiological release, there would be a loss of marine organisms near the released material. • No impact at Fort Yukon.	Temporary, minor impacts to wildlife and vegetation.	Not applicable.

Environmental Justice and Socioeconomics	No impacts.	• No Environmental Justice impacts.
		• In the improbable event of a radiological release, nearby communities may experience:
		  • The inconvenience and cost of temporarily relocating businesses and residences should evacuation be required.
		  • Economic impacts resulting from the costs of emergency response and cleanup activities.
		• Nearby hospitals may not be equipped to handle the increased number of patients.
			No impacts.	• No Environmental Justice impacts
				• In the improbable event of a radiological release, nearby communities may experience:
				  • The inconvenience and cost of temporarily relocating businesses and residences should evacuation be required
				  • Economic impacts resulting from the costs of emergency response and cleanup activities.
				• Nearby hospitals may not be equipped to handle the increased number of patients.
				• No impact at Fort Yukon.
					No impacts.	Not applicable.

Geology and Soils	• Temporary, minor impact to soils at Burnt Mountain. • No impacts at other sites.	In the event of a radiological release, soil contamination would be localized and would not migrate deep into the soil.	• Temporary, minor impact to soils at Burnt Mountain. • No impacts at other sites.	• In the event of a radiological release, soil contamination would be localized and would not migrate deep into the soil. • No impact at Fort Yukon.	No impacts.	Not applicable.
Health and Safety	• Up to 58 personnel* would be involved in the transport and temporary staging of the RTGs. • No impact to workers. • No impact to public.	• Up to 58 personnel* would be involved in the transport and temporary staging of the RTGs. • Injuries or fatalities to workers or the public would be primarily due to trauma from the accident. • Other severe hazards may include explosions, fire, and fuel spills. • The least likely, but greatest impact would be from the release of radiological materials.	• Up to 48 personnel would be involved in the transport and temporary staging of the RTGs. • No impact to workers. • No impact to public.	• Up to 48 personnel would be involved in the transport and temporary staging of the RTGs. • Injuries or fatalities to workers or the public would be primarily due to trauma from the accident. • Other severe hazards may include explosions, fire, and fuel spills. • No impact at Fort Yukon. • The least likely, but greatest impact would be from the release of radiological materials.	• 8 personnel would be involved in the maintenance and monitoring of the RTGs. • No impact to workers or the public.	Not applicable.

*This number does not include local law enforcement or other personnel who have no contact with the RTGs but may be required to coordinate efforts with the public.

Table 2-1

Summary of Potential Impacts from the Alternatives Analyzed

	Alternative 1		Alternative 2		No Action Alternative	
	Routine Operating Conditions	**Abnormal Events and Accidents**	**Routine Operating Conditions**	**Abnormal Events and Accidents**	**Routine Operating Conditions**	**Abnormal Events and Accidents**
Water Resources	No impacts.	• No impacts to groundwater. • In the improbable event that an aircraft accident crashes into a surface water body, contamination from fuel spills and radiological release of materials may occur.	No impacts.	• No impacts to groundwater. • In the improbable event that an aircraft accident crashes into a surface water body, contamination from fuel spills and radiological release of materials may occur. • No impact at Fort Yukon.	No impacts.	Not applicable.
Land Use	No impacts.	• Should a radiological release occur, land and infrastructure may be temporarily unusable until decontamination and cleanup activities are completed.	No impacts.	• Should a radiological release occur, land and infrastructure may be temporarily unusable until decontamination and cleanup activities are completed. • No impact at Fort Yukon.	No impacts.	Not applicable.
Noise	Minor noise impacts at the five sites.	• Temporary increase in noise levels from an aircraft or truck accident. • Temporary increase in noise levels during emergency response and cleanup activities.	• Minor noise impacts at four sites. • No noise impacts at Fort Yukon.	• Temporary increase in noise levels from an aircraft or truck accident. • Temporary increase in noise levels during emergency response and cleanup activities. • No impact at Fort Yukon.	• No impact during operation. • Temporary increase in noise levels during maintenance from the helicopter and ATV activities.	Not applicable.

Radiological Environment	• Minimal radiological impacts to up to 58 workers*.
	• Ground Operations
	  • Total collective dose to workers would be 1.3×10^{-1} person-rem.
	  • Total LCF probability for workers would be 5.3×10^{-5}, or 1 in 19,000 excess cancer fatalities.
	• Air Operations
	  • Total collective dose to workers would be 3.0×10^{-2} person-rem.
	  • LCF risk is estimated at 1.2×10^{-5} or the probability of about 1 in 82,700 of an LCF among the crew.
	• Negligible potential for radiation exposure to the public from air transport and staging.
	• Slight potential for increased public exposure during truck transport.
		• Improbable potential for up to 58 workers* to receive a dose.
		• In the unlikely event of an aircraft accident under scenario #1, the total population dose would be 710 rem. This results in an LCF of 0.35 or 1 in 2.8 chance of an excess cancer.
		• In the unlikely event of an aircraft accident under scenario #2, the total population dose is 9,198 rem. This results in an LCF of 4.6 or approximately 5 excess cancers in the exposed population.
		• Indirect impacts would be future health issues related to radiation exposure.
			• Minimal radiological impacts to up to 48 workers.
			• Ground Operations
			  • Total collective dose to workers would be 1.1×10^{-1} person-rem.
			  • Total LCF probability for workers would be 4.4×10^{-5}, or 1 in 23,000 excess cancer fatalities.
			• Air Operations
			  • Total collective dose to workers would be 3.5×10^{-2} person-rem.
			  • LCF risk is estimated at 1.4×10^{-5} or the probability of about 1 in 70,500 of an LCF among the crew.
			• Negligible potential for radiation exposure to the public from air transport and staging.
			• Slight potential for increased public exposure during truck transport.
				• Improbable potential for up to 48 workers to receive a dose.
				• In the unlikely event of an aircraft accident under scenario #1, the total population dose would be 710 rem. This results in an LCF of 0.35 or 1 in 2.8 chance of an excess cancer.
				• In the unlikely event of an aircraft accident under scenario #2, the total population dose is 9,198 rem. This results in an LCF of 4.6 or approximately 5 excess cancers in the exposed population.
				• Indirect impacts would be future health issues related to radiation exposure.
				• No impact at Fort Yukon.
					• Negligible radiological impacts to 8 workers annually.
					• No radiological impact to the public.
						Not applicable.

*This number does not include local law enforcement or other personnel who have no contact with the RTGs but may be required to coordinate efforts with the public.

LCF = Latent cancer fatality
rem = Roentgen-equivalent man

3.0 AFFECTED ENVIRONMENT

This section contains the description of the existing environmental conditions in the vicinity of the alternatives. During EA preparation, the most up-to-date and accurate information was used to describe the existing environment. The information serves as a baseline from which to identify and evaluate environmental changes resulting from Alternative 1, Alternative 2, and the No Action Alternative.

The USAF assessed numerous resources for potential to be affected by the alternatives. Table 3-1 shows the resources that would or would not be impacted by the alternatives. Resources that would not be affected will not be discussed further in this EA.

The environmental resources discussed in this section include climate and air quality, biological resources, cultural resources, environmental justice and socioeconomics, geology and soils, health and safety, water resources, land use, noise, and radiological environment.

Table 3-1
Resources That May Be Impacted

Resource	Not Present	Present/Not Affected	Present/May Be Affected	Rationale
Air Quality/Greenhouse Gas (GHG) Emissions		X		The USAF would ensure the project would be in compliance with all federal, state, and local air quality regulations for the duration of the activity. Currently there are no emission limits for suspected GHG emissions and no technically defensible methodology for predicting potential climate changes from GHG emissions. However, there are—and will continue to be—several efforts to address GHG emissions from federal activities.
Biological Resources Including Threatened and Endangered Species			X	Impacts assessed in EA.

Table 3-1
Resources That May Be Impacted

Resource	Not Present	Present/Not Affected	Present/May Be Affected	Rationale
Cultural Resources		X		There are no known historic or prehistoric cultural resources in the vicinity of Burnt Mountain, Fort Yukon Airfield, Creech AFB, or the NNSS RWMC. The Eielson AFB Flightline Historic District is eligible for listing on the National Register of Historic Places (Eielson AFB, 2006; U.S. Army Corps of Engineers [USACE], 2005), and two munitions historic districts have also been delineated at Eielson AFB. However, the actions would have no effect on the cultural resources because these resources are of sufficient distance away from the proposed activities.
Environmental Justice and Socioeconomics		X		Although no minority or low-income groups would be disproportionately affected by health or environmental effects, Census Bureau data are provided in the EA to support this conclusion.
Floodplains	X			The actions would not be located within a 100-year floodplain.
Geology and Soils			X	Impacts assessed in EA.
Health and Safety			X	Impacts assessed in EA.
Water Resources			X	Impacts assessed in EA.
Land Use			X	Impacts assessed in EA.
Noise			X	Impacts assessed in EA.
Radiological Effects			X	Impacts assessed in EA.
Recreation	X			Access to the areas is restricted. Therefore, no recreational opportunities are available at the sites.
Visual Resources	X			Access to the areas is restricted. Activities at each site would be consistent with existing visual landscapes, and would occur primarily in developed areas of the installations or in areas with similar activities.
Waste – Hazardous/Solid	X			The alternatives would not generate hazardous waste.

3.1 BURNT MOUNTAIN, AK

Burnt Mountain Seismic Observatory lies in the foothills of the Brooks Mountain Range, located in the remote northeast interior of Alaska, approximately 62 mi (100 km) north of the Arctic Circle and 50 mi (80 km) from the closest village and nearest airport. In 1972, Public Land Order (PLO) 5164 withdrew approximately 100 acres in the Burnt Mountain area on the boundary between the Arctic and Yukon Flats refuges for the USAF Burnt Mountain Seismic Observatory. Approximately 56 acres of the PLO withdrawal are within the Arctic National Wildlife Refuge, and 44 acres are within the adjacent Yukon Flats National Wildlife Refuge (U.S. Fish & Wildlife Service [USFWS], 2011). Detailed information about Burnt Mountain Seismic Observatory can be found in the *Power Assessment for the Burnt Mountain Seismic Observatory* (Lamp, 1994), *Power Sources for Remote Arctic Applications* (U.S. Congress, 1994), and the *Final Environmental Assessment for the Burnt Mountain Seismic Array Power Supply* (USAF, 1999).

3.1.1 CLIMATE AND AIR QUALITY

The climate in the region is characterized by extreme temperatures ranging from -71 degrees Fahrenheit (ºF) (-57 degrees Celsius [ºC]) to 100ºF (38ºC); and low precipitation, averaging 6.5 inches (in.) (16.5 centimeters [cm]). Wind speeds from the northeast and east–northeast average less than 5.8 miles per hour (mph) (9.3 km per hour or 5 knots).

Burnt Mountain and the surrounding region are designated as unclassifiable with respect to the National Ambient Air Quality Standards set forth in the *Clean Air Act* (USAF, 1999). Air quality in the region is good because the region is sparsely populated and absent of human activity most of the time. Maintenance, repair, and inspection activities by the USAF in the region typically require fewer than 21 days of activity at Burnt Mountain per year.

3.1.2 BIOLOGICAL RESOURCES

Burnt Mountain is located in an upland spruce hardwood forest and supports some populations of mammals, birds, and fish. Low-density populations of black bear (*Ursus americanus*), moose (*Alces alces*), caribou (*Rangifer tarandus*), and other small mammals can be found within the region. The observatory also provides habitat for raptors such as ospreys (*Pandion haliaetus*), Northern goshawks (*Accipiter gentilis*), red-tailed hawks (*Buteo jamaicensis*), and great horned owls (*Bubo virginianus*) and deciduous birds (USAF, 1999). King salmon (*Oncorhynchus tshawytscha*), chum salmon (*O. keta*), and some silver salmon (*O. kisutch*) spawn in the Sheenjek and Porcupine Rivers (approximately 11 mi [18 km] east and 60 mi [97 km] south of Burnt Mountain, respectively).

The dominant components of an upland spruce hardwood forest are fairly dense populations of black spruce (*Picea mariana*), quaking aspen (*Populus tremuloides*), and balsam poplar (*Populus balsamifera*). Low shrubs—such as Labrador-tea (*Ledum groenlandicum* and

L. decumbens), prickly rose (*Rosa acicularis*), blueberry/cranberry (*Vaccinium spp.*), and birch (*Betula glandulosa* and *B. papyrifera*)—are also typically dominant in the understory. Willow (*Salix spp.*) and alder (*Alnus spp.*) may be found in the understory. The ground has a patchy to continuous layer of mosses (e.g., *Pleurozium schreberi*, *Hylocomium splendens*, *Polytrichum spp.*, and *Sphagnum spp.*) and lichens (e.g., *Peltigera spp.* and *Cladonia spp.*) (USAF, 1999).

According to the USFWS, no threatened and endangered species are present at Burnt Mountain. However, Burnt Mountain is within the range of the delisted American peregrine falcon (*Falco peregrinus anatum*) and the delisted arctic peregrine falcon (*F. p. tundrius).* There are no known American or arctic peregrine falcon nests within 10 mi (16 km) of the facility, although they may migrate through the area (USAF, 1999; USFWS, 1993). Migratory bird season in the area is June 1 through July 31.

RTG sites BM01 and BM04 are located in black spruce wetlands. The U.S. Army Corps of Engineers (USACE) issued a general Nationwide 18 Permit to the USAF authorizing activities to occur within the wetlands. The general permit is applicable because no construction or excavation would occur within the wetlands.

3.1.3 ENVIRONMENTAL JUSTICE AND SOCIOECONOMICS

There are no existing economic conditions for Burnt Mountain, and there are no permanent workers at this facility. Facility operation is funded through the budget for Detachment 460 at Eielson AFB. Three traditional Athabascan villages are the nearest communities to Burnt Mountain: Venetie is approximately 50 mi (80 km) southwest, Arctic Village is approximately 50 mi (80 km) northwest, and Fort Yukon is approximately 61 mi (98 km) south. The populations of Venetie, Arctic Village, and Fort Yukon are 166, 152, and 583, respectively (Census Bureau, 2010).

Burnt Mountain is located in the Yukon-Koyukuk Borough Census Area, which comprises 6,588 people: 60.6 percent are American Indian and Alaskan Native, and 18.9 percent are White. The population living below the poverty level within the census area is 24.2 percent (Census Bureau, 2010).

3.1.4 GEOLOGY AND SOILS

The Burnt Mountain area consists of gently sloping out-wash fans of the Chandalar, Christian, and Sheenjek Rivers (Selkregg, 1974). The land is tundra that varies from barren rocky ground to areas of considerable cover. The bedrock consists of volcanic and intrusive rock. Overlying the bedrock is a very poorly drained gravelly soil layer 10 to 40 in. (25 to 101 cm) thick.

3.1.5 HEALTH AND SAFETY

Existing human health and safety concerns at Burnt Mountain include occupational hazards associated with maintaining the RTGs, the operation of ATVs and landing of helicopters on the tundra, seasonal driving and working conditions, and low-probability natural hazards associated with events such as wildfires.

3.1.6 WATER RESOURCES

Water resources include surface water and groundwater, as well as floodplain information.

3.1.6.1 SURFACE WATER

Burnt Mountain is not located in a floodplain (USAF, 1999). The southeastern side of Burnt Mountain (RTG sites BM02, BM03, BM04, and BM05) is part of the Christian River watershed, a hydrologic subunit of the Yukon River regional watershed (U.S. Geological Survey [USGS] Cataloging Unit: 19040303). Surface water runoff from rain and melting snow from this portion of Burnt Mountain flows south to an unnamed drainage ditch, through some lakes of the Yukon Flats area, and ultimately to the Christian River, a tributary of the Yukon River.

Surface water runoff from the northern portion of Burnt Mountain (RTG site BM01) flows into Thluichohnjik Creek, a tributary to the Sheenjek River. The Sheenjek River flows south to the Yukon River, and the Yukon River flows southwestward to the Bering Sea. Due to the fact that the region is absent of human activity most of the time, the water quality at Burnt Mountain is unaffected by limited onsite human activity. There is no water supply directly provided to Burnt Mountain; however, water is derived from the rivers or nearby wells, treated, and hauled by residents in the Venetie and Artic villages.

3.1.6.2 GROUNDWATER

The Burnt Mountain area has discontinuous permafrost to a depth of less than 18 in. (46 cm). There is no groundwater aquifer data for the Christian River watershed hydrologic unit, which includes the Burnt Mountain area (USGS, 2014). The lack of data is acknowledged in accordance with 40 CFR § 1502.22, "Incomplete or Unavailable Information."

3.1.7 LAND USE

Lands at Burnt Mountain, AK, were withdrawn from public domain for use by the USAF through Public Land Order (PLO) 5164 in 1972. The Burnt Mountain Seismic Array Observatory and ancillary power facilities, including the five RTG sites, are located on the withdrawn lands. Two additional shelters provide lodging for maintenance crews and storage for the station's ATVs. There are no roads to Burnt Mountain. Most of the land within a 20-mi (32-km) radius of Burnt Mountain is included in land withdrawals for use by the USAF

(PLO 5164) or as part of the Arctic National Wildlife Refuge and Yukon Flats National Wildlife Refuge.

3.1.8 NOISE

Burnt Mountain is located in an uninhabited area. Ambient noise is made up of natural sounds, and occasional ATV and aircraft noise. Current noise is minimal from the power systems in place at the Burnt Mountain Seismic Observatory. No noise-sensitive land uses occur in the area.

3.1.9 RADIOLOGICAL ENVIRONMENT

Aside from natural sources of radiation, Burnt Mountain radiological sources include the five remote shelters, each housing two RTGs. The annual compliance survey of the Burnt Mountain RTGs was conducted on August 31, 2014 (AFTAC, 2014a). Table 3-2 shows the maximum exposure rates observed in each unrestricted area next to the RTG storage buildings.

Table 3-2
Exposure Rates Near the RTG Storage Buildings

RTG Site	Location	Net Exposure Rate (mrem/hr)	Possible Exposure (hours per year)	Total dose per year (mrem) [a]
BM01	Highest Unrestricted Area	0.151	120	18.12
BM02		0.147		17.64
BM03		0.273		32.76
BM04		0.144		17.28
BM05		0.204		24.48

Source: AFTAC, 2014a

[a] Net exposure rate × 120 hours = Total dose per year for general public

mrem = Millirem

mrem/hr = Millirem per hour

The radiation absorbed dose (rad) is a measure of the absorbed dose (energy deposited) in a material. The roentgen-equivalent man (rem) is based on the biological damage caused by ionization in human body tissue. It is a term for dose equivalence and equals the biological damage that would be caused by one rad of dose. The rem accounts for the fact that not all types of radiation result in the same biological risk per unit of energy deposited. That is, the biological risk from one rad deposited by beta radiation is less than that caused by one rad of alpha radiation. The dose rate is the rate at which a person would (or did) receive a radiation dose (or dose equivalent). It is a measure of radiation dose intensity (or strength) per unit time. In Table 3-2, the dose equivalent rates shown are mrem (equals 1,000 rem) per hour. Common sources of radiation are shown in Table 3-3. Additional information relating to radiation exposure is presented in Section A.2.1 of Appendix A.

Table 3-3
Common Sources of Radiation

Source of Radiation	Dose (mrem/yr)
Cosmic Radiation (high-energy gamma radiation originating in outer space and filtered through the earth's atmosphere) – At sea level	26
Average Natural Background in the U.S.	310
Food and water, average	30
Medical Treatment	
• Chest x-ray	10
• Dental x-ray	1.5
• Mammogram	30
Consumer Goods	
• Cigarettes (1 pack a day)	15 - 20
• Gas lantern mantle	<1
• Natural gas heating and cooking	9
• Air travel (every 2,006 mi): 1 mrem	1
• Road construction material	4
• Porcelain dentures	<1
• Watching TV	1
• Smoke detector	<1

Source: DOE, 2012; NRC, 2012

3.2 FORT YUKON AIRFIELD, AK

Fort Yukon Airfield is located approximately 140 mi northeast of Fairbanks, AK. Aviation facilities at the Fort Yukon Airfield include a runway (Figure 2-3) and float plane pond facility, owned and managed by the Alaska Department of Transportation and Public Facilities (ADOT & PF). These facilities serve as the only year-round transportation link for Fort Yukon (ADOT & PF, 1990). Detailed information about the Fort Yukon Airfield can be found in the document *Fort Yukon Airport Improvements Phase I: Float Pond Area Improvements* (ADOT & PF, 1990).

The Fort Yukon Airfield encompasses roughly 261 acres (1.0 km^2) and is located on the northwest side of Fort Yukon. It sits on a low terrace overlooking the Yukon River at an elevation of about 440 ft (134 m) above mean sea level (amsl). The Fort Yukon Airfield is open to the public, and has a 5,000- ft (1,524 m) by 100-ft (30.5 m) lighted runway. There is no air-traffic control tower at the airfield (Federal Aviation Administration [FAA], 2014). Fort Yukon is accessible only by air or water.

3.2.1 CLIMATE AND AIR QUALITY

The climate of Fort Yukon is characterized by extreme temperatures and low precipitation. Temperatures range from –60ºF (-51ºC) in the winter to 80ºF (27ºC) in the summer. Total annual

rainfall averages 6.5 in. (16.5 cm), and the average winter snowfall is 43 in. (109 cm). Air quality in interior Alaska where Fort Yukon is located is considered to be relatively pristine, but is affected by both natural and man-made emission sources. Natural sources include wildland fires and windblown dust. Man-made sources include stationary and mobile sources from vehicles and equipment, wood-burning stoves, and industrial facility emissions (DOE, 2013a). The Fort Yukon area has been designated as in attainment for all criteria pollutants (DOE, 2013a).

3.2.2 BIOLOGICAL RESOURCES

Forty mammal species are known to occur near Fort Yukon, the most prominent being moose. Others include black bears and brown bears (*Ursus arctos*), caribou, wolves (*Canis lupus)*, foxes (*Vulpes spp.)*, beaver (*Castor spp.)*, North American river otter (*Lontra canadensis)*, muskrat (*Ondatra zibethicus)*, marten (*martes spp.*), mink (*Neovison vison)*, lynx (*lynx spp.*), weasel (*Mustela spp.),* and wolverines (*Gulo gulo)*. Common fish found in nearby rivers include king salmon, coho salmon (*Oncorhynchus kisutch*), chum salmon, whitefish (*Coregonus nelsonii*), northern pike (*Esox lucius)*, burbot (*Lota lota*), Arctic grayling (*Thymallus arcticus)*, and sheefish (*Stenodus nelma*). About 150 species of bird are known to nest in the area, the most notable being waterfowl. Common waterfowl include scaup (*Aythya marila*), pintail (*Anas acuta*), scoters (*Melanitta spp.*), wigeons (*A. americana*), mallards (*Anas platyrhynchos*), shovelers (*Anas clypeata*), green-winged teal (*Anas carolinensis*), canvasback (*Aythya valisineria*), and geese (*Chen caerulescens*). While most of the bird species are migratory, 13 remain in the area year-round, including hawks (*Accipitridge spp.),* owls, grouse (*Lagopus spp.)*, woodpeckers (*Picidae spp.*), gray jay (*Perisoreus canadensis*), and raven (*Corvus spp.*). The area hosts tree species including white spruce (*Picea glauca)*, poplar (*Populus spp.*), and birch. Other common vegetation includes polar grass, horsetail (*Equisetum spp.*), fireweed (*Chamerion angustifolium*), yarrow (*Achillea millefolium*), wild rose (*Rosa acicularis)*, bedstraw (*Galium spp.*), ragweed (*Ambrosia spp.*), marsh fleabane (*Senecio congestus)*, fescue (*Festuca spp.*), dandelion (*Taraxacum spp.*), dogwood (*Cornus nuttallii*), willow (*Salix spp.*), goldenrod (*Solidago spp.*), Alaska spring beauty (*Claytonia sarmentosa*), alder (*Alnus spp.*), and stickweed (*Ambrosia artemisiifolia*) (USAF & DOE, 2001).

Several wetlands exist at Fort Yukon and the nearby airfield; however, no wetlands survey has been conducted. No wetlands exist on the runway. The USFWS Alaska Region lists eight federally endangered or threatened species and three candidate species that may occur in Alaska. On March 26, 2013, the USFWS Fairbanks Fish and Wildlife Office indicated none of these listed or candidate species occur within Fort Yukon or its vicinity. Additionally, there is no critical habitat for any listed species within Fort Yukon or its vicinity (DOE, 2013a).

3.2.3 ENVIRONMENTAL JUSTICE AND SOCIOECONOMICS

Fort Yukon is located in the Yukon-Koyukuk Borough Census Area, which comprises 6,588 people: 60.6 percent are American Indian and Alaskan Native, and 18.9 percent are White. Fort Yukon, with an approximate population of 583, is a transportation, trading, supply, and administrative center for the Upper Yukon-Porcupine region. The population living below the poverty level within the census area is 24.2 percent (Census Bureau, 2010).

3.2.4 GEOLOGY AND SOILS

Fort Yukon lies within the physiographic region known as the Yukon Flats, an area of 13,700 square miles (mi^2) (35,483 km^2) characterized by low topographic relief, high stream density, marshy, lake-dotted flatland, and sand dunes. The region is underlain by more than 300 ft (91 m) of silt and silty sand deposited when the area was formed. These deposits are overlain by clay, silt, sand, and gravel. In some areas, the sediments are covered by a windblown layer of silty loam, ranging in depth from a few inches to several feet. Permafrost is present throughout the region and occurs about 8 to 10 ft (2 to 3 m) below ground surface (USAF & DOE, 2001).

Fort Yukon is located in Seismic Zone 4 of the Uniform Building Code. Seismic Zone 4 reflects a high hazard potential for earthquake damage to buildings.

3.2.5 HEALTH AND SAFETY

Existing human health and safety concerns in and adjacent to the airfield include occupational hazards associated with transporting the RTGs; maintenance of the runway, facilities, and aircraft; operation of vehicles on the runway and roads; seasonal driving and working conditions; and low-probability natural hazards associated with events such as wildfires. A public health clinic, Senior Citizens Service Center, and two schools are located approximately 0.5 mi (0.8 km) from the proposed airfield staging site.

3.2.6 WATER RESOURCES

Water resources include surface water and groundwater, as well as floodplain information.

3.2.6.1 SURFACE WATER

The Yukon Flats area is dotted with lakes, ponds, swamps, meandering channels, and sinkholes. The Yukon River flows through the flats, and, at high water, overflows into hundreds of sloughs. Although the Yukon River is subject to flooding in the spring, the Fort Yukon Airfield is located above the river and thus flooding does not pose a problem. Drainage at the site flows overland to the south into Yllota Slough or northward to adjacent wetlands.

3.2.6.2 GROUNDWATER

Groundwater is sporadic and tends to occur in isolated pockets. The water supply system at Fort Yukon consists of a regularly monitored shallow groundwater well, approximately 38 ft (12 m) deep, with a 75,000-gallon (284,000-liter) water storage tank.

3.2.7 LAND USE

The Fort Yukon Airfield is a state-owned, public-use airport managed by the ADOT & PF. The airport hosts a 5,000-ft (1,524-m) by 100-ft (30.5-m) gravel-surfaced, lighted runway (FAA, 2014). It also has a seaplane base called Hospital Lake north of the main runway. The float-plane parking area is within the primary surface of the main runway. A part of the access road leading to the parking area is also located within the primary surface of the runway. The runway was resurfaced in 2009 and has a 2 percent surface degradation rate per year (O'Halloran, 2011).

3.2.8 NOISE

Intermittent, man-made noise is generated by the use of heavy equipment, aircraft, vehicle and motorized equipment activities on and adjacent to the airfield.

3.2.9 RADIOLOGICAL ENVIRONMENT

The only sources of radiological exposure currently at Fort Yukon are naturally occurring radiation in the environment. This includes radon, cosmic radiation, and naturally occurring isotopes. There is no evidence of exposure from other sources.

3.3 EIELSON AFB, AK

Eielson AFB is located in central Alaska within the Fairbanks North Star Borough (FNSB), approximately 120 mi (193 km) south of the Arctic Circle and 26 mi (42 km) southeast of Fairbanks. Eielson AFB is located in the Tanana River Valley on a low, relatively flat, floodplain terrace approximately 2 mi (3.2 km) north of the active river channel.

The Eielson AFB runway is 14,530 ft (4,429 m) by 150 ft (46 m) long. It is lighted from dusk to dawn. There is an air-traffic control tower at Eielson AFB (GlobalAir, 2014a). The runway supports both routine training and Red Flag and other exercise activities conducted at this location. Approximately 22,000 airfield operations are conducted annually at Eielson AFB by the F-16s, KC-135s, and different transient aircraft types participating in the Red Flag exercises.

Additional information about Eielson AFB can be found in the *Baseline Conditions for Eielson Air Force Base, as of May 2013* (USAF, 2014), and the *General Plan Eielson Air Force Base, Alaska* (USAF, 2008).

3.3.1 CLIMATE AND AIR QUALITY

The climate at Eielson AFB is characterized by temperatures ranging from –64ºF (-53ºC) in the winter to 93ºF (34ºC) in the summer. Average annual precipitation is 13.3 in. (33.8 cm). The prevailing wind direction is north to north–northeast ranging from 0.6 to 2.5 mph (1 to 4 km per hour).

Eielson AFB is located on the outskirts of Fairbanks, AK, in the FNSB. FNSB is in attainment for all criteria pollutants except particulate matter 2.5 microns or less ($PM_{2.5}$) (EPA, 2013b). However, the $PM_{2.5}$ nonattainment area boundary was modified so it did not include Eielson AFB (USAF, 2014). Thus, Eielson AFB is in attainment for all criteria pollutants.

3.3.2 BIOLOGICAL RESOURCES

Eielson AFB's airfield and developed areas were constructed on fill material deposited in cleared forest wetlands of the river floodplain. Semi-improved grounds around airfields and other facilities support vegetation consisting of a mix of a wide variety of native and introduced plant species that receive annual mowing and brush control to maintain vegetation in an early stage of succession.

Mammals known to be present on or adjacent to Eielson AFB include black bears, red squirrels, martens, moose, snowshoe hare (*Lepus americanus*), beaver, mink, and muskrat. Birds present in the vicinity include the spruce grouse (*Dendragapus canadensis*), and ruffed grouse (*Bonasa umbellus*). Over 20 species of waterfowl—including geese, ducks, loons (*Gavia spp.*), grebes (*Podicipedidae spp.*), and scoters—use the aquatic habitat on Eielson AFB, and many of these species are protected under the *Migratory Bird Treaty Act* (Eielson AFB, 2011). Vegetation in the region includes cranberries, birch, black spruce, white spruce, rose hips, willow, and balsam poplar. No listed or proposed threatened or endangered species or critical habitats were found during surveys, or are known to occur on lands managed by Eielson AFB (Eielson AFB, 2008 and 2011).

3.3.3 ENVIRONMENTAL JUSTICE AND SOCIOECONOMICS

Eielson AFB is located in the FNSB Census Area, which comprises 97,581 people including the 2,647 people who live within the same zip code as Eielson AFB (Census Bureau, 2010). Seventy-seven percent of the population in FNSB are white, 8 percent are American Indian or Alaska Natives, 6 percent are black or African-Americans, 3 percent are Asian or Pacific Islanders, and 6 percent are of Hispanic origin (Census Bureau 2010). The population living below the poverty level within the census area is 8 percent (Census Bureau, 2010).

3.3.4 GEOLOGY AND SOILS

The developed area of Eielson AFB, including the airfield, encompasses 3,408 acres (14 km^2) of the 19,790 acres (80 km^2) of Eielson AFB. Eielson AFB lands are isolated from major urban areas and lie on the abandoned floodplain of the Tanana River with elevations ranging from 525 to 550 ft (160 to 168 m) amsl.

Soils in the Tanana River Valley consist of unconsolidated silty sands and gravels, organic and sandy silts, and clays. Approximately two-thirds of Eielson AFB is covered with soils containing discontinuous permafrost. This preponderance of permafrost soils contributes to the large percentage of vegetated wetlands occurring on undeveloped base lands.

This artificial substrate, on which Eielson AFB sits, is composed of quarried Tanana floodplain gravels, cobble, and soil material built up as poorly sorted material to a thickness of between 3 and 8 ft (1 to 2.5 m) and providing a firm platform for base construction devoid of wetlands, above the 100-year floodplain, and insulated from the permafrost layer (USAF, 2014).

3.3.5 HEALTH AND SAFETY

Existing human health and safety concerns in and adjacent to the airfield include occupational hazards associated with transporting the RTGs; maintenance of the runway, facilities, and aircraft; operation of vehicles on the runway and roads; and seasonal driving and working conditions; and low-probability natural hazards associated with events such as wildfires. Performance of day-to-day operations and maintenance activities at Eielson AFB are in accordance with applicable USAF safety regulations, published USAF Technical Orders, and standards prescribed by the USAF Occupational Safety and Health requirements.

3.3.6 WATER RESOURCES

Water resources include surface water and groundwater, as well as floodplain information.

3.3.6.1 SURFACE WATER

Water bodies within Eielson AFB boundaries include streams, wetlands, and lakes. Surface drainage on Eielson AFB is generally in a north–northwest direction and parallel to the Tanana River. Approximately 51 percent, or 10,133 acres (41 km^2), of Eielson AFB property is classified as wetlands, with 9,391 acres (38 km^2) being vegetated wetlands and the remainder being lakes, ponds, and streams. Wetlands and low-gradient alluvial streams compose most of the surface water resources on Eielson AFB, with wetlands dominating the low-lying areas within and surrounding the installation. Several lakes and extensive wetlands surround the airfield. Creeks found in the vicinity of the airfield include French and Moose creeks.

Piledriver and Garrison sloughs are the two largest streams in the vicinity of the airfield. Piledriver Slough, which discharges into the Tanana River, is located along the western edge of Eielson AFB and approximately 4,000 ft (1,219 m) west of the airfield and parallel to the runways. The slough receives no runoff from the urban developed area of the base and has good water quality. Garrison Slough crosses the developed portion of the installation in a somewhat channelized form, and is the only impaired water body located on Eielson AFB. In 1996, the U.S. Environmental Protection Agency (EPA) issued a Total Maximum Daily Load for polychlorinated biphenyls (PCBs), and the slough is listed by the State of Alaska as a Category 4a on the 2010 list of Impaired Waters for PCBs under Section 303 of *the Clean Water Act* (Eielson AFB, 2012).

This artificial substrate, on which Eielson AFB sits, provides a firm platform for base construction devoid of wetlands, above the 100-year floodplain, and insulated from the permafrost layer. A levee system maintains a flood safety margin for residential portions of the installation. As a result of this, the developed portion of Eielson AFB is situated above the surrounding forested wetlands and sloughs (USAF, 2014).

3.3.6.2 GROUNDWATER

Eielson AFB is located over a shallow, unconfined aquifer. The water table varies from the surface in adjacent wetlands to 10 ft (3 m) below ground surface in developed areas (USAF, 2014).

3.3.7 LAND USE

The airfield is the dominant land use at Eielson AFB, with a notably long 14,530 ft (4,429 m) runway and associated ramps and taxiways occupying the west side of the base (Figure 2-5). The runway parallels Richardson Highway, which runs through the base. Most of the aircraft's operational and industrial areas are immediately adjacent to the airfield on the east side, which is on the south end of the base. Land to the west of the airfield and highway is predominantly undeveloped, open space with lakes, wetlands, and forests.

The layout of the functional areas of the base provides some separation between the housing areas and the airfield. Most of the community services are situated in the center of the base between Kobuk Loop Road and north of Arctic Road and Broadway Road. The base has school facilities from kindergarten through high school, a medical center, chapel, commissary, and a selection of commercial businesses. Recreational uses include athletic fields, outdoor track, trails, campgrounds, and lakes, as well as indoor athletic facilities. Much of the base is wetland or floodplain, and is not suitable for construction. A few miles to the north of the base is the small community of Moose Creek with a population of about 550 persons. Most of the homes in this community are slightly west of the main axis of the runway and the flight paths in and out of the airfield. Lands outside the base to the west are a mixture of undeveloped natural forest and

some cultivated agricultural land with associated rural facilities and a small number of homes. Land to the south–southeast of the base is mostly uninhabited.

3.3.8 NOISE

The sound environment near Eielson AFB is dominated by military aircraft noise including F-16C/D, KC-135R, and many types of transient aircraft types. Transient and based aircraft operations tempo increases substantially during Large Force Exercises (LFEs), which typically occur in spring, summer, and fall. Under both LFE and non-LFE conditions, noise levels exceeding 65 decibels (dB) daylight noise level (L_{dn}) occur primarily on DoD-owned land. Under LFE conditions, approximately 495 acres (2 km^2) of off-installation land are affected by greater than 65 dB L_{dn} while under non-LFE conditions only 128 acres (0.5 km^2) of off-installation lands are affected. Off-installation land exceeding 65 dB L_{dn} is located almost entirely in the town of Moose Creek, with the remainder occurring in a small area along the western boundary of the installation (USAF, 2014).

3.3.9 RADIOLOGICAL ENVIRONMENT

The only sources of radiological exposure currently at Eielson AFB are naturally occurring radiation in the environment. This includes radon, cosmic radiation, and naturally occurring isotopes. There is no evidence of exposure from other sources.

3.4 CREECH AFB, NV

Creech AFB is located approximately 45 mi northwest of Las Vegas, NV, along US-95, at an elevation of about 3,100 ft (944 m) amsl. The AFB encompasses approximately 2,380 acres (10 km^2) of land in Clark County. Creech AFB is located in the northeastern portion of the Mojave Desert, which is characterized by low-lying enclosed basins surrounded by low mountains and bajadas formed of coalescing alluvial fans.

The main Creech AFB runway, which is 9,002 ft (2,744 m) by 150 ft (46 m), runs east–west across the base. The northwest–southeast runway, which is 5,468 ft (1,667 m) by 100 ft (30 m), supports MQ-1 Predator and MQ-9 Reaper RPA operations. An inactive third runway extends southwest–northeast across the base. The primary runways are lighted from dusk to dawn. There is an air-traffic control tower at Creech AFB (GlobalAir, 2014b). Additional information about Creech AFB can be found in the *Nellis and Creech Air Force Base Capital Improvements Program Environmental Assessment* (Headquarters Air Combat Command and Nellis AFB, 2008), and the *Acquisition of Resort Property Located in Indian Springs, Nevada Environmental Assessment* (Nellis AFB, 2011). An aerial image of Creech AFB is provided in Figure 2-7.

3.4.1 CLIMATE AND AIR QUALITY

The climate at Creech AFB in southern Nevada is characterized by limited precipitation, low humidity, and large diurnal temperature ranges. Temperatures range from 12ºF (-11ºC) in January, typically the coldest month of winter, to 109ºF (43ºC) in July, typically the warmest month of summer. The annual average temperature in the area is 66ºF (19ºC). The average annual wind speed is 8 mph (12.9 km per hour), with northwesterly prevailing winds during the winter months, and southwesterly prevailing winds during the summer months.

The Clark County Department of Air Quality and Environmental Management (DAQEM) monitors and regulates air emissions for the county. The existing air quality in Clark County is considered in attainment or unclassified for all criteria pollutants (40 CFR § 81.329, September, 2004) except for 8-hour ozone, particulate matter 10 microns or less (PM_{10}) and carbon monoxide. Clark County has been in attainment for carbon monoxide since 2005, and has an EPA accepted State Implementation Plan, which outlines how it would maintain its attainment status. No air quality monitoring stations are known to be located near Creech AFB; however, according to the USAF, Creech AFB is in attainment for all air quality standards (USAF, 2009).

3.4.2 BIOLOGICAL RESOURCES

Creech AFB is located in the northeastern portion of the Mojave Desert. Vegetation surrounding Creech AFB was systematically evaluated and mapped by Nellis AFB in 1996 (Nellis AFB, 1996). Mixed scrub vegetation typical of the Mojave Desert occurs on lands surrounding Creech AFB, where several associations including creosote bush, bursage, and different species of saltbush can be distinguished (Nellis AFB, 1996). Within the fenced area of the airfield, the vegetation is very sparse due to disturbance and is dominated by non-native Russian thistle. Surrounding vegetation and wildlife habitat outside the fence consists of creosote bush scrub and saltbush scrub.

Wildlife that typically occur in creosote bush scrub and saltbush scrub habitats have been observed on Creech AFB, primarily outside the fenced area. Mammals include black-tailed jackrabbits (*Lepus californicus*), desert woodrat (*Neotoma lepida*), kangaroo rats (*Dipodomys spp*.), coyote (*Canis latrans*), and desert kit fox (*Vulpes macrotis arsipus*). The diverse herpetofauna includes several species of lizards and snakes.

Bird species include a variety of ground-dwelling seed or insect eaters such as jays, wrens, shrikes, towhees (*Pipilo spp.*), sparrows (*Passeridae spp.*), Gambel's quail (*Callipepla gambelii*), sage thrasher (*Oreoscoptes montanus),* and mourning dove (*Zenaida macroura*); the omnivorous raven (*Corvus corax*); greater roadrunner (*Geococcyx californianus*), which feeds on snakes and lizards; and several species of raptors, including golden eagle (*Aquila chrysaetos*), redtailed hawk, ferruginous hawk (*Buteo regalis*), and northern harrier (*Circus cyaneus*) (USAF, 2010).

The desert tortoise (*Gopherus agassizii*) and western burrowing owl (*Athene cunicularia hypugaea*) are the only special-status plant or animal species known, or likely to occur at Creech AFB. Although present in the surrounding area, desert tortoises are not typically present on the airfield because of the level of disturbance and activity. Burrowing owls have been observed in burrows in the disturbed soil at the north end of the runway at Creech AFB (USAF, 2010).

There are no wetlands or jurisdictional waters of the U.S. at the airfield on Creech AFB (Headquarters Air Combat Command and Nellis AFB, 2008).

3.4.3 ENVIRONMENTAL JUSTICE AND SOCIOECONOMICS

Creech AFB is located in close proximity to the town of Indian Springs, NV. The population of Indian Springs is approximately 1,400 (DOE, 2013b). Seventy-nine percent of Indian Springs' population are reported to be White (Census Bureau, 2010). In 2010, about 17 percent of Indian Springs' residents and 12 percent of Clark County residents were reported to be living below the poverty line (Census Bureau, 2010). The primary economic influences in the area are DoD and DOE operations in the region. In 2011, Creech AFB had more than 2,200 military-assigned personnel (USAF, 2011).

3.4.4 GEOLOGY AND SOILS

Creech AFB is located in the southern opening of the Indian Springs Valley. The valley is bound by the Spotted Range and Buried Hills to the west and the Pintwater Range to the east. The valley areas are dominated by Quaternary alluvial deposits with patches of Quaternary playa and marsh deposits north of Creech AFB. Soils in the vicinity of Creech AFB are generally sandy, loose, and prone to erosion. The local mountains (southern Pintwater Range and Spotted Range) are primarily Paleozoic limestone, dolomite, shale, and quartzite. Due to western winds, the west sides of the mountains in the area are commonly flanked by dunes on top of deep alluvial fans. Based on the close proximity of Creech AFB to the NNSS, it is considered to be located in Seismic Zone 4 due to the possibility of seismic damage from previous underground test detonations on the NNSS.

3.4.5 HEALTH AND SAFETY

Existing human health and safety concerns in and adjacent to the airfield include occupational hazards associated with transporting the RTGs; maintenance of the runway, facilities, and aircraft; operation of vehicles on the runway and roads; seasonal driving and working conditions; and low-probability natural hazards associated with events such as wildfires. Performance of day-to-day operations and maintenance activities at Creech AFB are in accordance with applicable USAF safety regulations, published USAF Technical Orders, and standards prescribed by the USAF Occupational Safety and Health requirements.

3.4.6 WATER RESOURCES

Water resources include surface water and groundwater, as well as floodplain information.

3.4.6.1 SURFACE WATER

Natural surface water is scarce on and around Creech AFB, and there are no wetlands within the base. Surface flow is primarily towards the two local playas, located north of the airfield where it collects and evaporates. Due to the low precipitation and high evaporation rate, surface water rarely accumulates in these playas. The northwest corner of the installation is within a 100-year floodplain. Other than constructed ponds and structures, no permanent surface water occurs on or in the vicinity of Creech AFB (USAF, 2009).

3.4.6.2 GROUNDWATER

Creech AFB is located within the carbonate-rock province of the Great Basin. Because of the permeability of carbonate rocks, it supports an extensive, regional groundwater flow system. Groundwater in the region is high in total dissolved solids at levels of 500 to 1,000 milligrams per liter, and rich in calcium and magnesium bicarbonate; however, the groundwater is well within the EPA standards for drinking water quality (Nellis AFB, 2002).

3.4.7 LAND USE

Creech AFB encompasses approximately 2,380 acres (10 km^2) of land, mostly designated as open space in order to ensure Clear Zone safety around the airfield. Aircraft operations and maintenance facilities at Creech AFB lie south of the main runway developed area of the base. Facilities including a wastewater treatment plant and storage buildings are situated north of the runway. The main base area contains several industrial land uses (i.e., supply, vehicle maintenance, and transportation facilities) as well as shops, dining hall, and temporary lodging facilities. Creech AFB serves as a practice base for the Nellis AFB-based Thunderbirds demonstration team, as the base for several flying squadrons, and as the base for the remotely piloted aviation mission. Creech AFB is also used for readiness and security-force training.

3.4.8 NOISE

The primary existing noise sources in the general vicinity of Creech AFB are unmanned military aircraft, Thunderbird practice sessions, other jet flights, helicopter flights, and the loudspeaker announcement system at the base. The types of remote aircraft typically deployed at Creech AFB are much quieter than typical military or commercial jet aircraft. Secondary sources of noise include motor vehicle traffic on US-95, motor vehicle traffic along surface streets in Indian Springs, and wind-related sources. Highway vehicle traffic registers at approximately 75 decibels A-weighted (dBA) at 50 ft (15 m). Therefore, there are considerable sources of ambient noise within the vicinity of Creech AFB (USAF, 2009).

3.4.9 RADIOLOGICAL ENVIRONMENT

The only sources of radiological exposure currently in Clark County are naturally occurring radiation in the environment. This includes radon, cosmic radiation and naturally occurring isotopes. There is no evidence of exposure from other sources.

3.5 NNSS, NV

The NNSS occupies approximately 1,360 mi^2 (3,522 km^2) of desert and mountain terrain in southern Nevada about 65 mi (105 km) northwest of Las Vegas. Elevations range from 2,700 ft (823 m) amsl in the southern part of the NNSS to 7,680 ft (2,341 m) amsl in the mountainous northern region (NNSA/NSO, 2013). The NNSS is divided into numbered areas to facilitate management; communications; and the distribution, use, and control of resources (Figure 2-8).

Additional information about the NNSS may be found in the NNSS SWEIS (DOE, 2013b).

3.5.1 CLIMATE AND AIR QUALITY

The NNSS is located mostly in the southwestern corner of the Great Basin Desert, with the southern third of the NNSS located in the Mojave Desert (Warner, 2004). Average maximum temperatures range from 90 to 100 °F (32 to 38°C) in the summer and from 50 to 60 °F (10 to 16°C) in the winter. Locations in the southeastern NNSS receive an average of about 5 in. per year (13 cm) of precipitation (NNSA/NSO, 2008a). Precipitation falls most often during winter and early spring (during Pacific storm passage) and during mid- to late summer (during convective thunderstorms, monsoons, and occasional tropical storm remnants) (NOAA, 2006).

The NNSS is in attainment for all criteria pollutants (EPA, 2013a). There are no regularly operating ambient air quality monitors for criteria pollutants and hazardous air pollutants within the NNSS. The most comprehensive source of representative data on ambient concentrations of criteria pollutants and hazardous air pollutants for the area surrounding the NNSS is a special study conducted in the southwest portion of the NNSS from October 1991 through September 1995. Given the 1991 through 1995 ambient concentration measurements from the monitoring stations are still likely representative of the current concentrations on the NNSS, it remains very likely the ambient air quality on the NNSS is well within all applicable ambient air quality standards (DOE, 2013b).

3.5.2 BIOLOGICAL RESOURCES

The NNSS is located within the Basin and Range physiographic province and along the transition zone between the Mojave Desert and Great Basin ecoregions in south–central Nevada (DOE/NV, 2000). As a result, this site has a diverse and complex mosaic of plant and animal communities representative of both ecosystems, as well as some communities common only in

the transition zone. Lists of the vegetation and animals sighted on the NNSS may be found in the NNSS SWEIS (DOE, 2013b).

At least 1,163 taxa of invertebrates within the phylum Arthropoda (animals having an exoskeleton, a segmented body, and jointed appendages) have been identified on the NNSS. Of the known arthropods, 78 percent are insects (NNSA/NSO, 2013). Approximately 300 vertebrate species have been observed on the NNSS, including 60 species of mammals, 239 species of birds, 34 species of reptiles, and 3 species of introduced fish (Wills and Ostler, 2001). Approximately 80 percent of the bird species on the NNSS are migrants or seasonal residents (Wills and Ostler, 2001). As of 2010, 26 bird species, including 9 raptor species (birds of prey), are known to breed on the NNSS.

Typical Mojave Desert species found on the NNSS include kit fox (*Vulpes macrotis*), Merriam's kangaroo rat (*Dipodomys merriami*), desert tortoise, chuckwalla (*Sauromalus obesus*), western shovelnose snake (*Chionactis occipitalis)*, and sidewinder snake (*Crotalus cerastes*). Several species of state-designated game animals occur on the NNSS, including mule deer (*Odocoileus hemionus)* (National Security Technologies, LLC [NSTec], 2010) and an unknown number of mountain lions (*Puma concolor*), desert and Nuttall's cottontails (*Sylvilagus nuttallii*), chukar (*Alectoris chukar*), Gambel's quail, mourning dove, and several species of waterfowl. The western burrowing owl is found in most of the major valleys in the eastern and southern portions of the NNSS.

The only species listed by USFWS as threatened or endangered that occurs on the NNSS is the Mojave Desert population of the desert tortoise. The sensitive and protected/regulated species known to occur on or adjacent to the NNSS include 1 moss, 22 flowering plants (including 3 species of yucca, 1 of agave, and 18 cacti), 1 mollusk, 2 reptiles (including the desert tortoise), 15 birds, and 27 mammals (NSTec, 2010). Two of the bird species, chukar and Gambel's quail, are regulated as game species; and 7 mammals are regulated as game species, as follows: pronghorn antelope, Rocky Mountain elk (*Cervus elaphus*), desert bighorn sheep (*Ovis canadensis nelsoni*), mule deer, mountain lion, Audubon's cottontail (*Sylvilagus audubonii*), and Nuttall's cottontail. Three species are regulated as furbearers: bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), and kit fox (*Vulpes macrotis*).

3.5.3 ENVIRONMENTAL JUSTICE AND SOCIOECONOMICS

The NNSS is located in Nye County, NV. In 2013, the population for Nye County was 43,946 (Census Bureau, 2010). Pahrump, the largest and most rapidly growing community in Nye County, is located about 26 mi (42 km) south of the NNSS. The 2010 population for Pahrump was 36,441 (Census Bureau, 2010). Amargosa Valley, the nearest community to the NNSS, is located about 2 mi (3 km) south of the NNSS and has a population of 1,400. Beatty, about 17 mi west of the NNSS, had a population of 800 in 2000. Alamo, located about 42 mi (68 km)

northeast of the NNSS, had a population of 460 in 2000. Population data from the 2010 Census were not available for Beatty and Alamo.

There are no block groups in Nye County with minority populations greater than 50 percent. The closest block group to the NNSS with a minority population greater than 50 percent is in Clark County, approximately 2 mi (3 km) east of the southeastern corner of the NNSS.

3.5.4 GEOLOGY AND SOILS

The NNSS is located in the southern part of the Great Basin, the northernmost subprovince of the Basin and Range Physiographic Province. This region is characterized by north–south-trending, linear mountain ranges separated by broad sediment-filled basins. Frenchman Flat, the location of the Area 5 RWMC, is a topographically closed valley. Water from snowmelt and other runoff from higher elevations collects in the lowest portions of this valley during wet seasons.

Since 1992, several earthquakes ranging between magnitudes of 3.0 to 4.0 have occurred in the southern portions of the NNSS. The largest of these earthquakes are a magnitude of 4.0 in 1997, south of Calico Hills; magnitudes of 4.5 and 4.8 in January 1999 in Frenchman Flat; and a magnitude of 4.6 in 2002 southwest of Skull Mountain (USGS, 2010).

DOE policy is to design, construct, and operate its facilities so workers, the general public, and the environment are protected from the impacts of natural phenomena hazards (including seismic events) on DOE facilities. DOE seismic design criteria also meet the requirements of the International Building Code (International Code Council, Inc. [ICC], 2009).

There are few soil surveys for the NNSS and surrounding areas because the site was established as a nuclear weapons testing site before the nationwide soil survey program. Soils at the NNSS are similar to those throughout southern Nevada. Most of the soils form on the alluvial fans and valley floors, with thin soils forming on mesa and mountain surfaces. The soils at the NNSS are highly susceptible to erosion by wind and water. Although finer-grained soils on steep slopes are more easily erodible, mineral composition and topography can also affect the movement of topsoil. Because the NNSS has not undergone a comprehensive soil survey review, locations of soils easily erodible have not been identified.

3.5.5 HEALTH AND SAFETY

Existing human health and safety concerns at the NNSS include occupational hazards associated with transporting the RTGs; the handling and disposal of LLW; operation of vehicles on the roads; seasonal driving and working conditions; and low-probability natural hazards associated with events such as wildfires. Performance of day-to-day operations and maintenance activities at the NNSS are in accordance with applicable DOE and other federal safety regulations.

3.5.6 WATER RESOURCES

Water resources include surface water and groundwater, as well as floodplain and wetlands information.

3.5.6.1 SURFACE WATER

The NNSS lies within the Basin and Range Physiographic Province and the Great Basin, which is a closed hydrographic basin from which no surface water leaves, except by evaporation. The Great Basin comprises numerous smaller hydrographic basins. The basins covering the greatest amount of land area on the NNSS include (1) Fortymile Canyon (the Buckboard Mesa and Jackass Flats Subdivisions), (2) Yucca Flat, (3) Rock Valley, and (4) Frenchman Flat.

Streams are ephemeral and are fed by runoff from snowmelt and precipitation during storm events. There are no important perennial or intermittent streams on the NNSS. There are 26 known springs and seeps on the NNSS (DOE/NV, 1999; Hansen et al., 1997), although some are dry for most of the year. Most of the springs at the NNSS support wetland (hydrophytic) vegetation—such as cattail, sedges, and rushes—which likely constitute wetlands, as defined by USACE and EPA.

Flash flooding occurs on the NNSS in response to heavy precipitation events, especially during summer thunderstorms. The runoff from these storms is typically of short duration; however, the storms do result in large peak discharge rates. Flood hazards at NNSS facilities and activities are most likely associated with flooding in alluvial fans and playas. Throughout the NNSS, there is the potential for sheet flow or channelized flow through arroyos to cause localized flooding. In addition, a rise in any standing water on a playa creates a potential flood hazard.

Arroyos in Frenchman Flat that pose a potential flood hazard to existing facilities include Barren Wash, Scarp Canyon, Nye Canyon, and Cane Spring (DOE/NV, 1996). There is a 100-year flood hazard area along the southwest corner of the Area 5 RWMC associated with Barren Wash (Schmeltzer et al., 1993).

3.5.6.2 GROUNDWATER

The NNSS is located within the Death Valley regional groundwater flow system extending from central Nevada north of the NNSS to Death Valley. The Death Valley system encompasses approximately 16,000 mi^2 (41,440 km^2) of the Great Basin (Belcher et al., 2010). It is very complex, involving many aquifers and aquitards, which vary in their characteristics and presence over distance. The lower carbonate aquifer system is found primarily in the eastern and southern part of the NNSS and is not present in all areas. The Cenozoic aquifer system is found beneath the main valleys, such as Yucca and Frenchman Flats, and caldera areas. There is limited hydraulic connection between groundwater in the lower carbonate aquifer system and the Cenozoic aquifers (alluvial and volcanic) in many areas, controlled by the location and properties of low-permeability aquitards.

The depth to groundwater at the NNSS varies from approximately 30 ft (9 m) at Fortymile Wash to more than 2,000 ft (610 m) under the upland portions of Pahute Mesa. The depth to groundwater in Frenchman Flat is approximately 700 ft (213 m) (DOE/NV, 1997; NNSA/NSO, 2008a).

3.5.7 LAND USE

The NNSS is located about 57 mi northwest of downtown Las Vegas in the remote desert and mountainous terrain of southern Nye County, NV. The Federal Government (primarily Bureau of Land Management [BLM], DoD, DOE/National Nuclear Security Administration [NNSA], and the U.S. Forest Service [USFS]) manages more than 85 percent of the land in Nevada, and 93 percent in Nye County (DOE, 2008). Approximately 22 percent of the total land area in Nye County, including the NNSS, is designated for federally restricted access for U.S. Government activities.

The NNSS is controlled by DOE/NNSA and is the largest and most extensive of DOE/NNSA's sites in terms of the complexity of its facilities, buildings, and infrastructure; and its land area. Although the NNSS is under DOE/NNSA management, DoD and other customers use the site for National Security/Defense and Nondefense Mission-related experiments, training, and research. The NNSS currently supports work under three missions: (1) National Security/Defense, (2) Environmental Management, and (3) Nondefense. Non-worker access to the NNSS is restricted and limited to public bus tours. Tours must be scheduled in advance.

As of 2008, the NNSS had 486 buildings, 113 trailers, a 340-m (547-km) onsite network of paved roads, and over 300 mi (483 km) of unpaved roads within its 880,000 acres (3,531 km^2) (NNSA/NSO, 2008b). Most of the experimental facilities and infrastructure are concentrated along the main roadway thoroughfare (Mercury Highway); the majority of maintenance, support, and development activities also are located along this corridor.

3.5.8 NOISE

Major sources of noise at the NNSS include equipment and machines, blasting and explosives experiments, aircraft operations, and vehicles. Because of the NNSS's remote location, large size, access restrictions, and lack of a nearby population, the general public has little to no exposure to noise generated within the NNSS. The closest sensitive receptors to the site boundary are residences located approximately 2 mi (3 km) to the south, in Amargosa Valley. At the NNSS boundary, away from most facilities, noise from most sources within the NNSS is barely distinguishable above background noise levels. Traffic generated by personnel commuting to and from work and occasional aircraft operations are the main NNSS-related contributors to increased noise levels in nearby communities.

3.5.9 RADIOLOGICAL ENVIRONMENT

Releases of radionuclides to the environment from NNSS operations provide a potential source of radiation exposure to individuals in the vicinity of the NNSS. Maximally exposed individual (MEI) doses estimated in a similar manner for the years 2004 through 2008 range from 2 to 2.9 mrem per year. These doses fall within the limits invoked by DOE Order 458.1, Change 2 (DOE, 2013c), and are much lower than those due to background radiation.

No members of the public receive direct gamma radiation exposure above background levels as a result of past or present NNSS operations. Gamma radiation exposure rates measured at areas accessible to the public are comparable to natural background rates from cosmic and terrestrial radiation. Radioactively contaminated areas on the NNSS are isolated from members of the general public, given the considerable distances between these areas and the site boundary, so members of the public are not exposed to any measurably contaminated soil, either directly or through resuspension (NNSA/NSO, 2009).

NNSS workers receive the same dose as the general public from background radiation, but they receive an additional dose from working in and near facilities or areas with radioactive material. The average dose to the individual worker and the cumulative dose to all workers at the NNSS from operations in 2008 was 451 mrem (Enyeart, 2009); the increased risk of a latent cancer fatality (LCF) from this dose was 0.00027.

4.0 ENVIRONMENTAL CONSEQUENCES

This section focuses on human health and environmental impacts associated with Alternative 1, Alternative 2, and the No Action Alternative. The section assesses potential impacts that may result under routine incident-free operating conditions, and under accidents. This analysis addresses direct, indirect, and residual environmental effects, which are defined as follows:

- **Direct effects** are those impacts associated with the alternatives that would directly or immediately affect the environment. These effects could include temporary and permanent effects from the activities.
- **Indirect effects** would be caused by or result from the alternatives; these are uncertain in time but are reasonably certain to occur.
- **Residual effects** are those effects that would remain after appropriate mitigation measures were implemented.

The transport of the RTGs by truck from Creech AFB to the NNSS is considered routine operations for the DOE. The potential impacts of ground transport of radiological materials were analyzed in the NNSS SWEIS (DOE, 2013b) and are incorporated into this EA by reference. Therefore, no further discussion of potential impacts during ground transport are included in this EA.

Hazards Analyses and Safety Evaluations

AFTAC conducted a hazards analysis and safety evaluation addressing the transport of the 10 Sr-90 RTGs from Burnt Mountain to the NNSS titled *Sr^{90} Sealed Source Transport Hazard Analysis and Safety Evaluation In Support of the Environmental Assessment for the Transport of the USAF Radioisotope Thermoelectric Generators from Burnt Mountain, Alaska to the Nevada National Security Site Mercury, Nevada* (AFTAC, 2014b). This document is included as Appendix C and will be referred to as the Hazards Analysis (HA) for the remainder of this document.

The impacts analyses presented in this EA, particularly those relating to the potential for radiological release and exposure to humans and the environment, are based on the information contained in the HA. A brief description of the HA is presented in the following paragraphs.

The HA is a semi-quantitative risk analysis and safety evaluation prepared in support of this EA and is included as Appendix C. The purpose of the HA is to assess the radiological risks from non-routine transport of the RTG and the probability of accidents and the radiological risks associated with the transport of the 10 RTGs from Burnt Mountain, AK, to the NNSS, NV.

The HA evaluates multiple exposure scenarios, including incident-free transport and accident scenarios resulting in public exposures. The risk estimate should be considered an upper-bound estimate of the risks involved with the transport. Two worst-case accident scenarios are considered:

- Accident Scenario #1 is a CH-47F aircraft accident in an urban area.
- Accident Scenario #2 is a C-17 aircraft accident in a dense urban area.

The accident assessment consists of two components: (1) an accident risk assessment to determine the likelihood of an accident occurring during transport; and (2) an accident consequence assessment considering the radiological consequences to a population group from severe transportation-related accidents assumed to result in the largest releases of radioactive material.

Two types of radiation impacts are considered in the HA: (1) acute effects from high-dose short-duration exposures resulting in immediate health effects, and (2) long-term chronic effects from long-term radiation exposures. These effects, combined with the probability of occurrence, are a measure of the risk associated with the transport of the RTGs. Impacts are calculated considering the upper-bound dose for the MEI. Impacts are calculated for both workers involved in the transport, and for members of the public who may be exposed as a result of the transport.

In addition to determining the radiological risks associated with the action alternatives, the HA determined the probability of an aircraft mishap occurring based upon the likelihood of an aircraft accident happening factored with the probability the accident would be severe enough to result in the release of radioactive material. Not all mishaps would necessarily result in a breach of one or more RTGs. It is likely any mishap damaging an RTG to such an extent that radioactive material is released would also result in significant damage to the aircraft. Thus, the statistics for Class A mishaps are used to determine the risk of an aircraft accident severe enough to have the potential to result in the breach of the source containment. The 2013 Air Force Safety Center aircraft mishap data for Class A aircraft accidents and Army accident data for the CH-47 were used to determine the probability of an accident from the routes proposed in Alternatives 1 and 2. The probability of an aircraft accident is presented for each alternative in the Accidents sections of this EA (Sections 4.1.2 and 4.2.2).

4.1 ALTERNATIVE 1

The potential impacts resulting from Alternative 1 are described in this section under two main headings: Routine Incident-free Operating Conditions, and Accidents. The Accidents considered for Alternative 1 are briefly described in Section 4.1.2. Alternative 1 does not result in indirect or residual impacts to resources unless specifically stated.

4.1.1 ROUTINE INCIDENT-FREE OPERATING CONDITIONS

The 10 Sr-90 RTGs were designed as DOT Type B shipping containers. As such, it was demonstrated through testing and analysis, the RTGs are capable of withstanding the possible damage induced through routine operating conditions and hypothetical accident scenarios per 10 CFR Part 71. An inspection of the RTGs conducted by Teledyne in 2011 indicated the 10 RTGs are in very good condition (Teledyne, 2011). Based on the performance requirements and durability history of Type B containers, the RTGs and Type B shipping containers would withstand the transport and disposition activities described with minimal impacts to the human environment under routine operating conditions. To further reduce the potential for exposure impacts, qualified personnel would accompany the RTGs during transport, and monitoring of the RTGs would be conducted throughout the transport and staging activities.

4.1.1.1 CLIMATE AND AIR QUALITY

Transport of the RTGs from Burnt Mountain to the NNSS would have temporary, minor impacts to air quality from use of helicopters and other vehicles (ATVs, forklifts, trucks). There would be minor releases of air pollutants associated with equipment engines, and a minor increase in particulate dust associated with operation of forklifts or similar equipment used to move the RTGs during transport and disposition.

4.1.1.2 BIOLOGICAL RESOURCES

The potential impacts to biological resources at each possible site are described in this section.

Burnt Mountain

Implementation of Alternative 1 does not require any construction or earthmoving activities at Burnt Mountain causing disturbances to wildlife. However, at Burnt Mountain, the presence of the helicopter and forklift activities would result in the temporary displacement of wildlife, particularly to small mammals and reptiles not mobile enough to avoid the activities. Larger, more mobile wildlife species would avoid the activity and move into adjacent areas. Once activities cease, wildlife would return. Therefore, impacts to wildlife at Burnt Mountain would be temporary and minor.

According to USFWS, no threatened and endangered species are present at Burnt Mountain. However, Burnt Mountain is within the range of the delisted American peregrine falcon and the delisted arctic peregrine falcon. There are no known American or arctic peregrine falcon nests within 10 mi (16 km) of the facility, but they may migrate through the area. *The Migratory Bird Treaty Act* protects all migratory birds, including nesting birds, during the breeding season. More specifically, the *Migratory Bird Treaty Act* and Executive Order No. 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, 10 January 2001, direct federal agencies to

minimize or avoid impacts to migratory birds and/or raptors whenever possible. Therefore, surveys of the five RTG storage areas will be conducted to identify the presence of nests before RTG removal is initiated. Any nests present will be avoided to the extent possible.

Short-term, minor impacts to vegetation would result from forklift and ATV activities at BM02, BM03, and BM05. Although vegetation would be affected by drive and crush activities, it would recover quickly once activities cease. Sites BM01 and BM04 are located in black spruce wetlands. The USAF holds a general Nationwide 18 Permit from USACE authorizing activities to occur within the wetlands. The general permit is applicable because no construction or excavation would occur within the wetlands. Matting and plywood would be laid down before forklift/ATV operations begin to minimize the impact to the soft permafrost. The matting and plywood would be removed after activities were completed. Impacts to vegetation at BM01 and BM04 would be temporary and minor.

Fort Yukon

Activities at Fort Yukon under Alternative 1 may include the transport and temporary staging of the RTGs. The RTGs would be delivered to Fort Yukon using CH-47F helicopters, temporarily staged at a site within the airfield, and loaded on to a C-130 for transport to Eielson AFB. The arrival and departure of CH-47F and C-130 aircraft are common at the Fort Yukon Airfield. No wetlands exist within the developed areas of the airfield, and no threatened or endangered species have been observed within the boundaries of Fort Yukon (DOE, 2013a).

Activities associated with the transfer of the RTGs to and from the aircraft, and staging area would occur within already developed areas of the airfield. Therefore, no impacts to wildlife and vegetation would result from Alternative 1.

Eielson AFB

Activities at Eielson AFB under Alternative 1 include the transport and temporary staging of the RTGs. The RTGs would be delivered to Eielson AFB using C-130 aircraft, temporarily staged at a site near the airfield, and loaded on to a C-17 for transport to Creech AFB. The arrival and departure of C-130 and C-17 aircraft are routine at Eielson AFB. No listed or proposed threatened or endangered species or critical habitats were found during surveys, or are known to occur on lands managed by Eielson AFB (Eielson AFB, 2008 and 2011).

Activities associated with the transfer of the RTGs to and from the aircraft and staging area would occur within already developed areas of Eielson AFB. Therefore, no impacts to wildlife and vegetation would result from Alternative 1.

Creech AFB

Activities at Creech AFB include the transport and temporary staging of the RTGs. The RTGs would be delivered to Creech AFB using a C-17 aircraft, temporarily staged at a site near the airfield, and loaded on to a flatbed truck for transport to the NNSS. The arrival and departure of C-17 aircraft are common at Creech AFB. There are no wetlands or jurisdictional waters of the U.S. at the airfield on Creech AFB (Headquarters Air Combat Command and Nellis AFB, 2008). Vegetation within the fenced area of the airfield is very sparse due to disturbance.

The desert tortoise (a listed threatened species) and the western burrowing owl (a federal species of concern) are the only special-status plant or animal species known, or likely to occur, at Creech AFB. Desert tortoises are not typically present on the airfield because of the level of disturbance and activity. Burrowing owls have been observed in burrows in the disturbed soil at the north end of the runway (USAF, 2010).

Activities associated with the transfer of the RTGs to and from the aircraft and staging area would occur within the developed, fenced areas of Creech AFB. Therefore, no impacts to wildlife and vegetation would result. It is unlikely desert tortoises would be present in the area of activities, and no activities would occur at the north end of the runway; therefore, impacts to the desert tortoise and burrowing owl would not occur.

NNSS

Under Alternative 1, the truck containing the RTGs would stop at the NNSS at Gate 100 where possession of the RTG would transition from the UAF to the DOE (SNL). Biological impacts for DOE activity that would follow acceptance of the RTGS are addressed in the NNSS Site-Wide Environmental Impact Statement (NNSS SWEIS).

4.1.1.3 ENVIRONMENTAL JUSTICE AND SOCIOECONOMICS

No impacts to Environmental Justice populations would occur as a result of routine incident-free operating conditions under Alternative 1. Burnt Mountain and Fort Yukon are located in the Yukon-Koyukuk Borough census area, which has a 60.6-percent American Indian and Alaskan Native population. However, the nearest villages to Burnt Mountain are 50 mi (80 km) away and would not be impacted by Alternative 1. Airlift activities to be conducted at the Fort Yukon Airfield under Alternative 1 are similar to ongoing operations and pre-staging of supplies and equipment is similar to ongoing fire services activities. The staging and securing of the RTGs is non-routine and will require public engagement; however, no impacts to Environmental Justice populations at Fort Yukon are expected to occur. There are no Environmental Justice populations in the vicinity of Eielson AFB, Creech AFB, and the NNSS. Therefore, no Environmental Justice related impacts would occur.

Socioeconomics would not be impacted by implementation of Alternative 1 at any of the sites except Fort Yukon. All transportation activities would be conducted by USAF personnel. No additional personnel for transport or operations at any of the transfer sites would be necessary, except local law enforcement at Fort Yukon. Public engagement would be required at Fort Yukon to address inquiries about RTG transport activities, communicate risks, and coordinate with local law enforcement to secure the staging site; resulting in minor socioeconomic impact.

4.1.1.4 GEOLOGY AND SOILS

Transport of the 10 RTGs from Burnt Mountain would have minor impacts on the local soils at Burnt Mountain because some soil compaction would occur as the RTGs are being removed from their current positions and transferred to helicopter via forklift. The most vulnerable sites are BM01 and BM04. Matting and/or plywood would be placed between the RTG storage area and the helicopter at these locations to prevent the forklifts from sinking into wet areas and to prevent soil erosion. Helicopter landings and the use of ATVs at the Burnt Mountain sites would also cause some compaction and ground-surface disturbance, but these impacts would be temporary and minor.

The CH-47 does not leak fuel under normal operating conditions. However, under an abnormal start-up, which entails the engines not firing on first attempt, the pilot would wait 1 minute to allow the small amount of fuel in the chamber to drain out so the engine would not flood during the second attempt to start the engines. In this case, several drops of fuel would exit the helicopter through a drain tube. A container would be placed beneath the drain tube to capture the fuel and prevent contact with the ground. Therefore, no soil contamination would occur.

Impacts to soil would not occur at the Fort Yukon Airfield, Eielson AFB, Creech AFB, or the NNSS because transfer activities would occur on existing gravel, asphalt, or concrete runways or similarly compacted and disturbed areas.

4.1.1.5 HEALTH AND SAFETY

Under Alternative 1, up to 58 personnel, not including local law enforcement or other personnel who have no contact with the RTGs but may be required to coordinate efforts with the public, would be involved with the transport and temporary staging of the RTGs. Impacts to human health and safety under routine incident-free operating conditions would be negligible. Occupational hazards would be minimized by adhering to applicable USAF and DOE/NNSA safety regulations. Monitoring of the RTGs throughout the transport and staging process would ensure early detection of radiation should an unlikely shielding breach occur. Under routine incident-free operating conditions, the public would not be in close proximity to the RTGs and would therefore not be affected by implementation of Alternative 1.

4.1.1.6 WATER RESOURCES

There would be no impacts to surface or groundwater resources during transport of the RTGs under routine incident-free operating conditions because the RTGs would not come into contact with water resources. The lack of groundwater information for the Burnt Mountain area is not essential to a reasoned choice among alternatives.

4.1.1.7 LAND USE

There would be no impacts to land use at any of the sites. Current land use and operations at all sites would continue. Prime and unique farmland would not be impacted because none exists at any of the sites. State and national parks, forests, conservation areas, and other areas of recreational, ecological, scenic, or aesthetic importance would remain undisturbed.

4.1.1.8 NOISE

Noise levels at the Burnt Mountain RTG sites would temporarily increase during loading and transport activities. Burnt Mountain is located in an uninhabited area with no noise-sensitive land uses. Therefore, noise impacts at Burnt Mountain would be temporary and minor.

Temporary, minor noise impacts would occur at the Fort Yukon Airfield, Eielson AFB, Creech AFB, and NNSS from the aircraft and truck transporting the RTGs. Workers would adhere to standard operating procedures to determine whether hearing protection would be required while working in the vicinity of the aircraft. The noise created would be similar to existing noise in the areas and would not be identified by members of the public as anything new or different.

4.1.1.9 RADIOLOGICAL CONSEQUENCES

The average exposure rate at approximately 5 to 10 ft (1.5 to 3 m) outside the 5 RTG shelters at Burnt Mountain ranges from 0.144 to 0.273 mrem/hr with an average rate of 0.184 mrem/hr (Table 3-2) (AFTAC, 2014a). NRC's annual dose limit of 5,000 mrem for occupationally exposed workers is presented in 10 CFR § 20.1201. To reach the annual dose limit, occupational workers would need to be working around the RTG shelter for a continuous 3.2 years, 24 hours per day, 7 days per week (0.184 mrem/hr × 24 hours × 1,133 days = 5,003 mrem). Currently, workers are in close proximity to the RTGs only during limited maintenance activities. Maintenance personnel are routinely monitored for exposure to radiation. For comparison, 10 CFR § 20.1301 specifies an annual dose limit to individual members of the public from the licensed operation not to exceed 100 mrem in a year. This equates to 23 days of contact within 3 meters of the RTGs (0.184 mrem/hr × 24 hours × 23 days = 102 mrem).

The licensed RTG shipping containers were designed such that the maximum dose rate at the surface of the RTG is less than 200 mrem/hr. In August 2011, the surface dose rate for the RTGs was a maximum of 50 mrem/hr (Teledyne, 2011).

Transfer of the RTGs from Burnt Mountain to the NNSS would have minimal radiological impacts on worker health and safety during loading/unloading, temporary staging, transit, or disposition activities. Workers at Burnt Mountain, Fort Yukon Airfield, Eielson AFB, and Creech AFB would be in close proximity to the RTGs for only as long as it takes to load/unload them from the aircraft and transport them to the temporary staging areas. Personnel at the temporary staging sites would maintain safe distances from the RTGs during normal operating conditions. Appropriate radiological monitoring, including a complete radiological control and safety program, would be established, approved, and implemented as a precaution. Personnel access-control procedures would be established and followed, and monitoring would be conducted inside the facilities. Monitoring would include ambient air surveys and air monitoring if a significant release from the units is suspected; swipe surveys; and passive integrating area monitors, such as thermoluminescent dosimeters (TLDs), or hand-held surveys of radiation fields in the temporary staging areas. The doses to workers from loading/unloading and staging activities are summarized in Table 4-1.

Table 4-1
Radiation Doses from Alternative 1 Loading/Unloading and Staging Activities

Location	Activity	Number of Personnel	Dose Rate (mrem/hr)	Exposure Time	Total Exposure (person-rem)
Burnt Mountain, AK	Removal and Loading of RTGs	4	Dose at 1 m for each RTG	1 hour per RTG	5.4×10^{-2}
Fort Yukon, AK & Eielson AFB, AK	Unloading and Loading of RTGs	4 (at each site)	1.5	4 hours (2 hours at each site)	2.4×10^{-2}
Fort Yukon, AK; Eielson AFB, AK; & Creech AFB	Temporary Staging of RTGs (Security)	2 (at each site)	0.04	360 hours (5 days at each site)	2.9×10^{-2}
Creech AFB, NV	Unloading and Loading on Ground Vehicles	4	1.5	4	2.4×10^{-2}
TOTAL					**1.3×10^{-1}**

Source: AFTAC, 2014b

The total dose to workers from ground operations under routine incident-free operating conditions under Alternative 1 is 1.3×10^{-1}. The total LCF probability from this portion of the transport is estimated to be 5.3×10^{-5}, or 1 in 19,000 excess cancer fatalities for the personnel conducting the transport (AFTAC, 2014b). The phase when the RTGs have been loaded onto the aircraft for transport until the process of unloading them is termed "air operations." During this phase, occupational workers including flight crew have the potential to be exposed to radiation from the RTGs. The dose rate and total dose for each aircraft segment is listed in Table 4-2. The upper-bound total person dose is estimated to be 3.0×10^{-2} person-rem. The upper-bound LCF risk is estimated at 1.2×10^{-5}, or the probability of 1 in approximately 82,700 of an LCF among the crew as a result of implementing Alternative 1.

Workers at the NNSS who take possession of the RTGs would handle them in accordance with all DOE and NNSS procedures and safety requirements. Personnel at the NNSS are highly trained and experienced in the safe handling and disposal of LLW. Radiological monitoring is routinely conducted, and personnel are required to wear TLDs at all times while at the NNSS.

No increased radiation exposures to the public are expected at Burnt Mountain during RTG removal given that the nearest population center is 50 mi (81 km) away and the threat of human intrusion is extremely low. Fort Yukon, Eielson AFB, Creech AFB, and NNSS are either secure locations or extremely remote with little risk of public exposures to radiation when the RTGs are on the ground. Likewise, during air operations, members of the public would be far enough away that exposures would be negligible. Thus, there is no impact to the public from ground or air operations under routine operating conditions.

Table 4-2
Alternative 1 Upper-Bound Radiation Doses and Probability of LCF for Air Transport of RTGs

Aircraft	Maximum Dose Rate to Crew (rem/hr)	Total Dose to Crew (person rem)	LCF
CH-47	5.0×10^{-4}	1.3×10^{-2}	5.4×10^{-6}
C-130	2.9×10^{-4}	3.4×10^{-3}	1.4×10^{-6}
C-17	4.7×10^{-4}	1.3×10^{-2}	5.3×10^{-6}
TOTAL		$\mathbf{3.0 \times 10^{-2}}$	$\mathbf{1.2 \times 10^{-5}}$

Source: AFTAC, 2014b

The potential impacts resulting from the transport of radiological materials is addressed in the NNSS SWEIS (DOE, 2013b). There is the slight potential for increased public exposure once the RTGs are transferred from the aircraft onto a truck and the truck enters US-95, a public roadway. Trucks would be placarded with signs indicating radioactive materials are on board, thereby providing warning to the public and first responders.. Small amounts of radiation may be emitted by the RTGs during routine transportation operations (DOE, 2013b). The distance of drivers and passengers from the RTGs and the very limited time drivers and passengers would be near the RTGs eliminates the possibility of elevated public exposure during ground transportation on US-95. There is minimal development adjacent to the 20-mi (32-km) segment of US-95 between Creech AFB and the Mercury Highway, a paved federal road.

4.1.2 ACCIDENTS

Human health and environmental impacts from accidents under Alternative 1 have a very low probability of occurrence. During transport for disposition, the potential for a leak is very unlikely due to the special nature of the RTG containers.

The USAF defines four categories of aircraft mishaps:

- **Class A** mishaps result in a loss of life, permanent total disability, a total cost in excess of $1 million, destruction of an aircraft, or damage to an aircraft beyond economical repair.
- **Class B** mishaps result in total costs of more than $200,000, but less than $1 million, or result in permanent partial disability but do not result in fatalities.
- **Class C** mishaps involve costs of more than $10,000, but less than $200,000, or a loss of worker productivity of more than 8 hours.
- **High accident potential** represents minor incidents not meeting any of the criteria for Class A, B, or C.

The probability of a mishap occurring is based upon the likelihood of an aircraft accident occurring factored with the probability the accident will be severe enough to result in the release of radioactive material. Not all mishaps would necessarily result in a breach of one or more RTGs. It is likely any mishap damaging the RTG to such an extent that radioactive material is released would result in significant damage to the aircraft. Thus, the statistics for Class A mishaps are used to determine the risk of an aircraft accident severe enough to have the potential to result in the breach of the source containment. The HA uses a simplistic model assuming accidents are directly proportional to flight hours. However, this model does not account for important factors, such as special climatic conditions, multi-flights per day, equipment parameters, and combat conditions' effects on accident statistics.

Table 4-3 shows the probability of an aircraft accident occurring under Alternative 1 would be 1.4×10^{-4}, which is approximately 1 in 7,150. The probability of that accident resulting in a release of radiological material is 2.6×10^{-6}, which is approximately 1 in 385,000 (AFTAC, 2014b).

Table 4-3
Probability of a Class A Flight Accident for Alternative 1

Route	Aircraft	Flight Miles/Sorties	Probability of Accident	Adjusted Probability of Accident with Release [a]
Burnt Mountain, AK → Fort Yukon, AK	CH-47	305 mi/5 sorties	1.2×10^{-4}	1.2×10^{-6}
Fort Yukon, AK → Eielson AFB	C-130	284 mi/2 sorties	2.2×10^{-6}	1.2×10^{-7}
Eielson AFB → Creech AFB	C-17	2,332 mi/1 sortie	2.7×10^{-5}	1.3×10^{-6}
TOTAL			$\mathbf{1.4 \times 10^{-4}}$	$\mathbf{2.6 \times 10^{-6}}$

Source: AFTAC, 2014b

[a] The risk of a release of radioactive material from an RTG breach is assumed to be 0.05 during a Class A fixed-wing aircraft accident and 0.01 for a Class A rotary-wing aircraft accident.

The HA evaluates two aircraft accident scenarios considered to present the highest risk. Based upon a study by Boeing, approximately 36 percent of all aircraft accidents occur during final approach and landing (Boeing, 2013).

Accident scenario #1 is the crash of a CH-47 near Eielson AFB. While on approach to Eielson AFB, a CH-47 suffers a catastrophic failure and crashes in an urban area near the airfield. The helicopter is assumed to be carrying two RTGs. It is assumed there is a probability of 0.01 that one of the two RTGs would be severely damaged and release radioactive material, which would result in exposure of the surrounding population. The force of the crash and the related fire

would result in airborne transport of the source material. For this accident scenario, an additional factor of 0.4 is applied due to the fact that a majority of the transport route from Burnt Mountain to Fort Yukon is over undeveloped wilderness.

Based on population density and the quantity of material released, Total Effective Dose Equivalent (TEDE) was calculated for a 30-day period for the exposed population. It is assumed any area where the populace would receive greater than 1 rem of dose over a 30-day period would be evacuated until the area was remediated.

Table 4-4 shows the collective dose for the potentially exposed population. The total population dose would be 710 rem for Accident Scenario #1. This results in an LCF of 0.35 or 1 in 2.8 chance of an excess cancer. Population in the immediate area of the crash may receive a high radiation dose.

Table 4-4
Collective Dose to the Public from Accident Scenario #1

Dose Range (rem)	Number Exposed	Total Dose (person-rem)
>100	15	NA
50 - 100	22	NA
10 - 50	47	NA
5 - 10	67	NA
1 - 5	182	182
0.5 - 1	318	159
0.1 - 0.5	1,283	128.3
0.05 - 0.1	2,342	117.1
0.01 - 0.05	12,371	123.71
TOTAL		**710**

Source: AFTAC, 2014b

NA = Not applicable

Accident Scenario #2 is the crash of a C-17 into a nearby urban area while on approach to Creech AFB. It is assumed there is a probability of 0.05 the crash is severe enough to breach 3 of the 10 RTGs the aircraft is carrying. Much of the route from Eielson AFB is over unpopulated areas. However, both the landing and takeoff points are over urban centers, so no additional modifier is applied in this case.

Table 4-5 shows the collective dose for the potentially exposed population. The total population dose is 9,198 rem for Accident Scenario #2. This results in an LCF of 4.6 or approximately 5 excess cancers in the exposed population. Population in the immediate area of the crash may

receive a high radiation dose. The TEDE was calculated for a 30-day period for the exposed population. It is assumed any area were the populace would receive greater than 1 rem of dose over a 30-day period would be evacuated until the area was remediated.

Table 4-5
Collective Dose from Accident Scenario #2

Dose Range (rem)	Number Exposed	Total Dose (person-rem)
>100	128	NA
50 - 100	187	NA
10 - 50	482	NA
5 - 10	781	NA
1 - 5	2,575	2,575
0.5 - 1	4,086	2,043
0.1 - 0.5	18,355	1,835
0.05 - 0.1	33,761	1,688
0.01 - 0.05	105,683	1,056
TOTAL		**9,198**

Source: AFTAC, 2014b

The total risk of a fatality from radiological exposure resulting from an aircraft accident is approximately 1 in 10,000 (AFTAC, 2014b). Although, the impacts from an aircraft accident while transporting the 10 RTGs would be substantial, the probability of such an accident occurring is very small. The HA concludes the additional risks associated with exposure to radiological materials as a result of transporting the RTGs from Burnt Mountain, AK, to the NNSS are minimal.

4.1.2.1 CLIMATE AND AIR QUALITY

In the unlikely event an RTG container and radiation shielding is breached during an accident, an airborne release and respirable release of Sr-90 material may occur. Radioisotope materials may be carried an unknown distance from the breach site depending on wind trajectories and other weather conditions.

4.1.2.2 BIOLOGICAL RESOURCES

Impact to biological resources during implementation of Alternative 1 under the accident scenarios would be the same as those described in Section 4.1.1.2 with the added minimal potential for exposure to nearby wildlife and vegetation should a containment breach occur.

The probability of an aircraft accident occurring using the route included in Alternative 1 would be 1.4×10^{-4}, which is approximately 1 in 7,150. The probability of that accident resulting in a release of radiological material is 2.6×10^{-6}, which is 1 in 385,000. It is considered unlikely an accident would occur, and it is considered improbable a release of radiological material would occur. However, should it occur, there would be an increase in radiation exposure to biological resources in the vicinity. In addition to an improbable radiological hazard, there are other severe hazards associated with aircraft accidents, such as extreme fires and fuel spills, which could affect wildlife and vegetation.

The HA analysis of the potential environmental impacts of an accident over the global commons assumes the loss of the RTG packages to an aircraft accident over water. The analysis further assumes that through either acute or long-term processes, the entire contents of the packages would be released into the ocean. The analyses concluded there could be some loss of marine life directly exposed to radioactive material. Yet because of the large volumes of water involved, mixing mechanisms, existing background radiation concentrations, and radiation-resistance of aquatic biota, the radiological impact of an accident would be localized. An accident involving an aircraft carrying the RTGs from Alaska resulting in a crash in the ocean was assumed to result in a release of all of the radioactive materials. The release could be immediate, but the packaging and containerization would make a gradual failure and release more likely. Whether immediate or gradual, it is assumed the release would result in the loss of marine organisms near the released material.

4.1.2.3 ENVIRONMENTAL JUSTICE AND SOCIOECONOMICS

Impact to Environmental Justice populations during implementation of Alternative 1 under the accident scenarios would be the same as those described in Section 4.1.1.3 with the added potential for radiation exposure should a containment breach occur. However, Environmental Justice populations would not experience a greater impact than that of the general public.

Although the probability is low, an accident could affect socioeconomics. In the unlikely event of an aircraft accident in which radiological material is released, a large area (tens of square miles) may be contaminated with Sr-90. Most of this area would need to be mitigated before it could be reoccupied. The cost of such mitigation, as well as the relocation of businesses and residents, would result in substantial impacts.

In addition to a possible radiological hazard, there are other severe hazards associated with aircraft accidents, such as extreme fires and fuel spills. Local governments in the accident area may be called upon to assist with emergency response and cleanup efforts, which could result in potential economic impacts from the unexpected expenses. Injuries from the accident would increase the number of patients at nearby hospitals and clinics. In rural, remote areas, healthcare facilities may not be able to handle the additional patients.

4.1.2.4 GEOLOGY AND SOILS

Impact to geology and soils during implementation of Alternative 1 under the accident scenarios would be the same as those described in Section 4.1.1.4, with the added potential for radiological exposure to soils should a containment breach occur. In the event both layers of containment are breached, exposure to soils could occur. However, the Sr-90 titanate fuel element is fabricated as a very stable ceramic material, so dispersion is unlikely. If ceramic Sr-90 titanate is broken, it would most likely form relatively large particles that would not be readily dispersed in air (U.S. Congress, 1994). As a result, soil contamination would be localized and would not migrate deep into soils.

4.1.2.5 HEALTH AND SAFETY

Although the probability of an accident occurring is minimal, impacts to human health and safety would increase under the scenarios evaluated. This section describes the potential impacts to workers which may occur as a result of an aircraft accident. Radiological impacts to workers and the public are described in Section 4.1.2.9.

Under Alternative 1, up to 58 personnel, not including local law enforcement or other personnel who have no contact with the RTGs but may be required to coordinate efforts with the public, would be involved with the transport and temporary staging of the RTGs. In an accident situation, workers or the public may be harmed by direct impact from the crashing aircraft or flying debris. Any fatalities or injuries would be primarily due to trauma from the accident. Other severe hazards may include explosions, fire, and fuel spills. To minimize the impacts, workers and emergency responders would adhere to applicable safety and emergency regulations.

4.1.2.6 WATER RESOURCES

Impact to water resources during implementation of Alternative 1 under the accident scenarios would be the same as those described in Section 4.1.1.6 with the added potential for radiological exposure should a containment breach occur. Contamination could occur via dispersion of fuel material by air or water. However, the Sr-90 titanate fuel element is fabricated as a very stable ceramic material, so dispersion is unlikely. If ceramic Sr-90 titanate is broken, it would most likely form relatively large particles that would not be readily dispersed in air. As a result, contamination would not migrate into groundwater.

Surface water may be impacted in the unlikely event an aircraft carrying the RTGs crashed into or near a surface-water body. The water body may be affected by aircraft debris and fuel spills. A breach of the containment could result in radiological material being dispersed in the water. However, dispersion in water would be limited by its low solubility. Material could be dispersed

by surface water runoff and could contaminate the soil in the vicinity of the accident. However, this contamination could be cleaned up.

The HA concluded the radiological impact of an accident in the ocean would be localized because of the large volumes of water involved, mixing mechanisms, existing background radiation concentrations, and radiation-resistance of aquatic biota (AFTAC, 2014b). An accident involving an aircraft carrying the RTGs from Alaska resulting in a crash in the ocean was assumed to result in a release of all of the radioactive materials. The release could be immediate, but the packaging and containerization would make a gradual failure and release more likely. Whether immediate or gradual, it is assumed the release would result in water contamination near the released material. However, dilution would occur quickly given the large volume of water and mixing mechanisms.

4.1.2.7 LAND USE

Land use may be impacted if soils and infrastructure are exposed to radiation levels due to a breach in the fuel containment. Land and buildings may be temporarily unusable until decontamination and cleanup activities are completed. Prime and unique farmland would not be impacted because none exists at any of the sites. State and national parks, forests, conservation areas, and other areas of recreational, ecological, scenic, or aesthetic importance would remain undisturbed.

4.1.2.8 NOISE

After the initial sound and possible blast created from an aircraft accident, noise levels would temporarily increase during emergency response and cleanup activities. However, the noise resulting from cleanup activities would be similar to existing noise in the areas and would not be identified by members of the public as anything new or different.

4.1.2.9 RADIOLOGICAL CONSEQUENCES

Radiological impacts could result from the accidents if the outer and inner containers are somehow both breached resulting in radioactive source material being released to the environment. Inhalation of Sr-90 would result in internal exposures to radioactive materials. Beta radiation presents an external radiation hazard primarily to the eyes and skin including a risk of beta burns at higher doses. Beta particles, such as those from the decay of Sr-90, also create x-rays as they are slowed down in the surrounding fuel and shielding material. X-rays are penetrating radiation that can deliver a radiation dose from outside the body. Once taken into the body, Sr-90 behaves in a manner similar to calcium, assuming it is inhaled or ingested as a substance soluble in the bloodstream or other body fluids (U.S. Congress, 1994). Like calcium, Sr-90 accumulates in the bone, and from there delivers radiation to associated tissues as it decays. Exposure to Sr-90 has been associated with bone cancer and leukemia. If Sr-90 is

inhaled in an insoluble form (e.g., Sr-90 titanate), it is retained in the lung and is naturally cleared slowly such that lung tissues receive the majority of the radiation dose.

As stated in Section 4.1.2, the probability of an aircraft accident occurring using the route included in Alternative 1 would be 1.4×10^{-4}, which is approximately 1 in 7,150. The probability of that accident resulting in a release of radiological material is 2.6×10^{-6}, which is 1 in 385,000 (AFTAC, 2014b). If an aircraft accident were to affect workers (pilots, workers accompanying the RTGs in the air, drivers/handlers of trucks or forklifts) at transfer points or along transportation routes, impacts would be dependent upon the circumstances of the accident. Trained workers could become contaminated with radioactive material and receive a direct dose from radioactive beta emissions from Sr-90 and yttrium-90, a daughter product produced by the radioactive decay of Sr-90.

Should an accident occur, radiation exposure would be closely monitored and controlled to ensure there is no significant health effects to workers (security personnel, flight crew, radiation protection monitor, first responders, and clean-up personnel). The accident scene would be controlled, and radiation monitoring would be conducted to detect and contain or remove contamination as soon as possible. If a leak were detected, immediate action would be taken to contain the release of radioactive material to ensure the public is not exposed. The initial health effects of such an accident would be dominated by the injuries and fatalities resulting from the trauma of the crash. Thus, the release of the radioactive material would have relatively insignificant health consequences (AFTAC, 2014b).

The likelihood of exposure to the public increases with the occurrence of breaches in the RTG containment system. Leak tests have demonstrated the RTGs do not release Sr-90 fuel under the routine operating conditions encountered during staging at transfer sites. Such breaches would be the result of trauma to the RTGs, with enough force to impact the housing and/or fuel capsule. Moreover, the containment afforded by the transfer sites and controlled access provide the surrounding rural population with additional protection from exposure to the RTGs. Hence, the probability is extremely small the general public would be impacted, given a potential breach would result in localized contamination that would not reach populations.

4.2 ALTERNATIVE 2

The potential impacts resulting from Alternative 2 are described in this section under two main headings: Routine Incident-free Operating Conditions, and Abnormal Events and Accidents. The Abnormal Events and Accidents considered for Alternative 2 are the same as those described for Alternative 1 in Section 4.1.2. Alternative 2 does not result in indirect or residual impacts to resources unless specifically stated. The transport route included in Alternative 2 does not include Fort Yukon as a temporary staging site for the RTGs. Therefore, human health and environmental impacts at Fort Yukon would not occur.

4.2.1 ROUTINE INCIDENT-FREE OPERATING CONDITIONS

The routine incident-free operating conditions are the same as those described in Section 4.1.1.

4.2.1.1 CLIMATE AND AIR QUALITY

The impacts from implementation of Alternative 2 would be the same as those described in Section 4.1.1.1.

4.2.1.2 BIOLOGICAL RESOURCES

The potential impacts to biological resources as a result of implementing Alternative 2 would be the same as those described in Section 4.1.1.2.

4.2.1.3 ENVIRONMENTAL JUSTICE AND SOCIOECONOMICS

The potential impacts to Environmental Justice populations and socioeconomics as a result of implementing Alternative 2 would be the same as those described in Section 4.1.1.3.

4.2.1.4 GEOLOGY AND SOILS

The potential impacts to geology and soils as a result of implementing Alternative 2 would be the same as those described in Section 4.1.1.4.

4.2.1.5 HEALTH AND SAFETY

Under Alternative 2, up to 48 personnel would be involved with the transport and temporary staging of the RTGs. The potential impacts to health and safety as a result of implementing Alternative 2 would be similar to those described in Section 4.1.1.5. The differences are the reduction in workers and the use of the CH-47F helicopter to transport the RTGs from Burnt Mountain to Eielson AFB.

The CH-47F helicopters have increased capability, are fully instrument-flight-rule capable, and have a greater range than the CH-47D. U.S. Army aircrews currently use the CH-47F to routinely carry hazardous cargo over mountains in Afghanistan. Army personnel preliminarily assessed the transport of the RTGs by CH-47F helicopters, including flight over the White Mountains on a zero wind, sunny day. It was determined that it would be a low-risk operation (Collier, 2014). Once mission planning is completed, the Army would conduct a more in-depth risk assessment.

4.2.1.6 WATER RESOURCES

The potential impacts to water resources as a result of implementing Alternative 2 would be the same as those described in Section 4.1.1.6.

4.2.1.7 LAND USE

The potential impacts to land use as a result of implementing Alternative 2 would be the same as those described in Section 4.1.1.7.

4.2.1.8 NOISE

The potential noise impacts resulting from implementation of Alternative 2 would be the same as those described in Section 4.1.1.8. The exception would be at Fort Yukon. Because the Alternative 2 transportation route does not include Fort Yukon, there would be no noise impacts in that area.

4.2.1.9 RADIOLOGICAL CONSEQUENCES

Transfer of the RTGs from Burnt Mountain to the NNSS would have minimal radiological impacts on worker health and safety during loading/unloading, temporary staging, transit, or disposition activities. Under Alternative 2, activities would occur at 3 sites with up to 48 workers involved with the transport and temporary staging of the RTGs.

Workers at Burnt Mountain, Eielson AFB, and Creech AFB would be in close proximity to the RTGs for only as long as it takes to load/unload them from the aircraft and transport them to the temporary staging areas. Personnel at the temporary staging sites would maintain safe distances from the RTGs during normal operating conditions. Appropriate radiological monitoring, including a complete radiological control and safety program, would be established, approved, and implemented as a precaution. Personnel access-control procedures would be established and followed, and monitoring would be conducted inside the facilities. Monitoring would include ambient air surveys; swipe surveys; air monitoring; and passive integrating area monitors (such as TLDs) or real-time area monitors to observe radiation fields in the temporary staging areas. The doses to workers from loading/unloading and staging activities are summarized in Table 4-6.

The total dose to workers from the non-incident air transport ground operations is 1.1×10^{-1}. The total LCF probability from this portion of the transport is estimated to be 4.4×10^{-5}, or 1 in 23,000 excess cancer fatalities for the workers conducting the transport (AFTAC, 2014b).

During the air operations phase, occupational workers including flight crew have the potential to be exposed to radiation from the RTGs. Members of the public would be far enough away that exposures would be negligible. Thus, there is no impact to the public from air operations under routine operating conditions.

Table 4-6
Radiation Doses from Alternative 2 Loading/Unloading and Staging Activities

Location	Activity	Number of Personnel	Dose Rate (mrem/hr)	Exposure Time	Total Exposure (person-rem)
Burnt Mountain, AK	Removal and Loading of RTGs	4	Dose at 1 m for each unit	1 hour per unit	5.4×10^{-2}
Eielson AFB, AK	Unloading and Loading of RTGs	4	1.5	2 hours	1.2×10^{-2}
Eielson AFB, AK	Temporary Staging of RTGs (Security)	2	0.04	240 hours (5 days at each site)	1.9×10^{-2}
Creech AFB, NV	Unloading and Loading on Ground Vehicles	4	1.5	4	2.4×10^{-2}
TOTAL					$\mathbf{1.1 \times 10^{-1}}$

Source: AFTAC, 2014b

The dose rate and total dose for each aircraft segment is listed in Table 4-7. The upper-bound total person dose is estimated to be 3.5×10^{-2} person-rem. The upper-bound LCF risk is estimated at 1.4×10^{-5}, or the probability of 1 in approximately 70,500 of an LCF among the crew as a result of implementing Alternative 2 (AFTAC, 2014b).

Table 4-7
Alternative 2 Upper-Bound Radiation Doses and Probability of LCF for Air Transport of RTGs

Aircraft	Maximum Dose Rate to Crew (rem/hr)	Total Dose to Crew (person-rem)	LCF
CH-47	5.0×10^{-4}	2.2×10^{-2}	8.9×10^{-6}
C-17	4.7×10^{-4}	1.3×10^{-2}	5.3×10^{-6}
TOTAL		$\mathbf{3.5 \times 10^{-2}}$	$\mathbf{1.4 \times 10^{-5}}$

Source: AFTAC, 2014b

Note: Data in the table (and related text) are for all variants of the CH-47 helicopter, not specifically the CH-47F helicopter.

Workers at the NNSS would disposition the RTGs in accordance with all DOE and NNSS procedures and safety requirements. Personnel at the NNSS are highly trained and experienced in the safe handling and disposal of LLW. Radiological monitoring is routinely conducted, and personnel are required to wear TLDs at all times while at the NNSS.

There would be no impact to the public from ground or air operations under routine operating conditions due to the reasons described in Section 4.1.1.9. Impacts to the public during ground transport from Creech AFB to the NNSS would be the same as those described in Section 4.1.1.9.

4.2.2 ACCIDENTS

Human health and environmental impacts from the accident scenarios under Alternative 2 have a very low probability of occurrence. During transport for disposition, the potential for a leak is very unlikely due to the special nature of the RTG containers.

The probability of an aircraft accident under Alternative 2 and the probability of the accident resulting in a radiological release are presented in Table 4-8. The probability of an aircraft accident occurring using the route included in Alternative 2 would be 4.1×10^{-4}, which is approximately 1 in 2,450. The probability of that accident resulting in a release of radiological material is 5.2×10^{-6}, which is 1 in 192,000. The number of helicopter miles traveled under Alternative 2 increase the probability of an aircraft accident. However, factors not considered during calculation of accident probability are special climatic conditions, multi-flights per day, equipment parameters, and combat conditions. Additionally, rotary-wing aircraft speeds and altitudes are typically much lower likely resulting in a lower probability of severe RTG damage. Only two RTGs would be carried on each CH-47F, further reducing the probability of severe RTG damage.

Table 4-8
Probability of Class A Flight Accident for Alternative 2

Route	Aircraft	Flight Miles/Sorties	Probability of Accident	Adjusted Probability of Accident with Release [a]
Burnt Mountain, AK → Eielson AFB	CH-47	1,015 mi/5 sorties	3.8×10^{-4}	3.8×10^{-6}
Eielson AFB → Creech AFB	C-17	2,332 mi/1 sortie	2.7×10^{-5}	1.3×10^{-6}
TOTAL			$\mathbf{4.1 \times 10^{-4}}$	$\mathbf{5.2 \times 10^{-6}}$

Source: AFTAC, 2014b

[a] The risk of a release of radioactive material from an RTG breach is assumed to be 0.05 during a Class A fixed-wing aircraft accident and 0.01 for a Class A rotary-wing aircraft accident.

Note: Data in the table (and related text) are for all variants of the CH-47 helicopter, not specifically the CH-47F helicopter.

The total risk of a fatality from radiological exposure resulting from an aircraft accident is approximately 1 in 10,000 (AFTAC, 2014b). Although, the impacts from an accident in route would be substantial, the probability of such an accident occurring is very small. The HA

concluded the additional risks associated with exposure to radiological materials as a result of transporting the RTGs from Burnt Mountain, AK, to the NNSS are minimal.

As previously stated, human health and environmental impacts from the accident scenarios under the action alternatives have a very low probability of occurrence. However, should an accident occur resulting in a container breach, the potential impacts to each resource are described in the following subsections.

4.2.2.1 CLIMATE AND AIR QUALITY

The impacts from implementation of Alternative 2 would be the same as those described in Section 4.1.2.1.

4.2.2.2 BIOLOGICAL RESOURCES

The impacts from implementation of Alternative 2 would be the same as those described in Section 4.1.2.1.

4.2.2.3 ENVIRONMENTAL JUSTICE AND SOCIOECONOMICS

Impact to Environmental Justice populations during implementation of Alternative 2 from accidents would be the same as those described in Section 4.1.2.3. The socioeconomic impacts under Alternative 2 would be similar to those described in Section 4.1.2.4.

4.2.2.4 GEOLOGY AND SOILS

Impact to geology and soils during implementation of Alternative 2 from accidents would be the same as those described in Section 4.1.2.4.

4.2.2.5 HEALTH AND SAFETY

Health and safety impacts during implementation of Alternative 2 from accidents would be similar to those described in Section 4.1.2.5, except that up to 48 workers would be involved with the transport and temporary staging of the RTGs. Fort Yukon would not be used as a temporary staging area. Therefore, workers at Fort Yukon would not experience health and safety issues related to this action.

4.2.2.6 WATER RESOURCES

Impacts to water resources during implementation of Alternative 2 from accidents would be the same as those described in Section 4.1.2.6.

4.2.2.7 LAND USE

Impact to land use during implementation of Alternative 2 from accidents would be the same as those described in Section 4.1.2.7.

4.2.2.8 NOISE

Noise impacts during implementation of Alternative 2 from accidents would be the same as those described in Section 4.1.2.8.

4.2.2.9 RADIOLOGICAL CONSEQUENCES

Radiological impacts the may occur under Alternative 2 are similar to those described in Section 4.1.2.9, with two exceptions: the number of workers who could experience radiation exposure, and probability of an aircraft accident with RTGs onboard.

Under Alternative 2, up to 48 workers would be involved with the transport and temporary staging of the RTGs. Workers at Fort Yukon would not be affected by implementation of Alternative 2 because Fort Yukon would not be used as a temporary staging area.

As stated in Section 4.2.2, the probability of an aircraft accident occurring using the route included in Alternative 2 would be 4.1×10^{-4}, which is approximately 1 in 2,450. The probability of that accident resulting in a release of radiological material is 5.2×10^{-6}, which is 1 in 192,000. The number of helicopter miles traveled under Alternative 2 increase the probability of an aircraft accident because rotary-wing aircraft have a higher incident of crashes. However, factors not considered during calculation of accident probability are special climatic conditions, multi-flights per day, equipment parameters, and combat conditions. Additionally, rotary-wing aircraft speeds and altitudes are typically much lower likely resulting in a lower probability of severe RTG damage. Only 2 RTGs would be carried on each CH-47F, further reducing the probability of severe RTG damage.

4.3 NO ACTION ALTERNATIVE

Under the No Action Alternative, the 10 RTGs at Burnt Mountain would remain in place. The No Action Alternative would result in DOE delaying its responsibility under PLO 99-240 and would also delay commitments made to Congress in 1987 requiring DOE begin accepting GTCC waste for storage while developing a disposal option for this waste.

The potential impacts of continuing to operate and maintain the 10 RTGs at Burnt Mountain are described in this section under two main headings: Routine Incident-free Operating Conditions, and Accidents. The No Action Alternative does not result in indirect or residual impacts to resources unless specifically stated.

4.3.1 ROUTINE INCIDENT-FREE OPERATING CONDITIONS

The RTGs would be continuously monitored for integrity and isolation from the general public and intruders. Because the monitoring equipment is already in place, there would be no additional costs, other than those for routine maintenance and inspection of the RTGs. No additional regulatory requirements would be necessary for continued use or storage of the RTGs at Burnt Mountain.

4.3.1.1 AIR QUALITY AND CLIMATE

No impacts to air quality would result from the continued operation of the RTGs. Under routine operating conditions, RTGs would not generate any particulate or gaseous emissions that would deteriorate air quality. Detachment 460 records indicate there has never been a radiation leak from the RTGs that would deteriorate air quality at the site. The use of a CH-47F helicopter and ATVs during routine maintenance would not affect air quality because maintenance activities would occur only once per year. Additionally, the helicopter would operate on site only for several minutes as it loads or unloads passengers and equipment. The CH-47F helicopter would be shut down if it were to be on the ground for an extended period of time. Emissions from the ATVs would be minimal and temporary, as they would be operated primarily as a means of transportation between the five RTG sites (USAF, 1999).

4.3.1.2 BIOLOGICAL RESOURCES

Impacts to biological resources associated with annual maintenance activities would be minor. Helicopters used to transport personnel to the sites and ATVs used for maintenance activity would temporarily frighten animals from the area. However, once the maintenance crew departed, the animals would most likely return.

As part of the yearly maintenance activities, approximately 225 ft (69 m) around the RTG storage units would continue to be cleared. This activity has been done annually since installation of the RTGs; therefore, it is not a new disturbance to vegetation. Although two of the arrays (BM01 and BM04) are located in black spruce wetlands, no new activities would occur at the sites. The issuance of a general Nationwide 18 Permit to the USAF authorizing activities to occur in these areas indicates USACE considers the activities to have minimal adverse effects on the aquatic environment. No construction or excavation would occur within the wetlands.

The area does not support high-density populations of caribou, moose, or bears. Moreover, there would be no impacts to caribou migration if the RTGs were left in place. Residents of main caribou communities—including the Porcupine herd that ranges in Northern Alaska, Yukon, and the Northwest Territories—have been tested for radiation exposure. Extremely low levels of cesium-137, resulting from the Chernobyl nuclear reactor accident in 1986, were found (PCMB, 2013). There is no evidence the low levels of radiation could alter the migration

patterns, cause deformities in antlers, or increase mortality from radiation poisoning (USAF, 1999). In addition, Health and Welfare Canada concluded there was no risk to people, even on a steady diet of caribou (PCMB, 2013). The moose and caribou in the area have been sampled annually since 1994. The results indicate overall, the Caribou herd has low levels of contaminants (primarily arsenic, cadmium, lead, and mercury), and there is no immediate cause for concern (Gamberg, 2008). The aforementioned contaminants are not associated with emissions originating from the RTGs.

There are no threatened or endangered species present at Burnt Mountain. Therefore, none would be affected by the continued presence of the RTGs. The RTGs have routinely been monitored for leakage since installed and there have been no evidence of release to the environment.

4.3.1.3 ENVIRONMENTAL JUSTICE AND SOCIOECONOMICS

Implementation of the No Action Alternative would have no impacts on socioeconomics at Burnt Mountain or the nearby Native villages. Activities associated with operating Burnt Mountain are conducted by the USAF. Subsistence for the nearby native villages would remain unaffected.

4.3.1.4 GEOLOGY AND SOILS

Radiological monitoring results conducted during routine maintenance trips indicate the exposure limits and radiation levels at the Burnt Mountain facility have never exceeded NRC limits, and there has never been a leaking RTG (USAF, 2013a). Therefore, it is unlikely soils in the vicinity of the RTG storage areas would be affected.

The CH-47 does not leak fuel under normal operating conditions. However, under an abnormal start-up, which entails the engines not firing on first attempt, the pilot would wait 1 minute to allow the small amount of fuel in the chamber to drain out so the engine would not flood during the second attempt to start the engines. In this case, several drops of fuel would exit the helicopter through a drain tube. A container would be placed beneath the drain tube to capture the fuel and prevent contact with the ground. Therefore, no soil contamination would occur.

4.3.1.5 HEALTH AND SAFETY

Existing human health and safety concerns at Burnt Mountain include occupational hazards associated with maintaining the RTGs, the operation of ATVs and landing of helicopters on the tundra, seasonal driving and working conditions, and low-probability natural hazards associated with events such as wildfires. There would be no additional health and safety impacts above what are present from other maintenance activities conducted at Burnt Mountain. Results from radiological monitoring conducted during routine maintenance trips indicate there has never been a leaking RTG (USAF, 2013a). Ongoing monitoring of the RTGs would ensure they continue to operate without any adverse impacts to occupationally exposed workers or the environment.

Therefore, under routine operating conditions, there would be no potential for health or safety impacts on workers.

There would be no potential for environmental health or safety impacts on the general population under routine operating conditions because the nearest population center is 50 mi (81 km) away from Burnt Mountain. The threat of human intrusion is extremely low. Therefore, the continued operation of the RTGs at Burnt Mountain would not impact the public under routine operating conditions.

4.3.1.6 WATER RESOURCES

There are no water bodies in close proximity to the RTG storage units. Therefore, impacts to surface water are not expected. There are no groundwater aquifer data for the Burnt Mountain area (USGS, 2014). However, the area has discontinuous permafrost, which impedes flow and transport of contaminants. Therefore, impacts to groundwater are not expected.

4.3.1.7 LAND USE

The USAF would continue to use the land at Burnt Mountain for ongoing activities. The continued operation and maintenance of the RTGs under the No Action Alternative would not impact land use.

4.3.1.8 NOISE

The RTGs and associated facility equipment do not generate any audible noise. Noise would be generated only during maintenance trips from helicopters and USAF personnel. Workers would adhere to standard operating procedures to determine whether hearing protection would be required while working in the vicinity of the helicopters.

4.3.1.9 RADIOLOGICAL CONSEQUENCES

Radiological sources at Burnt Mountain include naturally occurring radon and the RTGs, which emit from 0.7 to 2 mrem/hr outside the shelters. RTGs have been designed to contain the radioactive material and radiation levels. Annual radiation surveys and leak tests have verified the source containment has not been breached and radiation exposures have not exceeded the limits (USAF, 2013a). Average exposure rates have been well below regulatory limits. Monitoring of the RTGs would ensure the RTGs continue to operate without any adverse impacts to the environment. While some RTG radiation would continue if they are left in place at Burnt Mountain, impacts to the environment would be negligible.

4.3.2 ACCIDENTS

The accident scenarios would not occur if the RTGs remain at Burnt Mountain. Therefore, under the No Action Alternative, there would be no impacts beyond those described in Section 4.3.1.

5.0 CUMULATIVE IMPACTS AND IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

This section addresses potential cumulative impacts to the environment that could be associated with the implementation of the alternatives in conjunction with one or more past, present, or reasonably foreseeable future actions or projects. Specifically, this section is prepared in accordance with the requirements of NEPA guidance from the CEQ handbook *Considering Cumulative Effects Under the National Environmental Policy Act* (CEQ, 1997). The CEQ regulations define a "cumulative impact" for purposes of NEPA as "incremental impacts of the action when added to other past, present, and reasonably foreseeable actions regardless of what agency (federal or non-federal) or person undertakes such other actions." Cumulatively significant impacts can result from individually minor, but collectively significant, actions taking place over a period of time.

Cumulative impacts were determined by combining the impacts of the alternatives with other past, present, and reasonably foreseeable future actions. Cumulative impacts are most likely to arise when a relationship exists between a proposed action and other actions that have, or are expected, to occur in a similar location, time period, or involving similar actions. Projects in close proximity to the alternatives that would occur during the same time period would be expected to have more potential for cumulative impacts than those separated by geography or scheduling. Projects with cumulative impacts can be federal, state, local, or private projects. The cumulative effects assessment in this EA focuses on addressing two fundamental questions:

- Are there potentially overlapping impacts of Alternative 1 or Alternative 2 with impacts of the other past, present, or reasonably foreseeable actions?
- If there are potentially overlapping impacts, does this impact analysis reveal any potentially significant impacts not identified when Alternative 1 or Alternative 2 are considered alone?

NEPA requires that environmental analysis include identification of any irreversible and irretrievable commitment of resources that would be involved in the proposed action should it be implemented. Irreversible and irretrievable resource commitments are related to the use of nonrenewable resources and the effects this use could have on future generations. Irreversible effects primarily result from the use or destruction of a specific resource (e.g., energy and minerals) that cannot be replaced within a reasonable time frame. Irretrievable resource commitments are the loss in value of an affected resource that cannot be restored (e.g., extinction of a threatened or endangered species, or disturbance of a cultural resource).

5.1 CUMULATIVE PROJECTS CONSIDERED

5.1.1 PAST ACTIONS

Past human actions include various construction activities on or near Burnt Mountain, Fort Yukon Airfield, Eielson AFB, Creech AFB, and the NNSS. These past actions are considered part of the existing environment.

5.1.2 PRESENT ACTIONS

Present actions include the alternatives, which are described in Section 2.0 and analyzed in Section 4.0. Present actions also include ongoing missions at Burnt Mountain, AK; Fort Yukon, AK; Eielson AFB, AK; Creech AFB, NV; and the NNSS, NV.

Burnt Mountain, AK: The unmanned Burnt Mountain Seismic Observatory would continue its mission to monitor nuclear treaty compliance. The array system has five remote seismic sensor sites clustered within a 1.5-mi (2.4-km) radius and linked to a central communications station. Each of the five sites consist of a borehole, a seismic sensor, and a metal frame shelter for housing the RTGs, and associated power conditioning equipment (U.S. Congress, 1994). Data from the five sensors are transmitted to various USAF sites electronically.

There are three site visits programmed each year: one scheduled maintenance, one scheduled inspection, and one unscheduled maintenance. However, additional maintenance and inspection visits are conducted as necessary (Ingram, 2014). Access to the site is by helicopter only, as no roads exist in the area. ATVs are used for traveling between the five remote seismic sensor sites.

Fort Yukon, AK: Fort Yukon Airfield is a state-owned public airport. Flight activity is shown in Table 5-1.

Table 5-1
Fort Yukon Airfield Activity

Type of Flight	Number per Year
General Aviation	3,100
Air Taxi	5,000
Military	250
TOTAL	**8,350**

Source: Aircraft Owners and Pilots Association, 2006

Eielson AFB, AK: A variety of transient and special mission aircraft operate at Eielson AFB, particularly during major flying exercises. Eielson supports six military tenant units. Approximately 6,631 sortie operations are conducted at Eielson AFB each year (USAF, 2013b).

A multi-year project to repair taxiway Golf (B8021) began in 2010 and will continue through at least 2015. Taxiway repair typically occurs in mid to late summer (Holdsworth, 2014).

Creech AFB, NV: Creech AFB is an active military installation that undergoes continuous change in mission and training requirements. The primary missions at Creech AFB are to (1) provide theater commanders with deployable long-range, long-endurance, real-time aerial reconnaissance, surveillance, target acquisition, and attack flying the Unmanned Aerial System aircraft, MQ-1 Predator, and the MQ-9 Reaper; and (2) provide an emergency divert airfield for military aircraft training at the Nellis Test and Training Range, and support the flying operations of the 57th Wing, other USAF units, U.S. Navy, U.S. Marine Corps, and allied air forces. Creech AFB is also the primary training site for the USAF Thunderbirds flying F-16s. Hundreds of sortie operations are conducted at Creech AFB each year.

NNSS: DOE/NNSA's primary mission at the NNSS is to support nuclear stockpile reliability through subcritical experiments. The NNSS supports national security missions, DOE waste management activities, environmental restoration activities; and research, development, and testing programs related to national security.

No other projects or actions are currently under way or are expected to be under way at any of the sites during the same time frame as the alternatives.

5.1.3 REASONABLY FORESEEABLE ACTIONS

No reasonably foreseeable actions have been identified for Burnt Mountain, Fort Yukon, Creech AFB, or the NNSS.

Reasonably foreseeable actions at Eielson AFB include the replacement of a concrete drain near Building 1335 and repair of runways with asphalt and overlays.

5.2 CUMULATIVE IMPACTS

Under the No Action Alternative, the Burnt Mountain facility would remain in its existing configuration and operations mode. There would be no additional environmental impacts. Therefore, cumulative impacts have not been identified for the No Action Alternative.

There would be no impact to cultural resources under the action alternatives. Thus, there would be no cumulative impact to cultural resources.

5.2.1 ROUTINE INCIDENT-FREE OPERATING CONDITIONS

Under routine incident-free operating conditions, the alternatives would result in no impacts to environmental justice and socioeconomics, water resources, health and safety, and land. There would be temporary and minor impacts to air quality and noise at all sites. Impacts to wildlife

and vegetation at Burnt Mountain would be temporary and minor. There would be no impact to wildlife and vegetation at the transfer sites. Radiological consequences to workers and the public would be negligible.

5.2.1.1 BURNT MOUNTAIN, AK

Ongoing activities at Burnt Mountain are minimal and have no impact on human health and a negligible impact on the environment. Under routine operating conditions, there would be no cumulative impacts from the temporary and minor impacts resulting from the alternatives and ongoing activities at Burnt Mountain. There is no potential for radiological exposure from ongoing activities at Burnt Mountain (other than from the RTGs), so the negligible potential for worker exposure from the alternatives would not result in a cumulative impact.

5.2.1.2 FORT YUKON, AK

CH-47F helicopters would transport the RTGs to the Fort Yukon Airfield in five trips under Alternative 1. The addition of five CH-47F helicopter sorties to the 8,350 flights occurring at Fort Yukon annually would not affect airfield operations. There would be no cumulative impact from the temporary and minor emission and noise increases resulting from the CH-47F helicopters. There is no potential for radiological exposure from ongoing activities at Fort Yukon Airfield, so the negligible potential for worker exposure from the alternatives would not result in a cumulative impact.

Under Alternative 2, the Fort Yukon Airfield would not be used as an RTG staging area.

5.2.1.3 EIELSON AFB, AK

Under Alternatives 1 and 2, two C-130 aircraft or five CH-47 helicopters would transport the RTGs to Eielson AFB, respectively. The addition of two C-130 aircraft or five CH-47 helicopters to the 6,631 sorties taking place at Eielson AFB annually would not affect base operations. There would be no cumulative impact from the temporary and minor emissions and noise increases resulting from the C-130 aircraft or CH-47 helicopters. There is no potential for radiological exposure from ongoing activities at Eielson AFB, so the negligible potential for worker exposure from the action alternatives would not result in a cumulative impact.

There would be no cumulative impact from the action alternatives when added to the ongoing repair of taxiway Golf, replacement of a concrete drain, or repair of runways. These activities would likely occur later in the summer than the RTG transport (Holdsworth, 2014).

5.2.1.4 CREECH AFB, NV

A C-17 aircraft would transport the RTGs to Creech AFB under both action alternatives. The addition of one aircraft to the hundreds of sorties taking place at Creech AFB would not affect

base operations. There would be no cumulative impact from the temporary and minor emissions and noise increases resulting from the C-17 aircraft. There is no potential for radiological exposure from ongoing activities at Creech AFB, so the negligible potential for worker exposure from the alternatives would not result in a cumulative impact.

A truck would transport the RTGs from Creech AFB to the NNSS via US-95 and Mercury Highway. There would be no cumulative impact from the addition of one truck on US-95. There is no known source of potential radiological exposure along this segment of US-95. No cumulative impact would result from the slightly increased potential for radiological exposure from the RTGs during truck transport.

5.2.1.5 NNSS, NV

Ongoing activities at the NNSS include the disposal of LLW; however, since this EA evaluates the non-routine aspects of the RTG transport and ends at the gates of NNSS when DOE takes possession, there would be no additional radiological exposure to NNSS workers. There would not be a cumulative impact.

Any potential for exposure once DOE takes possession is addressed in the NNSS SWEIS.

5.2.2 ACCIDENTS

Trauma, fire, and fuel spills from an aircraft accident could affect workers, members of the public, and the environment. The probability of aircraft accidents for Alternative 1 and Alternative 2 are shown in Table 5-2.

Table 5-2
Probability of Aircraft and Trucking Accidents

	Alternative 1		**Alternative 2**	
	Aircraft Accident	**Trucking Accident**	**Aircraft Accident**	**Trucking Accident**
Probability of Accident	1.4×10^{-4} (about 1 in 7,150)	Less than 1.0×10^{-4} to 1.0×10^{-6} (1 in 10,000 to 1 in 1 million occurrences per year)	4.1×10^{-4} (about 1 in 2,450)	Less than 1.0×10^{-4} to 1.0×10^{-6} (1 in 10,000 to 1 in 1 million occurrences per year)
Probability of Radiological Release from Accident	2.6×10^{-6} (about 1 in 385,000)	Greater than 1.0×10^{-6} (1 in 1 million occurrences per year)	5.2×10^{-6} (about 1 in 192,000)	Greater than 1.0×10^{-6} (1 in 1 million occurrences per year)

The probability of a radiological release from the RTGs as the result of an aircraft or trucking accident is considered to be improbable. However, for purposes of analysis, should a release occur, impacts to air quality, biological resources, workers and members of the public, water resources, and land use would result.

5.2.2.1 BURNT MOUNTAIN, AK

Ongoing activities at Burnt Mountain are minimal and have no impact on human health and a negligible impact on the environment. Thus, there would be no cumulative impacts at Burnt Mountain.

5.2.2.2 FORT YUKON, AK

There is no potential for radiological exposure from ongoing activities at the Fort Yukon Airfield. Although workers, members of the public, air quality, biological resources, soils, water resources, and socioeconomics could be affected by an aircraft accident resulting in radiological release from the RTGs, the impacts would be direct and indirect, not cumulative.

Under Alternative 2, the Fort Yukon Airfield would not be used as an RTG staging area.

5.2.2.3 EIELSON AFB, AK

There is no potential for radiological exposure from ongoing activities at the Eielson AFB. Although workers, members of the public, air quality, biological resources, soils, water resources, and socioeconomics could be affected by an aircraft accident resulting in radiological release from the RTGs, the impacts would be direct and indirect, not cumulative.

5.2.2.4 CREECH AFB, NV

There is no potential for radiological exposure from ongoing activities at the Creech AFB. Although workers, members of the public, air quality, biological resources, soils, water resources, and socioeconomics could be affected by an aircraft accident resulting in radiological release from the RTG, the impacts would be direct and indirect, not cumulative.

There is no known source of potential radiological exposure along this segment of US-95. Thus, there would be no cumulative impact from a trucking accident resulting in the release of radioactive materials from the RTGs.

5.2.2.5 NNSS, NV

Ongoing activities at the NNSS include the disposal of LLW; however, since this EA evaluates the non-routine aspects of the RTG transport and ends at the gates of NNSS when DOE takes possession, there would be no additional radiological exposure to NNSS workers. There would not be a cumulative impact.

Any potential for exposure once DOE takes possession is addressed in the NNSS SWEIS.

5.3. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Under routine operating conditions, none of the alternatives would result in irreversible or irretrievable commitments of resources. Most environmental consequences would be temporary and minor, such as air emissions from aircraft and ground vehicles, and displacement of wildlife during activities. All alternatives would require consumption of fuel. However, the amount of fuel used is not expected to significantly decrease the availability of the resource either locally or globally. Based on the analysis in this EA, implementation of the alternatives under routine operating conditions would not result in adverse impacts to the environment or to the health and safety of persons in the affected regions.

The probability of an abnormal event or accident to occur is extremely small, and the potential for a release of radiological material is even smaller. However, should a release occur, there is the potential for injury or fatalities to workers, the public, and wildlife. Additionally, soils and infrastructure may be contaminated. The loss of human life or wildlife would be an irreversible and irretrievable commitment of individuals but would not significantly decrease the species' population. Soils and infrastructure would be decontaminated; therefore, there would not be an irreversible and irretrievable commitment of those resources.

6.0 LIST OF PREPARERS AND INDIVIDUALS OR AGENCIES CONSULTED

Table 6-1 provides the list of individuals involved in the preparation of this EA .

Table 6-1
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Organization	Name	Title/Role
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	Les Reed	USAF Environmental Attorney
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	Carrie Stewart	NEPA Specialist & Primary Author

Table 6-2 provides the list of persons, agencies, and organizations consulted during the preparation of this EA.

Table 6-2
Individuals or Agencies Consulted

<table>
<tr><th colspan="2">Affiliation/Organization</th><th>Name</th><th>Title/Role</th></tr>
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<tr><td colspan="2">Creech AFB 799th Air Base Wing</td><td>Nicholas Dirosario</td><td>Point of Contact</td></tr>
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APPENDIX A
STRONTIUM-90 RADIOISOTOPE THERMOELECTRIC GENERATORS
(7 Pages)

APPENDIX B
PACKAGING AND TRANSPORTATION REQUIREMENTS
(4 Pages)

APPENDIX C
SR90 SEALED SOURCE TRANSPORT HAZARD ANALYSIS AND SAFETY EVALUATION
(363 Pages)

Attachment #1 Aircraft Fuel and Speed Data

Asset	Fuel Burn Rate (lbs/hour)	Fuel Weight (lbs/gallon)	Fuel Burn Rate (gallons/hour)	Block Speed (Mach)	Block Speed (miles/hour)	Fuel Efficiency (miles/gallon)
CH-47	2400	6.7	358.2089552	0.1	66	0.18425
C-130	5109	6.7	762.5373134	0.49	323.4	0.424110393
C-5	23132	6.7	3452.537313	0.77	508.2	0.147196092
C-17	19643	6.7	2931.791045	0.76	501.6	0.171089956
semi					40	6

Mach Speed 660

Attachment #2 Accident Probability for All Possible Routes

Path	Prob Accident					leg 2		leg 3		leg 4		leg 5		leg 6		
Number	5 year avg	10 year avg	lifetime	from		to	via	to	via	to	via	to	via	to	via	to
1	1.19E-03	4.96E-05	6.09E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-17	Tonopah	semi	Area-5
2	1.19E-03	5.18E-05	6.32E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-17	Creech	semi	Area-5
3	1.19E-03	5.16E-05	6.29E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-17	Desert Rock	semi	Area-5
4	1.19E-03	5.26E-05	6.40E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-17	Nellis	semi	Area-5
5	1.19E-03	6.56E-05	5.73E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-5	Tonopah	semi	Area-5
6	1.19E-03	6.85E-05	5.94E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-5	Creech	semi	Area-5
7	1.19E-03	6.82E-05	5.92E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-5	Desert Rock	semi	Area-5
8	1.19E-03	6.96E-05	6.02E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-5	Nellis	semi	Area-5
9	1.19E-03	5.17E-05	5.31E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-17	Tonopah	semi	Area-5
10	1.19E-03	5.39E-05	5.54E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-17	Creech	semi	Area-5
11	1.19E-03	5.36E-05	5.51E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-17	Desert Rock	semi	Area-5
12	1.19E-03	5.47E-05	5.62E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-17	Nellis	semi	Area-5
13	1.19E-03	6.76E-05	4.95E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-5	Tonopah	semi	Area-5
14	1.19E-03	7.06E-05	5.16E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-5	Creech	semi	Area-5
15	1.19E-03	7.02E-05	5.14E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-5	Desert Rock	semi	Area-5
16	1.19E-03	7.17E-05	5.24E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-5	Nellis	semi	Area-5
17	1.19E-03	4.80E-05	4.93E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-17	Tonopah	semi	Area-5		
18	1.19E-03	5.01E-05	5.15E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-17	Creech	semi	Area-5		
19	1.19E-03	4.99E-05	5.13E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-17	Desert Rock	semi	Area-5		
20	1.19E-03	5.09E-05	5.24E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-17	Nellis	semi	Area-5		
21	1.19E-03	5.36E-05	5.27E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-17	Tonopah	semi	Area-5
22	1.19E-03	5.58E-05	5.49E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-17	Creech	semi	Area-5
23	1.19E-03	5.56E-05	5.47E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-17	Desert Rock	semi	Area-5
24	1.19E-03	5.66E-05	5.58E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-17	Nellis	semi	Area-5
25	1.19E-03	6.96E-05	4.91E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-5	Tonopah	semi	Area-5
26	1.19E-03	7.25E-05	5.12E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-5	Creech	semi	Area-5
27	1.19E-03	7.22E-05	5.09E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-5	Desert Rock	semi	Area-5
28	1.19E-03	7.36E-05	5.19E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-5	Nellis	semi	Area-5
29	1.18E-03	6.46E-05	4.56E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-5	Tonopah	semi	Area-5		
30	1.19E-03	6.75E-05	4.76E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-5	Creech	semi	Area-5		
31	1.18E-03	6.72E-05	4.74E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-5	Desert Rock	semi	Area-5		
32	1.19E-03	6.86E-05	4.84E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Ft Wainwright	C-5	Nellis	semi	Area-5		
33	1.17E-03	4.95E-05	6.05E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-17	Tonopah	semi	Area-5
34	1.17E-03	5.17E-05	6.28E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-17	Creech	semi	Area-5
35	1.17E-03	5.15E-05	6.25E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-17	Desert Rock	semi	Area-5
36	1.17E-03	5.25E-05	6.36E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-17	Nellis	semi	Area-5
37	1.17E-03	6.55E-05	5.70E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-5	Tonopah	semi	Area-5
38	1.17E-03	6.84E-05	5.90E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-5	Creech	semi	Area-5
39	1.17E-03	6.81E-05	5.88E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-5	Desert Rock	semi	Area-5
40	1.17E-03	6.95E-05	5.98E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-5	Nellis	semi	Area-5
41	1.17E-03	5.15E-05	5.30E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-17	Tonopah	semi	Area-5
42	1.17E-03	5.37E-05	5.52E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-17	Creech	semi	Area-5
43	1.17E-03	5.35E-05	5.50E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-17	Desert Rock	semi	Area-5
44	1.17E-03	5.45E-05	5.61E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-17	Nellis	semi	Area-5
45	1.17E-03	6.75E-05	4.94E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-5	Tonopah	semi	Area-5
46	1.17E-03	7.04E-05	5.15E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-5	Creech	semi	Area-5
47	1.17E-03	7.01E-05	5.12E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-5	Desert Rock	semi	Area-5
48	1.17E-03	7.15E-05	5.22E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-5	Nellis	semi	Area-5
49	1.17E-03	4.76E-05	4.89E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-17	Tonopah	semi	Area-5		
50	1.17E-03	4.97E-05	5.11E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-17	Creech	semi	Area-5		
51	1.17E-03	4.95E-05	5.09E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-17	Desert Rock	semi	Area-5		
52	1.17E-03	5.05E-05	5.19E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-17	Nellis	semi	Area-5		
53	1.17E-03	5.34E-05	5.25E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-17	Tonopah	semi	Area-5
54	1.17E-03	5.56E-05	5.48E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-17	Creech	semi	Area-5
55	1.17E-03	5.54E-05	5.45E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-17	Desert Rock	semi	Area-5
56	1.17E-03	5.64E-05	5.56E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-17	Nellis	semi	Area-5
57	1.17E-03	6.94E-05	4.89E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-5	Tonopah	semi	Area-5
58	1.17E-03	7.23E-05	5.10E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-5	Creech	semi	Area-5
59	1.17E-03	7.20E-05	5.08E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-5	Desert Rock	semi	Area-5
60	1.17E-03	7.34E-05	5.18E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-5	Nellis	semi	Area-5
61	1.17E-03	6.41E-05	4.52E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-5	Tonopah	semi	Area-5		
62	1.17E-03	6.70E-05	4.73E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-5	Creech	semi	Area-5		
63	1.17E-03	6.67E-05	4.71E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-5	Desert Rock	semi	Area-5		
64	1.17E-03	6.80E-05	4.80E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	CH-47	Eielson	C-5	Nellis	semi	Area-5		
65	7.24E-04	5.13E-05	6.73E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-17	Tonopah	semi	Area-5
66	7.25E-04	5.35E-05	6.95E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-17	Creech	semi	Area-5
67	7.25E-04	5.32E-05	6.93E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-17	Desert Rock	semi	Area-5
68	7.25E-04	5.43E-05	7.04E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-17	Nellis	semi	Area-5
69	7.20E-04	6.73E-05	6.37E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-5	Tonopah	semi	Area-5
70	7.21E-04	7.02E-05	6.58E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-5	Creech	semi	Area-5
71	7.20E-04	6.99E-05	6.55E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-5	Desert Rock	semi	Area-5
72	7.21E-04	7.13E-05	6.65E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-5	Nellis	semi	Area-5
73	7.23E-04	5.34E-05	5.95E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-17	Tonopah	semi	Area-5
74	7.24E-04	5.55E-05	6.17E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-17	Creech	semi	Area-5
75	7.24E-04	5.53E-05	6.15E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-17	Desert Rock	semi	Area-5
76	7.24E-04	5.64E-05	6.26E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-17	Nellis	semi	Area-5
77	7.18E-04	6.93E-05	5.59E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-5	Tonopah	semi	Area-5
78	7.19E-04	7.23E-05	5.80E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-5	Creech	semi	Area-5
79	7.19E-04	7.19E-05	5.77E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-5	Desert Rock	semi	Area-5
80	7.20E-04	7.34E-05	5.88E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-5	Nellis	semi	Area-5
81	7.21E-04	4.97E-05	5.57E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-17	Tonopah	semi	Area-5		
82	7.22E-04	5.18E-05	5.79E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-17	Creech	semi	Area-5		
83	7.22E-04	5.16E-05	5.77E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-17	Desert Rock	semi	Area-5		
84	7.22E-04	5.26E-05	5.87E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-17	Nellis	semi	Area-5		
85	7.22E-04	5.53E-05	5.90E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-17	Tonopah	semi	Area-5
86	7.23E-04	5.75E-05	6.13E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-17	Creech	semi	Area-5
87	7.23E-04	5.73E-05	6.10E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-17	Desert Rock	semi	Area-5

88	7.24E-04	5.83E-05	6.21E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-17	Nellis	semi	Area-5
89	7.18E-04	7.13E-05	5.55E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-5	Tonopah	semi	Area-5
90	7.19E-04	7.42E-05	5.75E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-5	Creech	semi	Area-5
91	7.19E-04	7.39E-05	5.73E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-5	Desert Rock	semi	Area-5
92	7.19E-04	7.53E-05	5.83E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-5	Nellis	semi	Area-5
93	7.16E-04	6.63E-05	5.20E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-5	Tonopah	semi	Area-5		
94	7.17E-04	6.92E-05	5.40E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-5	Creech	semi	Area-5		
95	7.17E-04	6.89E-05	5.38E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-5	Desert Rock	semi	Area-5		
96	7.18E-04	7.03E-05	5.48E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Ft Wainwright	C-5	Nellis	semi	Area-5		
97	7.24E-04	5.11E-05	6.67E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-130	JBER	C-17	Tonopah	semi	Area-5
98	7.25E-04	5.33E-05	6.89E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-130	JBER	C-17	Creech	semi	Area-5
99	7.25E-04	5.31E-05	6.86E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-130	JBER	C-17	Desert Rock	semi	Area-5
100	7.25E-04	5.41E-05	6.97E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-130	JBER	C-17	Nellis	semi	Area-5
101	7.19E-04	6.71E-05	6.31E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-130	JBER	C-5	Tonopah	semi	Area-5
102	7.20E-04	7.01E-05	6.52E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-130	JBER	C-5	Creech	semi	Area-5
103	7.20E-04	6.97E-05	6.49E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-130	JBER	C-5	Desert Rock	semi	Area-5
104	7.21E-04	7.11E-05	6.59E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-130	JBER	C-5	Nellis	semi	Area-5
105	7.22E-04	5.31E-05	5.91E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-17	JBER	C-17	Tonopah	semi	Area-5
106	7.24E-04	5.53E-05	6.13E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-17	JBER	C-17	Creech	semi	Area-5
107	7.23E-04	5.51E-05	6.11E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-17	JBER	C-17	Desert Rock	semi	Area-5
108	7.24E-04	5.61E-05	6.22E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-17	JBER	C-17	Nellis	semi	Area-5
109	7.18E-04	6.91E-05	5.55E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-17	JBER	C-5	Tonopah	semi	Area-5
110	7.19E-04	7.20E-05	5.76E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-17	JBER	C-5	Creech	semi	Area-5
111	7.19E-04	7.17E-05	5.73E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-17	JBER	C-5	Desert Rock	semi	Area-5
112	7.20E-04	7.31E-05	5.83E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-17	JBER	C-5	Nellis	semi	Area-5
113	7.20E-04	4.92E-05	5.50E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-17	Tonopah	semi	Area-5		
114	7.22E-04	5.14E-05	5.72E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-17	Creech	semi	Area-5		
115	7.21E-04	5.12E-05	5.70E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-17	Desert Rock	semi	Area-5		
116	7.22E-04	5.21E-05	5.80E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-17	Nellis	semi	Area-5		
117	7.22E-04	5.50E-05	5.86E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-5	JBER	C-17	Tonopah	semi	Area-5
118	7.23E-04	5.72E-05	6.09E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-5	JBER	C-17	Creech	semi	Area-5
119	7.23E-04	5.70E-05	6.06E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-5	JBER	C-17	Desert Rock	semi	Area-5
120	7.24E-04	5.81E-05	6.17E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-5	JBER	C-17	Nellis	semi	Area-5
121	7.18E-04	7.10E-05	5.51E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-5	JBER	C-5	Tonopah	semi	Area-5
122	7.19E-04	7.40E-05	5.71E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-5	JBER	C-5	Creech	semi	Area-5
123	7.19E-04	7.36E-05	5.69E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-5	JBER	C-5	Desert Rock	semi	Area-5
124	7.19E-04	7.50E-05	5.79E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-5	JBER	C-5	Nellis	semi	Area-5
125	7.16E-04	6.57E-05	5.13E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-5	Tonopah	semi	Area-5		
126	7.17E-04	6.86E-05	5.34E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-5	Creech	semi	Area-5		
127	7.17E-04	6.83E-05	5.32E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-5	Desert Rock	semi	Area-5		
128	7.17E-04	6.96E-05	5.41E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	Eielson	C-5	Nellis	semi	Area-5		
129	7.23E-04	5.11E-05	6.63E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	JBER	C-17	Tonopah	semi	Area-5		
130	7.25E-04	5.33E-05	6.86E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	JBER	C-17	Creech	semi	Area-5		
131	7.24E-04	5.30E-05	6.83E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	JBER	C-17	Desert Rock	semi	Area-5		
132	7.25E-04	5.41E-05	6.94E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	JBER	C-17	Nellis	semi	Area-5		
133	7.19E-04	6.70E-05	6.28E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	JBER	C-5	Tonopah	semi	Area-5		
134	7.20E-04	7.00E-05	6.48E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	JBER	C-5	Creech	semi	Area-5		
135	7.20E-04	6.96E-05	6.46E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	JBER	C-5	Desert Rock	semi	Area-5		
136	7.21E-04	7.11E-05	6.56E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	C-130	JBER	C-5	Nellis	semi	Area-5		
137	7.22E-04	4.96E-05	6.09E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-17	Tonopah	semi	Area-5
138	7.23E-04	5.18E-05	6.32E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-17	Creech	semi	Area-5
139	7.23E-04	5.16E-05	6.29E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-17	Desert Rock	semi	Area-5
140	7.23E-04	5.26E-05	6.40E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-17	Nellis	semi	Area-5
141	7.18E-04	6.56E-05	5.73E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-5	Tonopah	semi	Area-5
142	7.19E-04	6.85E-05	5.94E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-5	Creech	semi	Area-5
143	7.19E-04	6.82E-05	5.92E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-5	Desert Rock	semi	Area-5
144	7.19E-04	6.96E-05	6.02E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-5	Nellis	semi	Area-5
145	7.21E-04	5.17E-05	5.31E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-17	Tonopah	semi	Area-5
146	7.22E-04	5.39E-05	5.54E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-17	Creech	semi	Area-5
147	7.22E-04	5.36E-05	5.51E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-17	Desert Rock	semi	Area-5
148	7.22E-04	5.47E-05	5.62E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-17	Nellis	semi	Area-5
149	7.17E-04	6.76E-05	4.95E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-5	Tonopah	semi	Area-5
150	7.18E-04	7.06E-05	5.16E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-5	Creech	semi	Area-5
151	7.17E-04	7.02E-05	5.14E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-5	Desert Rock	semi	Area-5
152	7.18E-04	7.17E-05	5.24E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-5	Nellis	semi	Area-5
153	7.19E-04	4.80E-05	4.93E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-17	Tonopah	semi	Area-5		
154	7.20E-04	5.01E-05	5.15E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-17	Creech	semi	Area-5		
155	7.20E-04	4.99E-05	5.13E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-17	Desert Rock	semi	Area-5		
156	7.20E-04	5.09E-05	5.24E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-17	Nellis	semi	Area-5		
157	7.20E-04	5.36E-05	5.27E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-17	Tonopah	semi	Area-5
158	7.21E-04	5.58E-05	5.49E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-17	Creech	semi	Area-5
159	7.21E-04	5.56E-05	5.47E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-17	Desert Rock	semi	Area-5
160	7.22E-04	5.66E-05	5.58E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-17	Nellis	semi	Area-5
161	7.16E-04	6.96E-05	4.91E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-5	Tonopah	semi	Area-5
162	7.17E-04	7.25E-05	5.12E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-5	Creech	semi	Area-5
163	7.17E-04	7.22E-05	5.09E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-5	Desert Rock	semi	Area-5
164	7.17E-04	7.36E-05	5.19E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-5	Nellis	semi	Area-5
165	7.14E-04	6.46E-05	4.56E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-5	Tonopah	semi	Area-5		
166	7.15E-04	6.75E-05	4.76E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-5	Creech	semi	Area-5		
167	7.15E-04	6.72E-05	4.74E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-5	Desert Rock	semi	Area-5		
168	7.16E-04	6.86E-05	4.84E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Ft Wainwright	C-5	Nellis	semi	Area-5		
169	7.22E-04	4.95E-05	6.05E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-130	JBER	C-17	Tonopah	semi	Area-5
170	7.23E-04	5.17E-05	6.28E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-130	JBER	C-17	Creech	semi	Area-5
171	7.23E-04	5.15E-05	6.25E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-130	JBER	C-17	Desert Rock	semi	Area-5
172	7.23E-04	5.25E-05	6.36E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-130	JBER	C-17	Nellis	semi	Area-5
173	7.18E-04	6.55E-05	5.70E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-130	JBER	C-5	Tonopah	semi	Area-5
174	7.19E-04	6.84E-05	5.90E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-130	JBER	C-5	Creech	semi	Area-5
175	7.18E-04	6.81E-05	5.88E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-130	JBER	C-5	Desert Rock	semi	Area-5
176	7.19E-04	6.95E-05	5.98E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-130	JBER	C-5	Nellis	semi	Area-5

177	7.21E-04	5.15E-05	5.30E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-17	JBER	C-17	Tonopah	semi	Area-5
178	7.22E-04	5.37E-05	5.52E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-17	JBER	C-17	Creech	semi	Area-5
179	7.22E-04	5.35E-05	5.50E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-17	JBER	C-17	Desert Rock	semi	Area-5
180	7.22E-04	5.45E-05	5.61E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-17	JBER	C-17	Nellis	semi	Area-5
181	7.16E-04	6.75E-05	4.94E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-17	JBER	C-5	Tonopah	semi	Area-5
182	7.17E-04	7.04E-05	5.15E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-17	JBER	C-5	Creech	semi	Area-5
183	7.17E-04	7.01E-05	5.12E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-17	JBER	C-5	Desert Rock	semi	Area-5
184	7.18E-04	7.15E-05	5.22E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-17	JBER	C-5	Nellis	semi	Area-5
185	7.19E-04	4.76E-05	4.89E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-17	Tonopah	semi	Area-5		
186	7.20E-04	4.97E-05	5.11E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-17	Creech	semi	Area-5		
187	7.20E-04	4.95E-05	5.09E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-17	Desert Rock	semi	Area-5		
188	7.20E-04	5.05E-05	5.19E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-17	Nellis	semi	Area-5		
189	7.20E-04	5.34E-05	5.25E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-5	JBER	C-17	Tonopah	semi	Area-5
190	7.21E-04	5.56E-05	5.48E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-5	JBER	C-17	Creech	semi	Area-5
191	7.21E-04	5.54E-05	5.45E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-5	JBER	C-17	Desert Rock	semi	Area-5
192	7.22E-04	5.64E-05	5.56E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-5	JBER	C-17	Nellis	semi	Area-5
193	7.16E-04	6.94E-05	4.89E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-5	JBER	C-5	Tonopah	semi	Area-5
194	7.17E-04	7.23E-05	5.10E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-5	JBER	C-5	Creech	semi	Area-5
195	7.17E-04	7.20E-05	5.08E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-5	JBER	C-5	Desert Rock	semi	Area-5
196	7.17E-04	7.34E-05	5.18E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-5	JBER	C-5	Nellis	semi	Area-5
197	7.14E-04	6.41E-05	4.52E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-5	Tonopah	semi	Area-5		
198	7.15E-04	6.70E-05	4.73E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-5	Creech	semi	Area-5		
199	7.15E-04	6.67E-05	4.71E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-5	Desert Rock	semi	Area-5		
200	7.16E-04	6.80E-05	4.80E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Circle	semi	Eielson	C-5	Nellis	semi	Area-5		
201	1.01E-03	4.96E-05	6.09E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-130	JBER	C-17	Tonopah	semi	Area-5		
202	1.01E-03	5.18E-05	6.32E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-130	JBER	C-17	Creech	semi	Area-5		
203	1.01E-03	5.16E-05	6.29E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-130	JBER	C-17	Desert Rock	semi	Area-5		
204	1.02E-03	5.26E-05	6.40E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-130	JBER	C-17	Nellis	semi	Area-5		
205	1.01E-03	6.56E-05	5.73E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-130	JBER	C-5	Tonopah	semi	Area-5		
206	1.01E-03	6.85E-05	5.94E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-130	JBER	C-5	Creech	semi	Area-5		
207	1.01E-03	6.82E-05	5.92E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-130	JBER	C-5	Desert Rock	semi	Area-5		
208	1.01E-03	6.96E-05	6.02E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-130	JBER	C-5	Nellis	semi	Area-5		
209	1.01E-03	5.17E-05	5.31E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-17	JBER	C-17	Tonopah	semi	Area-5		
210	1.01E-03	5.39E-05	5.54E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-17	JBER	C-17	Creech	semi	Area-5		
211	1.01E-03	5.36E-05	5.51E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-17	JBER	C-17	Desert Rock	semi	Area-5		
212	1.01E-03	5.47E-05	5.62E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-17	JBER	C-17	Nellis	semi	Area-5		
213	1.01E-03	6.76E-05	4.95E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-17	JBER	C-5	Tonopah	semi	Area-5		
214	1.01E-03	7.06E-05	5.16E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-17	JBER	C-5	Creech	semi	Area-5		
215	1.01E-03	7.02E-05	5.14E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-17	JBER	C-5	Desert Rock	semi	Area-5		
216	1.01E-03	7.17E-05	5.24E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-17	JBER	C-5	Nellis	semi	Area-5		
217	1.01E-03	4.80E-05	4.93E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-17	Tonopah	semi	Area-5				
218	1.01E-03	5.01E-05	5.15E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-17	Creech	semi	Area-5				
219	1.01E-03	4.99E-05	5.13E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-17	Desert Rock	semi	Area-5				
220	1.01E-03	5.09E-05	5.24E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-17	Nellis	semi	Area-5				
221	1.01E-03	5.36E-05	5.27E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-5	JBER	C-17	Tonopah	semi	Area-5		
222	1.01E-03	5.58E-05	5.49E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-5	JBER	C-17	Creech	semi	Area-5		
223	1.01E-03	5.56E-05	5.47E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-5	JBER	C-17	Desert Rock	semi	Area-5		
224	1.01E-03	5.66E-05	5.58E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-5	JBER	C-17	Nellis	semi	Area-5		
225	1.01E-03	6.96E-05	4.91E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-5	JBER	C-5	Tonopah	semi	Area-5		
226	1.01E-03	7.25E-05	5.12E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-5	JBER	C-5	Creech	semi	Area-5		
227	1.01E-03	7.22E-05	5.09E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-5	JBER	C-5	Desert Rock	semi	Area-5		
228	1.01E-03	7.36E-05	5.19E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-5	JBER	C-5	Nellis	semi	Area-5		
229	1.01E-03	6.46E-05	4.56E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-5	Tonopah	semi	Area-5				
230	1.01E-03	6.75E-05	4.76E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-5	Creech	semi	Area-5				
231	1.01E-03	6.72E-05	4.74E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-5	Desert Rock	semi	Area-5				
232	1.01E-03	6.86E-05	4.84E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Ft Wainwright	C-5	Nellis	semi	Area-5				
233	1.03E-03	4.95E-05	6.05E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-130	JBER	C-17	Tonopah	semi	Area-5		
234	1.03E-03	5.17E-05	6.28E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-130	JBER	C-17	Creech	semi	Area-5		
235	1.03E-03	5.15E-05	6.25E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-130	JBER	C-17	Desert Rock	semi	Area-5		
236	1.03E-03	5.25E-05	6.36E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-130	JBER	C-17	Nellis	semi	Area-5		
237	1.02E-03	6.55E-05	5.70E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-130	JBER	C-5	Tonopah	semi	Area-5		
238	1.03E-03	6.84E-05	5.90E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-130	JBER	C-5	Creech	semi	Area-5		
239	1.03E-03	6.81E-05	5.88E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-130	JBER	C-5	Desert Rock	semi	Area-5		
240	1.03E-03	6.95E-05	5.98E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-130	JBER	C-5	Nellis	semi	Area-5		
241	1.03E-03	5.15E-05	5.30E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-17	JBER	C-17	Tonopah	semi	Area-5		
242	1.03E-03	5.37E-05	5.52E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-17	JBER	C-17	Creech	semi	Area-5		
243	1.03E-03	5.35E-05	5.50E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-17	JBER	C-17	Desert Rock	semi	Area-5		
244	1.03E-03	5.45E-05	5.61E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-17	JBER	C-17	Nellis	semi	Area-5		
245	1.02E-03	6.75E-05	4.94E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-17	JBER	C-5	Tonopah	semi	Area-5		
246	1.02E-03	7.04E-05	5.15E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-17	JBER	C-5	Creech	semi	Area-5		
247	1.02E-03	7.01E-05	5.12E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-17	JBER	C-5	Desert Rock	semi	Area-5		
248	1.02E-03	7.15E-05	5.22E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-17	JBER	C-5	Nellis	semi	Area-5		
249	1.03E-03	4.76E-05	4.89E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-17	Tonopah	semi	Area-5				
250	1.03E-03	4.97E-05	5.11E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-17	Creech	semi	Area-5				
251	1.03E-03	4.95E-05	5.09E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-17	Desert Rock	semi	Area-5				
252	1.03E-03	5.05E-05	5.19E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-17	Nellis	semi	Area-5				
253	1.03E-03	5.34E-05	5.25E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-5	JBER	C-17	Tonopah	semi	Area-5		
254	1.03E-03	5.56E-05	5.48E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-5	JBER	C-17	Creech	semi	Area-5		
255	1.03E-03	5.54E-05	5.45E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-5	JBER	C-17	Desert Rock	semi	Area-5		
256	1.03E-03	5.64E-05	5.56E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-5	JBER	C-17	Nellis	semi	Area-5		
257	1.02E-03	6.94E-05	4.89E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-5	JBER	C-5	Tonopah	semi	Area-5		
258	1.02E-03	7.23E-05	5.10E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-5	JBER	C-5	Creech	semi	Area-5		
259	1.02E-03	7.20E-05	5.08E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-5	JBER	C-5	Desert Rock	semi	Area-5		
260	1.02E-03	7.34E-05	5.18E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-5	JBER	C-5	Nellis	semi	Area-5		
261	1.02E-03	6.41E-05	4.52E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-5	Tonopah	semi	Area-5				
262	1.02E-03	6.70E-05	4.73E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-5	Creech	semi	Area-5				
263	1.02E-03	6.67E-05	4.71E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-5	Desert Rock	semi	Area-5				
264	1.02E-03	6.80E-05	4.80E-05	Burnt Mountain	CH-47	Ft Yukon	CH-47	Eielson	C-5	Nellis	semi	Area-5				
265	9.61E-04	5.04E-05	6.40E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-130	JBER	C-17	Tonopah	semi	Area-5

266	9.63E-04	5.26E-05	6.63E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-130	JBER	C-17	Creech	semi	Area-5
267	9.62E-04	5.24E-05	6.60E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-130	JBER	C-17	Desert Rock	semi	Area-5
268	9.63E-04	5.35E-05	6.71E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-130	JBER	C-17	Nellis	semi	Area-5
269	9.57E-04	6.64E-05	6.05E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-130	JBER	C-5	Tonopah	semi	Area-5
270	9.58E-04	6.94E-05	6.25E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-130	JBER	C-5	Creech	semi	Area-5
271	9.58E-04	6.90E-05	6.23E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-130	JBER	C-5	Desert Rock	semi	Area-5
272	9.59E-04	7.05E-05	6.33E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-130	JBER	C-5	Nellis	semi	Area-5
273	9.60E-04	5.25E-05	5.62E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-17	JBER	C-17	Tonopah	semi	Area-5
274	9.61E-04	5.47E-05	5.85E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-17	JBER	C-17	Creech	semi	Area-5
275	9.61E-04	5.44E-05	5.82E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-17	JBER	C-17	Desert Rock	semi	Area-5
276	9.62E-04	5.55E-05	5.93E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-17	JBER	C-17	Nellis	semi	Area-5
277	9.56E-04	6.85E-05	5.27E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-17	JBER	C-5	Tonopah	semi	Area-5
278	9.57E-04	7.14E-05	5.47E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-17	JBER	C-5	Creech	semi	Area-5
279	9.57E-04	7.11E-05	5.45E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-17	JBER	C-5	Desert Rock	semi	Area-5
280	9.57E-04	7.25E-05	5.55E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-17	JBER	C-5	Nellis	semi	Area-5
281	9.58E-04	4.88E-05	5.25E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-17	Tonopah	semi	Area-5		
282	9.59E-04	5.10E-05	5.47E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-17	Creech	semi	Area-5		
283	9.59E-04	5.07E-05	5.44E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-17	Desert Rock	semi	Area-5		
284	9.60E-04	5.18E-05	5.55E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-17	Nellis	semi	Area-5		
285	9.60E-04	5.45E-05	5.58E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-5	JBER	C-17	Tonopah	semi	Area-5
286	9.61E-04	5.67E-05	5.81E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-5	JBER	C-17	Creech	semi	Area-5
287	9.61E-04	5.64E-05	5.78E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-5	JBER	C-17	Desert Rock	semi	Area-5
288	9.61E-04	5.75E-05	5.89E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-5	JBER	C-17	Nellis	semi	Area-5
289	9.56E-04	7.04E-05	5.22E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-5	JBER	C-5	Tonopah	semi	Area-5
290	9.57E-04	7.34E-05	5.43E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-5	JBER	C-5	Creech	semi	Area-5
291	9.56E-04	7.30E-05	5.41E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-5	JBER	C-5	Desert Rock	semi	Area-5
292	9.57E-04	7.45E-05	5.51E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-5	JBER	C-5	Nellis	semi	Area-5
293	9.54E-04	6.55E-05	4.87E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-5	Tonopah	semi	Area-5		
294	9.55E-04	6.83E-05	5.08E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-5	Creech	semi	Area-5		
295	9.55E-04	6.81E-05	5.06E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-5	Desert Rock	semi	Area-5		
296	9.55E-04	6.94E-05	5.15E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Ft Wainwright	C-5	Nellis	semi	Area-5		
297	9.42E-04	5.04E-05	6.37E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-130	JBER	C-17	Tonopah	semi	Area-5
298	9.43E-04	5.25E-05	6.59E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-130	JBER	C-17	Creech	semi	Area-5
299	9.43E-04	5.23E-05	6.57E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-130	JBER	C-17	Desert Rock	semi	Area-5
300	9.44E-04	5.34E-05	6.68E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-130	JBER	C-17	Nellis	semi	Area-5
301	9.38E-04	6.63E-05	6.01E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-130	JBER	C-5	Tonopah	semi	Area-5
302	9.39E-04	6.93E-05	6.22E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-130	JBER	C-5	Creech	semi	Area-5
303	9.39E-04	6.89E-05	6.19E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-130	JBER	C-5	Desert Rock	semi	Area-5
304	9.40E-04	7.04E-05	6.29E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-130	JBER	C-5	Nellis	semi	Area-5
305	9.41E-04	5.23E-05	5.61E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-17	JBER	C-17	Tonopah	semi	Area-5
306	9.42E-04	5.45E-05	5.84E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-17	JBER	C-17	Creech	semi	Area-5
307	9.42E-04	5.43E-05	5.81E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-17	JBER	C-17	Desert Rock	semi	Area-5
308	9.43E-04	5.54E-05	5.92E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-17	JBER	C-17	Nellis	semi	Area-5
309	9.37E-04	6.83E-05	5.25E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-17	JBER	C-5	Tonopah	semi	Area-5
310	9.38E-04	7.13E-05	5.46E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-17	JBER	C-5	Creech	semi	Area-5
311	9.38E-04	7.09E-05	5.44E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-17	JBER	C-5	Desert Rock	semi	Area-5
312	9.38E-04	7.24E-05	5.54E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-17	JBER	C-5	Nellis	semi	Area-5
313	9.39E-04	4.84E-05	5.21E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-17	Tonopah	semi	Area-5		
314	9.40E-04	5.06E-05	5.43E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-17	Creech	semi	Area-5		
315	9.40E-04	5.04E-05	5.41E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-17	Desert Rock	semi	Area-5		
316	9.41E-04	5.13E-05	5.51E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-17	Nellis	semi	Area-5		
317	9.41E-04	5.43E-05	5.57E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-5	JBER	C-17	Tonopah	semi	Area-5
318	9.42E-04	5.65E-05	5.79E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-5	JBER	C-17	Creech	semi	Area-5
319	9.42E-04	5.62E-05	5.77E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-5	JBER	C-17	Desert Rock	semi	Area-5
320	9.42E-04	5.73E-05	5.88E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-5	JBER	C-17	Nellis	semi	Area-5
321	9.37E-04	7.02E-05	5.21E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-5	JBER	C-5	Tonopah	semi	Area-5
322	9.38E-04	7.32E-05	5.42E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-5	JBER	C-5	Creech	semi	Area-5
323	9.37E-04	7.28E-05	5.39E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-5	JBER	C-5	Desert Rock	semi	Area-5
324	9.38E-04	7.43E-05	5.49E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-5	JBER	C-5	Nellis	semi	Area-5
325	9.35E-04	6.49E-05	4.83E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-5	Tonopah	semi	Area-5		
326	9.36E-04	6.78E-05	5.04E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-5	Creech	semi	Area-5		
327	9.36E-04	6.75E-05	5.02E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-5	Desert Rock	semi	Area-5		
328	9.36E-04	6.89E-05	5.11E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	CH-47	Eielson	C-5	Nellis	semi	Area-5		
329	4.94E-04	5.21E-05	7.04E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-130	JBER	C-17	Tonopah	semi	Area-5
330	4.95E-04	5.43E-05	7.27E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-130	JBER	C-17	Creech	semi	Area-5
331	4.95E-04	5.41E-05	7.24E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-130	JBER	C-17	Desert Rock	semi	Area-5
332	4.95E-04	5.51E-05	7.35E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-130	JBER	C-17	Nellis	semi	Area-5
333	4.89E-04	6.81E-05	6.68E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-130	JBER	C-5	Tonopah	semi	Area-5
334	4.90E-04	7.10E-05	6.89E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-130	JBER	C-5	Creech	semi	Area-5
335	4.90E-04	7.07E-05	6.87E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-130	JBER	C-5	Desert Rock	semi	Area-5
336	4.91E-04	7.21E-05	6.97E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-130	JBER	C-5	Nellis	semi	Area-5
337	4.93E-04	5.42E-05	6.26E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-17	JBER	C-17	Tonopah	semi	Area-5
338	4.94E-04	5.64E-05	6.49E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-17	JBER	C-17	Creech	semi	Area-5
339	4.94E-04	5.61E-05	6.46E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-17	JBER	C-17	Desert Rock	semi	Area-5
340	4.94E-04	5.72E-05	6.57E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-17	JBER	C-17	Nellis	semi	Area-5
341	4.88E-04	7.01E-05	5.90E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-17	JBER	C-5	Tonopah	semi	Area-5
342	4.89E-04	7.31E-05	6.11E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-17	JBER	C-5	Creech	semi	Area-5
343	4.89E-04	7.28E-05	6.09E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-17	JBER	C-5	Desert Rock	semi	Area-5
344	4.90E-04	7.42E-05	6.19E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-17	JBER	C-5	Nellis	semi	Area-5
345	4.91E-04	5.05E-05	5.88E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-17	Tonopah	semi	Area-5		
346	4.92E-04	5.26E-05	6.10E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-17	Creech	semi	Area-5		
347	4.92E-04	5.24E-05	6.08E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-17	Desert Rock	semi	Area-5		
348	4.92E-04	5.35E-05	6.19E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-17	Nellis	semi	Area-5		
349	4.92E-04	5.61E-05	6.22E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-5	JBER	C-17	Tonopah	semi	Area-5
350	4.93E-04	5.83E-05	6.44E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-5	JBER	C-17	Creech	semi	Area-5
351	4.93E-04	5.81E-05	6.42E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-5	JBER	C-17	Desert Rock	semi	Area-5
352	4.94E-04	5.92E-05	6.53E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-5	JBER	C-17	Nellis	semi	Area-5
353	4.88E-04	7.21E-05	5.86E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-5	JBER	C-5	Tonopah	semi	Area-5
354	4.89E-04	7.51E-05	6.07E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-5	JBER	C-5	Creech	semi	Area-5

355	4.89E-04	7.47E-05	6.04E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-5	JBER	C-5	Desert Rock	semi	Area-5
356	4.89E-04	7.61E-05	6.14E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-5	JBER	C-5	Nellis	semi	Area-5
357	4.86E-04	6.72E-05	5.51E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-5	Tonopah	semi	Area-5		
358	4.87E-04	7.00E-05	5.71E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-5	Creech	semi	Area-5		
359	4.87E-04	6.97E-05	5.69E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-5	Desert Rock	semi	Area-5		
360	4.88E-04	7.11E-05	5.79E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Ft Wainwright	C-5	Nellis	semi	Area-5		
361	4.93E-04	5.20E-05	6.98E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-130	JBER	C-17	Tonopah	semi	Area-5
362	4.95E-04	5.42E-05	7.20E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-130	JBER	C-17	Creech	semi	Area-5
363	4.94E-04	5.39E-05	7.18E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-130	JBER	C-17	Desert Rock	semi	Area-5
364	4.95E-04	5.50E-05	7.29E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-130	JBER	C-17	Nellis	semi	Area-5
365	4.89E-04	6.79E-05	6.62E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-130	JBER	C-5	Tonopah	semi	Area-5
366	4.90E-04	7.09E-05	6.83E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-130	JBER	C-5	Creech	semi	Area-5
367	4.90E-04	7.05E-05	6.80E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-130	JBER	C-5	Desert Rock	semi	Area-5
368	4.91E-04	7.20E-05	6.91E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-130	JBER	C-5	Nellis	semi	Area-5
369	4.92E-04	5.40E-05	6.22E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-17	JBER	C-17	Tonopah	semi	Area-5
370	4.94E-04	5.62E-05	6.45E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-17	JBER	C-17	Creech	semi	Area-5
371	4.93E-04	5.59E-05	6.42E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-17	JBER	C-17	Desert Rock	semi	Area-5
372	4.94E-04	5.70E-05	6.53E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-17	JBER	C-17	Nellis	semi	Area-5
373	4.88E-04	6.99E-05	5.86E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-17	JBER	C-5	Tonopah	semi	Area-5
374	4.89E-04	7.29E-05	6.07E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-17	JBER	C-5	Creech	semi	Area-5
375	4.89E-04	7.25E-05	6.05E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-17	JBER	C-5	Desert Rock	semi	Area-5
376	4.90E-04	7.40E-05	6.15E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-17	JBER	C-5	Nellis	semi	Area-5
377	4.90E-04	5.00E-05	5.82E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-17	Tonopah	semi	Area-5		
378	4.91E-04	5.22E-05	6.04E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-17	Creech	semi	Area-5		
379	4.91E-04	5.20E-05	6.02E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-17	Desert Rock	semi	Area-5		
380	4.92E-04	5.30E-05	6.12E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-17	Nellis	semi	Area-5		
381	4.92E-04	5.59E-05	6.18E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-5	JBER	C-17	Tonopah	semi	Area-5
382	4.93E-04	5.81E-05	6.40E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-5	JBER	C-17	Creech	semi	Area-5
383	4.93E-04	5.78E-05	6.38E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-5	JBER	C-17	Desert Rock	semi	Area-5
384	4.93E-04	5.89E-05	6.49E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-5	JBER	C-17	Nellis	semi	Area-5
385	4.88E-04	7.18E-05	5.82E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-5	JBER	C-5	Tonopah	semi	Area-5
386	4.89E-04	7.48E-05	6.03E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-5	JBER	C-5	Creech	semi	Area-5
387	4.89E-04	7.44E-05	6.00E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-5	JBER	C-5	Desert Rock	semi	Area-5
388	4.89E-04	7.59E-05	6.10E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-5	JBER	C-5	Nellis	semi	Area-5
389	4.86E-04	6.65E-05	5.45E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-5	Tonopah	semi	Area-5		
390	4.87E-04	6.94E-05	5.65E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-5	Creech	semi	Area-5		
391	4.87E-04	6.92E-05	5.63E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-5	Desert Rock	semi	Area-5		
392	4.87E-04	7.05E-05	5.72E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	Eielson	C-5	Nellis	semi	Area-5		
393	4.93E-04	5.19E-05	6.95E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	JBER	C-17	Tonopah	semi	Area-5		
394	4.94E-04	5.41E-05	7.17E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	JBER	C-17	Creech	semi	Area-5		
395	4.94E-04	5.38E-05	7.15E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	JBER	C-17	Desert Rock	semi	Area-5		
396	4.95E-04	5.49E-05	7.26E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	JBER	C-17	Nellis	semi	Area-5		
397	4.89E-04	6.78E-05	6.59E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	JBER	C-5	Tonopah	semi	Area-5		
398	4.90E-04	7.08E-05	6.80E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	JBER	C-5	Creech	semi	Area-5		
399	4.90E-04	7.05E-05	6.77E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	JBER	C-5	Desert Rock	semi	Area-5		
400	4.91E-04	7.19E-05	6.87E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	C-130	JBER	C-5	Nellis	semi	Area-5		
401	4.92E-04	5.04E-05	6.40E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-130	JBER	C-17	Tonopah	semi	Area-5
402	4.93E-04	5.26E-05	6.63E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-130	JBER	C-17	Creech	semi	Area-5
403	4.93E-04	5.24E-05	6.60E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-130	JBER	C-17	Desert Rock	semi	Area-5
404	4.93E-04	5.35E-05	6.71E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-130	JBER	C-17	Nellis	semi	Area-5
405	4.88E-04	6.64E-05	6.05E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-130	JBER	C-5	Tonopah	semi	Area-5
406	4.89E-04	6.94E-05	6.25E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-130	JBER	C-5	Creech	semi	Area-5
407	4.88E-04	6.90E-05	6.23E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-130	JBER	C-5	Desert Rock	semi	Area-5
408	4.89E-04	7.05E-05	6.33E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-130	JBER	C-5	Nellis	semi	Area-5
409	4.91E-04	5.25E-05	5.62E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-17	JBER	C-17	Tonopah	semi	Area-5
410	4.92E-04	5.47E-05	5.85E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-17	JBER	C-17	Creech	semi	Area-5
411	4.92E-04	5.44E-05	5.82E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-17	JBER	C-17	Desert Rock	semi	Area-5
412	4.92E-04	5.55E-05	5.93E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-17	JBER	C-17	Nellis	semi	Area-5
413	4.86E-04	6.85E-05	5.27E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-17	JBER	C-5	Tonopah	semi	Area-5
414	4.87E-04	7.14E-05	5.47E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-17	JBER	C-5	Creech	semi	Area-5
415	4.87E-04	7.11E-05	5.45E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-17	JBER	C-5	Desert Rock	semi	Area-5
416	4.88E-04	7.25E-05	5.55E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-17	JBER	C-5	Nellis	semi	Area-5
417	4.89E-04	4.88E-05	5.25E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-17	Tonopah	semi	Area-5		
418	4.90E-04	5.10E-05	5.47E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-17	Creech	semi	Area-5		
419	4.90E-04	5.07E-05	5.44E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-17	Desert Rock	semi	Area-5		
420	4.90E-04	5.18E-05	5.55E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-17	Nellis	semi	Area-5		
421	4.90E-04	5.45E-05	5.58E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-5	JBER	C-17	Tonopah	semi	Area-5
422	4.91E-04	5.67E-05	5.81E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-5	JBER	C-17	Creech	semi	Area-5
423	4.91E-04	5.64E-05	5.78E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-5	JBER	C-17	Desert Rock	semi	Area-5
424	4.92E-04	5.75E-05	5.89E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-5	JBER	C-17	Nellis	semi	Area-5
425	4.86E-04	7.04E-05	5.22E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-5	JBER	C-5	Tonopah	semi	Area-5
426	4.87E-04	7.34E-05	5.43E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-5	JBER	C-5	Creech	semi	Area-5
427	4.87E-04	7.30E-05	5.41E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-5	JBER	C-5	Desert Rock	semi	Area-5
428	4.87E-04	7.45E-05	5.51E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-5	JBER	C-5	Nellis	semi	Area-5
429	4.84E-04	6.55E-05	4.87E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-5	Tonopah	semi	Area-5		
430	4.85E-04	6.83E-05	5.08E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-5	Creech	semi	Area-5		
431	4.85E-04	6.81E-05	5.06E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-5	Desert Rock	semi	Area-5		
432	4.86E-04	6.94E-05	5.15E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Ft Wainwright	C-5	Nellis	semi	Area-5		
433	4.92E-04	5.04E-05	6.37E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-130	JBER	C-17	Tonopah	semi	Area-5
434	4.93E-04	5.25E-05	6.59E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-130	JBER	C-17	Creech	semi	Area-5
435	4.93E-04	5.23E-05	6.57E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-130	JBER	C-17	Desert Rock	semi	Area-5
436	4.93E-04	5.34E-05	6.68E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-130	JBER	C-17	Nellis	semi	Area-5
437	4.87E-04	6.63E-05	6.01E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-130	JBER	C-5	Tonopah	semi	Area-5
438	4.88E-04	6.93E-05	6.22E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-130	JBER	C-5	Creech	semi	Area-5
439	4.88E-04	6.89E-05	6.19E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-130	JBER	C-5	Desert Rock	semi	Area-5
440	4.89E-04	7.04E-05	6.29E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-130	JBER	C-5	Nellis	semi	Area-5
441	4.91E-04	5.23E-05	5.61E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-17	JBER	C-17	Tonopah	semi	Area-5
442	4.92E-04	5.45E-05	5.84E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-17	JBER	C-17	Creech	semi	Area-5
443	4.92E-04	5.43E-05	5.81E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-17	JBER	C-17	Desert Rock	semi	Area-5

444	4.92E-04	5.54E-05	5.92E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-17	JBER	C-17	Nellis	semi	Area-5
445	4.86E-04	6.83E-05	5.25E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-17	JBER	C-5	Tonopah	semi	Area-5
446	4.87E-04	7.13E-05	5.46E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-17	JBER	C-5	Creech	semi	Area-5
447	4.87E-04	7.09E-05	5.44E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-17	JBER	C-5	Desert Rock	semi	Area-5
448	4.88E-04	7.24E-05	5.54E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-17	JBER	C-5	Nellis	semi	Area-5
449	4.88E-04	4.84E-05	5.21E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-17	Tonopah	semi	Area-5		
450	4.90E-04	5.06E-05	5.43E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-17	Creech	semi	Area-5		
451	4.89E-04	5.04E-05	5.41E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-17	Desert Rock	semi	Area-5		
452	4.90E-04	5.13E-05	5.51E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-17	Nellis	semi	Area-5		
453	4.90E-04	5.43E-05	5.57E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-5	JBER	C-17	Tonopah	semi	Area-5
454	4.91E-04	5.65E-05	5.79E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-5	JBER	C-17	Creech	semi	Area-5
455	4.91E-04	5.62E-05	5.77E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-5	JBER	C-17	Desert Rock	semi	Area-5
456	4.92E-04	5.73E-05	5.88E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-5	JBER	C-17	Nellis	semi	Area-5
457	4.86E-04	7.02E-05	5.21E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-5	JBER	C-5	Tonopah	semi	Area-5
458	4.87E-04	7.32E-05	5.42E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-5	JBER	C-5	Creech	semi	Area-5
459	4.87E-04	7.28E-05	5.39E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-5	JBER	C-5	Desert Rock	semi	Area-5
460	4.87E-04	7.43E-05	5.49E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-5	JBER	C-5	Nellis	semi	Area-5
461	4.84E-04	6.49E-05	4.83E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-5	Tonopah	semi	Area-5		
462	4.85E-04	6.78E-05	5.04E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-5	Creech	semi	Area-5		
463	4.85E-04	6.75E-05	5.02E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-5	Desert Rock	semi	Area-5		
464	4.85E-04	6.89E-05	5.11E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Circle	semi	Eielson	C-5	Nellis	semi	Area-5		
465	4.93E-04	5.15E-05	6.80E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-130	JBER	C-17	Tonopah	semi	Area-5		
466	4.94E-04	5.37E-05	7.02E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-130	JBER	C-17	Creech	semi	Area-5		
467	4.94E-04	5.34E-05	7.00E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-130	JBER	C-17	Desert Rock	semi	Area-5		
468	4.94E-04	5.45E-05	7.11E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-130	JBER	C-17	Nellis	semi	Area-5		
469	4.89E-04	6.75E-05	6.44E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-130	JBER	C-5	Tonopah	semi	Area-5		
470	4.90E-04	7.04E-05	6.65E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-130	JBER	C-5	Creech	semi	Area-5		
471	4.90E-04	7.01E-05	6.62E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-130	JBER	C-5	Desert Rock	semi	Area-5		
472	4.90E-04	7.15E-05	6.73E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-130	JBER	C-5	Nellis	semi	Area-5		
473	4.92E-04	5.35E-05	6.02E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-17	JBER	C-17	Tonopah	semi	Area-5		
474	4.93E-04	5.57E-05	6.25E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-17	JBER	C-17	Creech	semi	Area-5		
475	4.93E-04	5.55E-05	6.22E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-17	JBER	C-17	Desert Rock	semi	Area-5		
476	4.93E-04	5.66E-05	6.33E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-17	JBER	C-17	Nellis	semi	Area-5		
477	4.88E-04	6.95E-05	5.66E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-17	JBER	C-5	Tonopah	semi	Area-5		
478	4.89E-04	7.25E-05	5.87E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-17	JBER	C-5	Creech	semi	Area-5		
479	4.88E-04	7.21E-05	5.85E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-17	JBER	C-5	Desert Rock	semi	Area-5		
480	4.89E-04	7.35E-05	5.95E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-17	JBER	C-5	Nellis	semi	Area-5		
481	4.90E-04	4.99E-05	5.64E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-17	Tonopah	semi	Area-5				
482	4.91E-04	5.20E-05	5.86E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-17	Creech	semi	Area-5				
483	4.91E-04	5.18E-05	5.84E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-17	Desert Rock	semi	Area-5				
484	4.91E-04	5.28E-05	5.95E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-17	Nellis	semi	Area-5				
485	4.91E-04	5.55E-05	5.98E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-5	JBER	C-17	Tonopah	semi	Area-5		
486	4.92E-04	5.77E-05	6.20E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-5	JBER	C-17	Creech	semi	Area-5		
487	4.92E-04	5.74E-05	6.18E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-5	JBER	C-17	Desert Rock	semi	Area-5		
488	4.93E-04	5.85E-05	6.28E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-5	JBER	C-17	Nellis	semi	Area-5		
489	4.87E-04	7.15E-05	5.62E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-5	JBER	C-5	Tonopah	semi	Area-5		
490	4.88E-04	7.44E-05	5.83E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-5	JBER	C-5	Creech	semi	Area-5		
491	4.88E-04	7.41E-05	5.80E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-5	JBER	C-5	Desert Rock	semi	Area-5		
492	4.88E-04	7.55E-05	5.90E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-5	JBER	C-5	Nellis	semi	Area-5		
493	4.86E-04	6.65E-05	5.27E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-5	Tonopah	semi	Area-5				
494	4.86E-04	6.94E-05	5.47E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-5	Creech	semi	Area-5				
495	4.86E-04	6.91E-05	5.45E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-5	Desert Rock	semi	Area-5				
496	4.87E-04	7.05E-05	5.55E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Ft Wainwright	C-5	Nellis	semi	Area-5				
497	4.93E-04	5.15E-05	6.78E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-130	JBER	C-17	Tonopah	semi	Area-5		
498	4.94E-04	5.37E-05	7.01E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-130	JBER	C-17	Creech	semi	Area-5		
499	4.94E-04	5.34E-05	6.98E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-130	JBER	C-17	Desert Rock	semi	Area-5		
500	4.94E-04	5.45E-05	7.09E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-130	JBER	C-17	Nellis	semi	Area-5		
501	4.89E-04	6.74E-05	6.42E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-130	JBER	C-5	Tonopah	semi	Area-5		
502	4.90E-04	7.04E-05	6.63E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-130	JBER	C-5	Creech	semi	Area-5		
503	4.90E-04	7.00E-05	6.61E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-130	JBER	C-5	Desert Rock	semi	Area-5		
504	4.90E-04	7.15E-05	6.71E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-130	JBER	C-5	Nellis	semi	Area-5		
505	4.92E-04	5.34E-05	6.02E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-17	JBER	C-17	Tonopah	semi	Area-5		
506	4.93E-04	5.56E-05	6.25E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-17	JBER	C-17	Creech	semi	Area-5		
507	4.93E-04	5.54E-05	6.22E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-17	JBER	C-17	Desert Rock	semi	Area-5		
508	4.93E-04	5.65E-05	6.33E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-17	JBER	C-17	Nellis	semi	Area-5		
509	4.88E-04	6.94E-05	5.67E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-17	JBER	C-5	Tonopah	semi	Area-5		
510	4.89E-04	7.24E-05	5.88E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-17	JBER	C-5	Creech	semi	Area-5		
511	4.88E-04	7.20E-05	5.85E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-17	JBER	C-5	Desert Rock	semi	Area-5		
512	4.89E-04	7.35E-05	5.95E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-17	JBER	C-5	Nellis	semi	Area-5		
513	4.90E-04	4.95E-05	5.62E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-17	Tonopah	semi	Area-5				
514	4.91E-04	5.17E-05	5.84E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-17	Creech	semi	Area-5				
515	4.91E-04	5.15E-05	5.82E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-17	Desert Rock	semi	Area-5				
516	4.91E-04	5.24E-05	5.92E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-17	Nellis	semi	Area-5				
517	4.91E-04	5.54E-05	5.98E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-5	JBER	C-17	Tonopah	semi	Area-5		
518	4.92E-04	5.76E-05	6.21E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-5	JBER	C-17	Creech	semi	Area-5		
519	4.92E-04	5.73E-05	6.18E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-5	JBER	C-17	Desert Rock	semi	Area-5		
520	4.93E-04	5.84E-05	6.29E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-5	JBER	C-17	Nellis	semi	Area-5		
521	4.87E-04	7.13E-05	5.62E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-5	JBER	C-5	Tonopah	semi	Area-5		
522	4.88E-04	7.43E-05	5.83E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-5	JBER	C-5	Creech	semi	Area-5		
523	4.88E-04	7.39E-05	5.81E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-5	JBER	C-5	Desert Rock	semi	Area-5		
524	4.88E-04	7.54E-05	5.91E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-5	JBER	C-5	Nellis	semi	Area-5		
525	4.85E-04	6.60E-05	5.25E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-5	Tonopah	semi	Area-5				
526	4.86E-04	6.89E-05	5.46E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-5	Creech	semi	Area-5				
527	4.86E-04	6.86E-05	5.44E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-5	Desert Rock	semi	Area-5				
528	4.87E-04	7.00E-05	5.53E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	Eielson	C-5	Nellis	semi	Area-5				
529	4.93E-04	5.15E-05	6.78E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	JBER	C-17	Tonopah	semi	Area-5				
530	4.94E-04	5.37E-05	7.01E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	JBER	C-17	Creech	semi	Area-5				
531	4.94E-04	5.34E-05	6.98E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	JBER	C-17	Desert Rock	semi	Area-5				
532	4.94E-04	5.45E-05	7.09E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	JBER	C-17	Nellis	semi	Area-5				

533	4.89E-04	6.74E-05	6.42E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	JBER	C-5	Tonopah	semi	Area-5				
534	4.90E-04	7.04E-05	6.63E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	JBER	C-5	Creech	semi	Area-5				
535	4.90E-04	7.00E-05	6.61E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	JBER	C-5	Desert Rock	semi	Area-5				
536	4.90E-04	7.15E-05	6.71E-05	Burnt Mountain	CH-47	Ft Yukon	C-130	JBER	C-5	Nellis	semi	Area-5				
537	4.92E-04	5.26E-05	6.39E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-130	JBER	C-17	Tonopah	semi	Area-5		
538	4.93E-04	5.48E-05	6.62E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-130	JBER	C-17	Creech	semi	Area-5		
539	4.93E-04	5.45E-05	6.59E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-130	JBER	C-17	Desert Rock	semi	Area-5		
540	4.94E-04	5.56E-05	6.70E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-130	JBER	C-17	Nellis	semi	Area-5		
541	4.88E-04	6.85E-05	6.03E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-130	JBER	C-5	Tonopah	semi	Area-5		
542	4.89E-04	7.15E-05	6.24E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-130	JBER	C-5	Creech	semi	Area-5		
543	4.89E-04	7.11E-05	6.22E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-130	JBER	C-5	Desert Rock	semi	Area-5		
544	4.89E-04	7.26E-05	6.32E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-130	JBER	C-5	Nellis	semi	Area-5		
545	4.91E-04	5.46E-05	5.61E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-17	JBER	C-17	Tonopah	semi	Area-5		
546	4.92E-04	5.68E-05	5.84E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-17	JBER	C-17	Creech	semi	Area-5		
547	4.92E-04	5.66E-05	5.81E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-17	JBER	C-17	Desert Rock	semi	Area-5		
548	4.93E-04	5.76E-05	5.92E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-17	JBER	C-17	Nellis	semi	Area-5		
549	4.87E-04	7.06E-05	5.26E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-17	JBER	C-5	Tonopah	semi	Area-5		
550	4.88E-04	7.35E-05	5.46E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-17	JBER	C-5	Creech	semi	Area-5		
551	4.88E-04	7.32E-05	5.44E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-17	JBER	C-5	Desert Rock	semi	Area-5		
552	4.88E-04	7.46E-05	5.54E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-17	JBER	C-5	Nellis	semi	Area-5		
553	4.89E-04	5.09E-05	5.24E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-17	Tonopah	semi	Area-5				
554	4.90E-04	5.31E-05	5.46E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-17	Creech	semi	Area-5				
555	4.90E-04	5.29E-05	5.43E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-17	Desert Rock	semi	Area-5				
556	4.91E-04	5.39E-05	5.54E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-17	Nellis	semi	Area-5				
557	4.91E-04	5.66E-05	5.57E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-5	JBER	C-17	Tonopah	semi	Area-5		
558	4.92E-04	5.88E-05	5.80E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-5	JBER	C-17	Creech	semi	Area-5		
559	4.92E-04	5.85E-05	5.77E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-5	JBER	C-17	Desert Rock	semi	Area-5		
560	4.92E-04	5.96E-05	5.88E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-5	JBER	C-17	Nellis	semi	Area-5		
561	4.87E-04	7.25E-05	5.21E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-5	JBER	C-5	Tonopah	semi	Area-5		
562	4.88E-04	7.55E-05	5.42E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-5	JBER	C-5	Creech	semi	Area-5		
563	4.87E-04	7.51E-05	5.40E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-5	JBER	C-5	Desert Rock	semi	Area-5		
564	4.88E-04	7.66E-05	5.50E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-5	JBER	C-5	Nellis	semi	Area-5		
565	4.85E-04	6.76E-05	4.86E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-5	Tonopah	semi	Area-5				
566	4.86E-04	7.05E-05	5.07E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-5	Creech	semi	Area-5				
567	4.86E-04	7.02E-05	5.05E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-5	Desert Rock	semi	Area-5				
568	4.86E-04	7.15E-05	5.14E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Ft Wainwright	C-5	Nellis	semi	Area-5				
569	4.92E-04	5.26E-05	6.37E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-130	JBER	C-17	Tonopah	semi	Area-5		
570	4.93E-04	5.47E-05	6.59E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-130	JBER	C-17	Creech	semi	Area-5		
571	4.93E-04	5.45E-05	6.57E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-130	JBER	C-17	Desert Rock	semi	Area-5		
572	4.94E-04	5.56E-05	6.68E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-130	JBER	C-17	Nellis	semi	Area-5		
573	4.88E-04	6.85E-05	6.01E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-130	JBER	C-5	Tonopah	semi	Area-5		
574	4.89E-04	7.15E-05	6.22E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-130	JBER	C-5	Creech	semi	Area-5		
575	4.89E-04	7.11E-05	6.19E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-130	JBER	C-5	Desert Rock	semi	Area-5		
576	4.89E-04	7.26E-05	6.29E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-130	JBER	C-5	Nellis	semi	Area-5		
577	4.91E-04	5.45E-05	5.61E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-17	JBER	C-17	Tonopah	semi	Area-5		
578	4.92E-04	5.67E-05	5.83E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-17	JBER	C-17	Creech	semi	Area-5		
579	4.92E-04	5.65E-05	5.81E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-17	JBER	C-17	Desert Rock	semi	Area-5		
580	4.93E-04	5.76E-05	5.92E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-17	JBER	C-17	Nellis	semi	Area-5		
581	4.87E-04	7.05E-05	5.25E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-17	JBER	C-5	Tonopah	semi	Area-5		
582	4.88E-04	7.35E-05	5.46E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-17	JBER	C-5	Creech	semi	Area-5		
583	4.88E-04	7.31E-05	5.43E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-17	JBER	C-5	Desert Rock	semi	Area-5		
584	4.88E-04	7.46E-05	5.53E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-17	JBER	C-5	Nellis	semi	Area-5		
585	4.89E-04	5.06E-05	5.20E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-17	Tonopah	semi	Area-5				
586	4.90E-04	5.28E-05	5.43E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-17	Creech	semi	Area-5				
587	4.90E-04	5.26E-05	5.40E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-17	Desert Rock	semi	Area-5				
588	4.91E-04	5.35E-05	5.50E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-17	Nellis	semi	Area-5				
589	4.91E-04	5.65E-05	5.56E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-5	JBER	C-17	Tonopah	semi	Area-5		
590	4.92E-04	5.87E-05	5.79E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-5	JBER	C-17	Creech	semi	Area-5		
591	4.92E-04	5.84E-05	5.76E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-5	JBER	C-17	Desert Rock	semi	Area-5		
592	4.92E-04	5.95E-05	5.87E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-5	JBER	C-17	Nellis	semi	Area-5		
593	4.87E-04	7.24E-05	5.21E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-5	JBER	C-5	Tonopah	semi	Area-5		
594	4.88E-04	7.54E-05	5.41E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-5	JBER	C-5	Creech	semi	Area-5		
595	4.87E-04	7.50E-05	5.39E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-5	JBER	C-5	Desert Rock	semi	Area-5		
596	4.88E-04	7.65E-05	5.49E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-5	JBER	C-5	Nellis	semi	Area-5		
597	4.85E-04	6.71E-05	4.83E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-5	Tonopah	semi	Area-5				
598	4.86E-04	7.00E-05	5.04E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-5	Creech	semi	Area-5				
599	4.86E-04	6.97E-05	5.02E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-5	Desert Rock	semi	Area-5				
600	4.86E-04	7.11E-05	5.11E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Eielson	C-5	Nellis	semi	Area-5				
601	4.91E-04	5.45E-05	5.61E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	JBER	C-17	Tonopah	semi	Area-5				
602	4.92E-04	5.67E-05	5.83E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	JBER	C-17	Creech	semi	Area-5				
603	4.92E-04	5.65E-05	5.81E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	JBER	C-17	Desert Rock	semi	Area-5				
604	4.93E-04	5.76E-05	5.92E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	JBER	C-17	Nellis	semi	Area-5				
605	4.87E-04	7.05E-05	5.25E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	JBER	C-5	Tonopah	semi	Area-5				
606	4.88E-04	7.35E-05	5.46E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	JBER	C-5	Creech	semi	Area-5				
607	4.88E-04	7.31E-05	5.43E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	JBER	C-5	Desert Rock	semi	Area-5				
608	4.88E-04	7.46E-05	5.53E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	JBER	C-5	Nellis	semi	Area-5				
609	4.88E-04	4.87E-05	5.01E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Tonopah	semi	Area-5						
610	4.89E-04	5.09E-05	5.23E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Creech	semi	Area-5						
611	4.89E-04	5.07E-05	5.21E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Desert Rock	semi	Area-5						
612	4.90E-04	5.16E-05	5.30E-05	Burnt Mountain	CH-47	Ft Yukon	C-17	Nellis	semi	Area-5						
613	9.19E-04	4.96E-05	6.09E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-17	Tonopah	semi	Area-5		
614	9.20E-04	5.18E-05	6.32E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-17	Creech	semi	Area-5		
615	9.20E-04	5.16E-05	6.29E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-17	Desert Rock	semi	Area-5		
616	9.20E-04	5.26E-05	6.40E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-17	Nellis	semi	Area-5		
617	9.15E-04	6.56E-05	5.73E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-5	Tonopah	semi	Area-5		
618	9.16E-04	6.85E-05	5.94E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-5	Creech	semi	Area-5		
619	9.15E-04	6.82E-05	5.92E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-5	Desert Rock	semi	Area-5		
620	9.16E-04	6.96E-05	6.02E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-130	JBER	C-5	Nellis	semi	Area-5		
621	9.18E-04	5.17E-05	5.31E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-17	Tonopah	semi	Area-5		

622	9.19E-04	5.39E-05	5.54E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-17	Creech	semi	Area-5		
623	9.19E-04	5.36E-05	5.51E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-17	Desert Rock	semi	Area-5		
624	9.19E-04	5.47E-05	5.62E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-17	Nellis	semi	Area-5		
625	9.14E-04	6.76E-05	4.95E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-5	Tonopah	semi	Area-5		
626	9.15E-04	7.06E-05	5.16E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-5	Creech	semi	Area-5		
627	9.14E-04	7.02E-05	5.14E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-5	Desert Rock	semi	Area-5		
628	9.15E-04	7.17E-05	5.24E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-17	JBER	C-5	Nellis	semi	Area-5		
629	9.16E-04	4.80E-05	4.93E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-17	Tonopah	semi	Area-5				
630	9.17E-04	5.01E-05	5.15E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-17	Creech	semi	Area-5				
631	9.17E-04	4.99E-05	5.13E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-17	Desert Rock	semi	Area-5				
632	9.17E-04	5.09E-05	5.24E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-17	Nellis	semi	Area-5				
633	9.17E-04	5.36E-05	5.27E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-17	Tonopah	semi	Area-5		
634	9.18E-04	5.58E-05	5.49E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-17	Creech	semi	Area-5		
635	9.18E-04	5.56E-05	5.47E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-17	Desert Rock	semi	Area-5		
636	9.19E-04	5.66E-05	5.58E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-17	Nellis	semi	Area-5		
637	9.13E-04	6.96E-05	4.91E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-5	Tonopah	semi	Area-5		
638	9.14E-04	7.25E-05	5.12E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-5	Creech	semi	Area-5		
639	9.14E-04	7.22E-05	5.09E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-5	Desert Rock	semi	Area-5		
640	9.14E-04	7.36E-05	5.19E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-5	JBER	C-5	Nellis	semi	Area-5		
641	9.11E-04	6.46E-05	4.56E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-5	Tonopah	semi	Area-5				
642	9.12E-04	6.75E-05	4.76E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-5	Creech	semi	Area-5				
643	9.12E-04	6.72E-05	4.74E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-5	Desert Rock	semi	Area-5				
644	9.13E-04	6.86E-05	4.84E-05	Burnt Mountain	CH-47	Circle	CH-47	Ft Wainwright	C-5	Nellis	semi	Area-5				
645	9.00E-04	4.95E-05	6.05E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-17	Tonopah	semi	Area-5		
646	9.01E-04	5.17E-05	6.28E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-17	Creech	semi	Area-5		
647	9.01E-04	5.15E-05	6.25E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-17	Desert Rock	semi	Area-5		
648	9.01E-04	5.25E-05	6.36E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-17	Nellis	semi	Area-5		
649	8.96E-04	6.55E-05	5.70E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-5	Tonopah	semi	Area-5		
650	8.97E-04	6.84E-05	5.90E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-5	Creech	semi	Area-5		
651	8.96E-04	6.81E-05	5.88E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-5	Desert Rock	semi	Area-5		
652	8.97E-04	6.95E-05	5.98E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-130	JBER	C-5	Nellis	semi	Area-5		
653	8.99E-04	5.15E-05	5.30E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-17	Tonopah	semi	Area-5		
654	9.00E-04	5.37E-05	5.52E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-17	Creech	semi	Area-5		
655	9.00E-04	5.35E-05	5.50E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-17	Desert Rock	semi	Area-5		
656	9.00E-04	5.45E-05	5.61E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-17	Nellis	semi	Area-5		
657	8.95E-04	6.75E-05	4.94E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-5	Tonopah	semi	Area-5		
658	8.95E-04	7.04E-05	5.15E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-5	Creech	semi	Area-5		
659	8.95E-04	7.01E-05	5.12E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-5	Desert Rock	semi	Area-5		
660	8.96E-04	7.15E-05	5.22E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-17	JBER	C-5	Nellis	semi	Area-5		
661	8.97E-04	4.76E-05	4.89E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-17	Tonopah	semi	Area-5				
662	8.98E-04	4.97E-05	5.11E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-17	Creech	semi	Area-5				
663	8.98E-04	4.95E-05	5.09E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-17	Desert Rock	semi	Area-5				
664	8.98E-04	5.05E-05	5.19E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-17	Nellis	semi	Area-5				
665	8.98E-04	5.34E-05	5.25E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-17	Tonopah	semi	Area-5		
666	8.99E-04	5.56E-05	5.48E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-17	Creech	semi	Area-5		
667	8.99E-04	5.54E-05	5.45E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-17	Desert Rock	semi	Area-5		
668	9.00E-04	5.64E-05	5.56E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-17	Nellis	semi	Area-5		
669	8.94E-04	6.94E-05	4.89E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-5	Tonopah	semi	Area-5		
670	8.95E-04	7.23E-05	5.10E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-5	Creech	semi	Area-5		
671	8.95E-04	7.20E-05	5.08E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-5	Desert Rock	semi	Area-5		
672	8.95E-04	7.34E-05	5.18E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-5	JBER	C-5	Nellis	semi	Area-5		
673	8.92E-04	6.41E-05	4.52E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-5	Tonopah	semi	Area-5				
674	8.93E-04	6.70E-05	4.73E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-5	Creech	semi	Area-5				
675	8.93E-04	6.67E-05	4.71E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-5	Desert Rock	semi	Area-5				
676	8.94E-04	6.80E-05	4.80E-05	Burnt Mountain	CH-47	Circle	CH-47	Eielson	C-5	Nellis	semi	Area-5				
677	4.51E-04	5.13E-05	6.73E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-17	Tonopah	semi	Area-5		
678	4.52E-04	5.35E-05	6.95E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-17	Creech	semi	Area-5		
679	4.52E-04	5.32E-05	6.93E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-17	Desert Rock	semi	Area-5		
680	4.53E-04	5.43E-05	7.04E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-17	Nellis	semi	Area-5		
681	4.47E-04	6.73E-05	6.37E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-5	Tonopah	semi	Area-5		
682	4.48E-04	7.02E-05	6.58E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-5	Creech	semi	Area-5		
683	4.48E-04	6.99E-05	6.55E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-5	Desert Rock	semi	Area-5		
684	4.48E-04	7.13E-05	6.65E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-130	JBER	C-5	Nellis	semi	Area-5		
685	4.50E-04	5.34E-05	5.95E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-17	Tonopah	semi	Area-5		
686	4.51E-04	5.55E-05	6.17E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-17	Creech	semi	Area-5		
687	4.51E-04	5.53E-05	6.15E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-17	Desert Rock	semi	Area-5		
688	4.51E-04	5.64E-05	6.26E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-17	Nellis	semi	Area-5		
689	4.46E-04	6.93E-05	5.59E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-5	Tonopah	semi	Area-5		
690	4.47E-04	7.23E-05	5.80E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-5	Creech	semi	Area-5		
691	4.47E-04	7.19E-05	5.77E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-5	Desert Rock	semi	Area-5		
692	4.47E-04	7.34E-05	5.88E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-17	JBER	C-5	Nellis	semi	Area-5		
693	4.48E-04	4.97E-05	5.57E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-17	Tonopah	semi	Area-5				
694	4.49E-04	5.18E-05	5.79E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-17	Creech	semi	Area-5				
695	4.49E-04	5.16E-05	5.77E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-17	Desert Rock	semi	Area-5				
696	4.50E-04	5.26E-05	5.87E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-17	Nellis	semi	Area-5				
697	4.49E-04	5.53E-05	5.90E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-17	Tonopah	semi	Area-5		
698	4.51E-04	5.75E-05	6.13E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-17	Creech	semi	Area-5		
699	4.50E-04	5.73E-05	6.10E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-17	Desert Rock	semi	Area-5		
700	4.51E-04	5.83E-05	6.21E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-17	Nellis	semi	Area-5		
701	4.45E-04	7.13E-05	5.55E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-5	Tonopah	semi	Area-5		
702	4.46E-04	7.42E-05	5.75E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-5	Creech	semi	Area-5		
703	4.46E-04	7.39E-05	5.73E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-5	Desert Rock	semi	Area-5		
704	4.47E-04	7.53E-05	5.83E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-5	JBER	C-5	Nellis	semi	Area-5		
705	4.44E-04	6.63E-05	5.20E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-5	Tonopah	semi	Area-5				
706	4.45E-04	6.92E-05	5.40E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-5	Creech	semi	Area-5				
707	4.44E-04	6.89E-05	5.38E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-5	Desert Rock	semi	Area-5				
708	4.45E-04	7.03E-05	5.48E-05	Burnt Mountain	CH-47	Circle	C-130	Ft Wainwright	C-5	Nellis	semi	Area-5				
709	4.51E-04	5.11E-05	6.67E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-130	JBER	C-17	Tonopah	semi	Area-5		
710	4.52E-04	5.33E-05	6.89E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-130	JBER	C-17	Creech	semi	Area-5		

711	4.52E-04	5.31E-05	6.86E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-130	JBER	C-17	Desert Rock	semi	Area-5		
712	4.52E-04	5.41E-05	6.97E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-130	JBER	C-17	Nellis	semi	Area-5		
713	4.47E-04	6.71E-05	6.31E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-130	JBER	C-5	Tonopah	semi	Area-5		
714	4.48E-04	7.01E-05	6.52E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-130	JBER	C-5	Creech	semi	Area-5		
715	4.48E-04	6.97E-05	6.49E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-130	JBER	C-5	Desert Rock	semi	Area-5		
716	4.48E-04	7.11E-05	6.59E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-130	JBER	C-5	Nellis	semi	Area-5		
717	4.50E-04	5.31E-05	5.91E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-17	JBER	C-17	Tonopah	semi	Area-5		
718	4.51E-04	5.53E-05	6.13E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-17	JBER	C-17	Creech	semi	Area-5		
719	4.51E-04	5.51E-05	6.11E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-17	JBER	C-17	Desert Rock	semi	Area-5		
720	4.51E-04	5.61E-05	6.22E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-17	JBER	C-17	Nellis	semi	Area-5		
721	4.46E-04	6.91E-05	5.55E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-17	JBER	C-5	Tonopah	semi	Area-5		
722	4.47E-04	7.20E-05	5.76E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-17	JBER	C-5	Creech	semi	Area-5		
723	4.46E-04	7.17E-05	5.73E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-17	JBER	C-5	Desert Rock	semi	Area-5		
724	4.47E-04	7.31E-05	5.83E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-17	JBER	C-5	Nellis	semi	Area-5		
725	4.48E-04	4.92E-05	5.50E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-17	Tonopah	semi	Area-5				
726	4.49E-04	5.14E-05	5.72E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-17	Creech	semi	Area-5				
727	4.49E-04	5.12E-05	5.70E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-17	Desert Rock	semi	Area-5				
728	4.49E-04	5.21E-05	5.80E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-17	Nellis	semi	Area-5				
729	4.49E-04	5.50E-05	5.86E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-5	JBER	C-17	Tonopah	semi	Area-5		
730	4.50E-04	5.72E-05	6.09E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-5	JBER	C-17	Creech	semi	Area-5		
731	4.50E-04	5.70E-05	6.06E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-5	JBER	C-17	Desert Rock	semi	Area-5		
732	4.51E-04	5.81E-05	6.17E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-5	JBER	C-17	Nellis	semi	Area-5		
733	4.45E-04	7.10E-05	5.51E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-5	JBER	C-5	Tonopah	semi	Area-5		
734	4.46E-04	7.40E-05	5.71E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-5	JBER	C-5	Creech	semi	Area-5		
735	4.46E-04	7.36E-05	5.69E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-5	JBER	C-5	Desert Rock	semi	Area-5		
736	4.46E-04	7.50E-05	5.79E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-5	JBER	C-5	Nellis	semi	Area-5		
737	4.43E-04	6.57E-05	5.13E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-5	Tonopah	semi	Area-5				
738	4.44E-04	6.86E-05	5.34E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-5	Creech	semi	Area-5				
739	4.44E-04	6.83E-05	5.32E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-5	Desert Rock	semi	Area-5				
740	4.45E-04	6.96E-05	5.41E-05	Burnt Mountain	CH-47	Circle	C-130	Eielson	C-5	Nellis	semi	Area-5				
741	4.51E-04	5.11E-05	6.63E-05	Burnt Mountain	CH-47	Circle	C-130	JBER	C-17	Tonopah	semi	Area-5				
742	4.52E-04	5.33E-05	6.86E-05	Burnt Mountain	CH-47	Circle	C-130	JBER	C-17	Creech	semi	Area-5				
743	4.52E-04	5.30E-05	6.83E-05	Burnt Mountain	CH-47	Circle	C-130	JBER	C-17	Desert Rock	semi	Area-5				
744	4.52E-04	5.41E-05	6.94E-05	Burnt Mountain	CH-47	Circle	C-130	JBER	C-17	Nellis	semi	Area-5				
745	4.47E-04	6.70E-05	6.28E-05	Burnt Mountain	CH-47	Circle	C-130	JBER	C-5	Tonopah	semi	Area-5				
746	4.48E-04	7.00E-05	6.48E-05	Burnt Mountain	CH-47	Circle	C-130	JBER	C-5	Creech	semi	Area-5				
747	4.47E-04	6.96E-05	6.46E-05	Burnt Mountain	CH-47	Circle	C-130	JBER	C-5	Desert Rock	semi	Area-5				
748	4.48E-04	7.11E-05	6.56E-05	Burnt Mountain	CH-47	Circle	C-130	JBER	C-5	Nellis	semi	Area-5				
749	4.49E-04	4.96E-05	6.09E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-17	Tonopah	semi	Area-5		
750	4.50E-04	5.18E-05	6.32E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-17	Creech	semi	Area-5		
751	4.50E-04	5.16E-05	6.29E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-17	Desert Rock	semi	Area-5		
752	4.51E-04	5.26E-05	6.40E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-17	Nellis	semi	Area-5		
753	4.45E-04	6.56E-05	5.73E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-5	Tonopah	semi	Area-5		
754	4.46E-04	6.85E-05	5.94E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-5	Creech	semi	Area-5		
755	4.46E-04	6.82E-05	5.92E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-5	Desert Rock	semi	Area-5		
756	4.46E-04	6.96E-05	6.02E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-130	JBER	C-5	Nellis	semi	Area-5		
757	4.48E-04	5.17E-05	5.31E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-17	Tonopah	semi	Area-5		
758	4.49E-04	5.39E-05	5.54E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-17	Creech	semi	Area-5		
759	4.49E-04	5.36E-05	5.51E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-17	Desert Rock	semi	Area-5		
760	4.50E-04	5.47E-05	5.62E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-17	Nellis	semi	Area-5		
761	4.44E-04	6.76E-05	4.95E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-5	Tonopah	semi	Area-5		
762	4.45E-04	7.06E-05	5.16E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-5	Creech	semi	Area-5		
763	4.45E-04	7.02E-05	5.14E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-5	Desert Rock	semi	Area-5		
764	4.45E-04	7.17E-05	5.24E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-17	JBER	C-5	Nellis	semi	Area-5		
765	4.46E-04	4.80E-05	4.93E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-17	Tonopah	semi	Area-5				
766	4.47E-04	5.01E-05	5.15E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-17	Creech	semi	Area-5				
767	4.47E-04	4.99E-05	5.13E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-17	Desert Rock	semi	Area-5				
768	4.48E-04	5.09E-05	5.24E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-17	Nellis	semi	Area-5				
769	4.47E-04	5.36E-05	5.27E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-17	Tonopah	semi	Area-5		
770	4.49E-04	5.58E-05	5.49E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-17	Creech	semi	Area-5		
771	4.49E-04	5.56E-05	5.47E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-17	Desert Rock	semi	Area-5		
772	4.49E-04	5.66E-05	5.58E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-17	Nellis	semi	Area-5		
773	4.43E-04	6.96E-05	4.91E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-5	Tonopah	semi	Area-5		
774	4.44E-04	7.25E-05	5.12E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-5	Creech	semi	Area-5		
775	4.44E-04	7.22E-05	5.09E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-5	Desert Rock	semi	Area-5		
776	4.45E-04	7.36E-05	5.19E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-5	JBER	C-5	Nellis	semi	Area-5		
777	4.42E-04	6.46E-05	4.56E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-5	Tonopah	semi	Area-5				
778	4.43E-04	6.75E-05	4.76E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-5	Creech	semi	Area-5				
779	4.43E-04	6.72E-05	4.74E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-5	Desert Rock	semi	Area-5				
780	4.43E-04	6.86E-05	4.84E-05	Burnt Mountain	CH-47	Circle	semi	Ft Wainwright	C-5	Nellis	semi	Area-5				
781	4.49E-04	4.95E-05	6.05E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-130	JBER	C-17	Tonopah	semi	Area-5		
782	4.50E-04	5.17E-05	6.28E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-130	JBER	C-17	Creech	semi	Area-5		
783	4.50E-04	5.15E-05	6.25E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-130	JBER	C-17	Desert Rock	semi	Area-5		
784	4.51E-04	5.25E-05	6.36E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-130	JBER	C-17	Nellis	semi	Area-5		
785	4.45E-04	6.55E-05	5.70E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-130	JBER	C-5	Tonopah	semi	Area-5		
786	4.46E-04	6.84E-05	5.90E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-130	JBER	C-5	Creech	semi	Area-5		
787	4.46E-04	6.81E-05	5.88E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-130	JBER	C-5	Desert Rock	semi	Area-5		
788	4.46E-04	6.95E-05	5.98E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-130	JBER	C-5	Nellis	semi	Area-5		
789	4.48E-04	5.15E-05	5.30E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-17	JBER	C-17	Tonopah	semi	Area-5		
790	4.49E-04	5.37E-05	5.52E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-17	JBER	C-17	Creech	semi	Area-5		
791	4.49E-04	5.35E-05	5.50E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-17	JBER	C-17	Desert Rock	semi	Area-5		
792	4.50E-04	5.45E-05	5.61E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-17	JBER	C-17	Nellis	semi	Area-5		
793	4.44E-04	6.75E-05	4.94E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-17	JBER	C-5	Tonopah	semi	Area-5		
794	4.45E-04	7.04E-05	5.15E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-17	JBER	C-5	Creech	semi	Area-5		
795	4.45E-04	7.01E-05	5.12E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-17	JBER	C-5	Desert Rock	semi	Area-5		
796	4.45E-04	7.15E-05	5.22E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-17	JBER	C-5	Nellis	semi	Area-5		
797	4.46E-04	4.76E-05	4.89E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-17	Tonopah	semi	Area-5				
798	4.47E-04	4.97E-05	5.11E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-17	Creech	semi	Area-5				
799	4.47E-04	4.95E-05	5.09E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-17	Desert Rock	semi	Area-5				

800	4.47E-04	5.05E-05	5.19E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-17	Nellis	semi	Area-5				
801	4.47E-04	5.34E-05	5.25E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-5	JBER	C-17	Tonopah	semi	Area-5		
802	4.49E-04	5.56E-05	5.48E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-5	JBER	C-17	Creech	semi	Area-5		
803	4.48E-04	5.54E-05	5.45E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-5	JBER	C-17	Desert Rock	semi	Area-5		
804	4.49E-04	5.64E-05	5.56E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-5	JBER	C-17	Nellis	semi	Area-5		
805	4.43E-04	6.94E-05	4.89E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-5	JBER	C-5	Tonopah	semi	Area-5		
806	4.44E-04	7.23E-05	5.10E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-5	JBER	C-5	Creech	semi	Area-5		
807	4.44E-04	7.20E-05	5.08E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-5	JBER	C-5	Desert Rock	semi	Area-5		
808	4.45E-04	7.34E-05	5.18E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-5	JBER	C-5	Nellis	semi	Area-5		
809	4.42E-04	6.41E-05	4.52E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-5	Tonopah	semi	Area-5				
810	4.42E-04	6.70E-05	4.73E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-5	Creech	semi	Area-5				
811	4.42E-04	6.67E-05	4.71E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-5	Desert Rock	semi	Area-5				
812	4.43E-04	6.80E-05	4.80E-05	Burnt Mountain	CH-47	Circle	semi	Eielson	C-5	Nellis	semi	Area-5				
813	7.79E-04	4.96E-05	6.09E-05	Burnt Mountain	CH-47	Ft Wainwright	C-130	JBER	C-17	Tonopah	semi	Area-5				
814	7.80E-04	5.18E-05	6.32E-05	Burnt Mountain	CH-47	Ft Wainwright	C-130	JBER	C-17	Creech	semi	Area-5				
815	7.80E-04	5.16E-05	6.29E-05	Burnt Mountain	CH-47	Ft Wainwright	C-130	JBER	C-17	Desert Rock	semi	Area-5				
816	7.80E-04	5.26E-05	6.40E-05	Burnt Mountain	CH-47	Ft Wainwright	C-130	JBER	C-17	Nellis	semi	Area-5				
817	7.74E-04	6.56E-05	5.73E-05	Burnt Mountain	CH-47	Ft Wainwright	C-130	JBER	C-5	Tonopah	semi	Area-5				
818	7.75E-04	6.85E-05	5.94E-05	Burnt Mountain	CH-47	Ft Wainwright	C-130	JBER	C-5	Creech	semi	Area-5				
819	7.75E-04	6.82E-05	5.92E-05	Burnt Mountain	CH-47	Ft Wainwright	C-130	JBER	C-5	Desert Rock	semi	Area-5				
820	7.76E-04	6.96E-05	6.02E-05	Burnt Mountain	CH-47	Ft Wainwright	C-130	JBER	C-5	Nellis	semi	Area-5				
821	7.78E-04	5.17E-05	5.31E-05	Burnt Mountain	CH-47	Ft Wainwright	C-17	JBER	C-17	Tonopah	semi	Area-5				
822	7.79E-04	5.39E-05	5.54E-05	Burnt Mountain	CH-47	Ft Wainwright	C-17	JBER	C-17	Creech	semi	Area-5				
823	7.79E-04	5.36E-05	5.51E-05	Burnt Mountain	CH-47	Ft Wainwright	C-17	JBER	C-17	Desert Rock	semi	Area-5				
824	7.79E-04	5.47E-05	5.62E-05	Burnt Mountain	CH-47	Ft Wainwright	C-17	JBER	C-17	Nellis	semi	Area-5				
825	7.73E-04	6.76E-05	4.95E-05	Burnt Mountain	CH-47	Ft Wainwright	C-17	JBER	C-5	Tonopah	semi	Area-5				
826	7.74E-04	7.06E-05	5.16E-05	Burnt Mountain	CH-47	Ft Wainwright	C-17	JBER	C-5	Creech	semi	Area-5				
827	7.74E-04	7.02E-05	5.14E-05	Burnt Mountain	CH-47	Ft Wainwright	C-17	JBER	C-5	Desert Rock	semi	Area-5				
828	7.75E-04	7.17E-05	5.24E-05	Burnt Mountain	CH-47	Ft Wainwright	C-17	JBER	C-5	Nellis	semi	Area-5				
829	7.76E-04	4.80E-05	4.93E-05	Burnt Mountain	CH-47	Ft Wainwright	C-17	Tonopah	semi	Area-5						
830	7.77E-04	5.01E-05	5.15E-05	Burnt Mountain	CH-47	Ft Wainwright	C-17	Creech	semi	Area-5						
831	7.77E-04	4.99E-05	5.13E-05	Burnt Mountain	CH-47	Ft Wainwright	C-17	Desert Rock	semi	Area-5						
832	7.77E-04	5.09E-05	5.24E-05	Burnt Mountain	CH-47	Ft Wainwright	C-17	Nellis	semi	Area-5						
833	7.77E-04	5.36E-05	5.27E-05	Burnt Mountain	CH-47	Ft Wainwright	C-5	JBER	C-17	Tonopah	semi	Area-5				
834	7.78E-04	5.58E-05	5.49E-05	Burnt Mountain	CH-47	Ft Wainwright	C-5	JBER	C-17	Creech	semi	Area-5				
835	7.78E-04	5.56E-05	5.47E-05	Burnt Mountain	CH-47	Ft Wainwright	C-5	JBER	C-17	Desert Rock	semi	Area-5				
836	7.79E-04	5.66E-05	5.58E-05	Burnt Mountain	CH-47	Ft Wainwright	C-5	JBER	C-17	Nellis	semi	Area-5				
837	7.73E-04	6.96E-05	4.91E-05	Burnt Mountain	CH-47	Ft Wainwright	C-5	JBER	C-5	Tonopah	semi	Area-5				
838	7.74E-04	7.25E-05	5.12E-05	Burnt Mountain	CH-47	Ft Wainwright	C-5	JBER	C-5	Creech	semi	Area-5				
839	7.74E-04	7.22E-05	5.09E-05	Burnt Mountain	CH-47	Ft Wainwright	C-5	JBER	C-5	Desert Rock	semi	Area-5				
840	7.74E-04	7.36E-05	5.19E-05	Burnt Mountain	CH-47	Ft Wainwright	C-5	JBER	C-5	Nellis	semi	Area-5				
841	7.71E-04	6.46E-05	4.56E-05	Burnt Mountain	CH-47	Ft Wainwright	C-5	Tonopah	semi	Area-5						
842	7.72E-04	6.75E-05	4.76E-05	Burnt Mountain	CH-47	Ft Wainwright	C-5	Creech	semi	Area-5						
843	7.72E-04	6.72E-05	4.74E-05	Burnt Mountain	CH-47	Ft Wainwright	C-5	Desert Rock	semi	Area-5						
844	7.73E-04	6.86E-05	4.84E-05	Burnt Mountain	CH-47	Ft Wainwright	C-5	Nellis	semi	Area-5						
845	7.97E-04	4.95E-05	6.05E-05	Burnt Mountain	CH-47	Eielson	C-130	JBER	C-17	Tonopah	semi	Area-5				
846	7.99E-04	5.17E-05	6.28E-05	Burnt Mountain	CH-47	Eielson	C-130	JBER	C-17	Creech	semi	Area-5				
847	7.98E-04	5.15E-05	6.25E-05	Burnt Mountain	CH-47	Eielson	C-130	JBER	C-17	Desert Rock	semi	Area-5				
848	7.99E-04	5.25E-05	6.36E-05	Burnt Mountain	CH-47	Eielson	C-130	JBER	C-17	Nellis	semi	Area-5				
849	7.93E-04	6.55E-05	5.70E-05	Burnt Mountain	CH-47	Eielson	C-130	JBER	C-5	Tonopah	semi	Area-5				
850	7.94E-04	6.84E-05	5.90E-05	Burnt Mountain	CH-47	Eielson	C-130	JBER	C-5	Creech	semi	Area-5				
851	7.94E-04	6.81E-05	5.88E-05	Burnt Mountain	CH-47	Eielson	C-130	JBER	C-5	Desert Rock	semi	Area-5				
852	7.95E-04	6.95E-05	5.98E-05	Burnt Mountain	CH-47	Eielson	C-130	JBER	C-5	Nellis	semi	Area-5				
853	7.96E-04	5.15E-05	5.30E-05	Burnt Mountain	CH-47	Eielson	C-17	JBER	C-17	Tonopah	semi	Area-5				
854	7.98E-04	5.37E-05	5.52E-05	Burnt Mountain	CH-47	Eielson	C-17	JBER	C-17	Creech	semi	Area-5				
855	7.97E-04	5.35E-05	5.50E-05	Burnt Mountain	CH-47	Eielson	C-17	JBER	C-17	Desert Rock	semi	Area-5				
856	7.98E-04	5.45E-05	5.61E-05	Burnt Mountain	CH-47	Eielson	C-17	JBER	C-17	Nellis	semi	Area-5				
857	7.92E-04	6.75E-05	4.94E-05	Burnt Mountain	CH-47	Eielson	C-17	JBER	C-5	Tonopah	semi	Area-5				
858	7.93E-04	7.04E-05	5.15E-05	Burnt Mountain	CH-47	Eielson	C-17	JBER	C-5	Creech	semi	Area-5				
859	7.93E-04	7.01E-05	5.12E-05	Burnt Mountain	CH-47	Eielson	C-17	JBER	C-5	Desert Rock	semi	Area-5				
860	7.94E-04	7.15E-05	5.22E-05	Burnt Mountain	CH-47	Eielson	C-17	JBER	C-5	Nellis	semi	Area-5				
861	7.94E-04	4.76E-05	4.89E-05	Burnt Mountain	CH-47	Eielson	C-17	Tonopah	semi	Area-5						
862	7.95E-04	4.97E-05	5.11E-05	Burnt Mountain	CH-47	Eielson	C-17	Creech	semi	Area-5						
863	7.95E-04	4.95E-05	5.09E-05	Burnt Mountain	CH-47	Eielson	C-17	Desert Rock	semi	Area-5						
864	7.96E-04	5.05E-05	5.19E-05	Burnt Mountain	CH-47	Eielson	C-17	Nellis	semi	Area-5						
865	7.96E-04	5.34E-05	5.25E-05	Burnt Mountain	CH-47	Eielson	C-5	JBER	C-17	Tonopah	semi	Area-5				
866	7.97E-04	5.56E-05	5.48E-05	Burnt Mountain	CH-47	Eielson	C-5	JBER	C-17	Creech	semi	Area-5				
867	7.97E-04	5.54E-05	5.45E-05	Burnt Mountain	CH-47	Eielson	C-5	JBER	C-17	Desert Rock	semi	Area-5				
868	7.97E-04	5.64E-05	5.56E-05	Burnt Mountain	CH-47	Eielson	C-5	JBER	C-17	Nellis	semi	Area-5				
869	7.92E-04	6.94E-05	4.89E-05	Burnt Mountain	CH-47	Eielson	C-5	JBER	C-5	Tonopah	semi	Area-5				
870	7.93E-04	7.23E-05	5.10E-05	Burnt Mountain	CH-47	Eielson	C-5	JBER	C-5	Creech	semi	Area-5				
871	7.93E-04	7.20E-05	5.08E-05	Burnt Mountain	CH-47	Eielson	C-5	JBER	C-5	Desert Rock	semi	Area-5				
872	7.93E-04	7.34E-05	5.18E-05	Burnt Mountain	CH-47	Eielson	C-5	JBER	C-5	Nellis	semi	Area-5				
873	7.90E-04	6.41E-05	4.52E-05	Burnt Mountain	CH-47	Eielson	C-5	Tonopah	semi	Area-5						
874	7.91E-04	6.70E-05	4.73E-05	Burnt Mountain	CH-47	Eielson	C-5	Creech	semi	Area-5						
875	7.91E-04	6.67E-05	4.71E-05	Burnt Mountain	CH-47	Eielson	C-5	Desert Rock	semi	Area-5						
876	7.91E-04	6.80E-05	4.80E-05	Burnt Mountain	CH-47	Eielson	C-5	Nellis	semi	Area-5						

Attachment #5 Routing Data

From: Burnt Mountain, Ft Yukon, Circle, Ft Wainwright, Eielson, JBER, Tonopah, Desert Rock, Creech, Nellis (aircraft rows: CH-47, C-130, C-5, C-17, semi)

To: Ft Yukon

From	Aircraft	distance	sorties	fuel needed	prob of accident: 5 year avg	10 year avg	lifetime
Burnt Mountain	CH-47	51	20	3.01E+02	2.31E-05	0.00E+00	0.00E+00

To: Circle

From	Aircraft	distance	sorties	fuel needed	prob of accident: 5 year avg	10 year avg	lifetime
Burnt Mountain	CH-47	111	10	5.52E+02	4.20E-05	0.00E+00	0.00E+00
Ft Yukon	CH-47	61	10	3.31E+02	2.31E-05	0.00E+00	0.00E+00
Ft Yukon	C-130		2	1.84E+02	4.73E-07	4.15E-07	1.57E-06

To: Ft Wainwright

From	Aircraft	distance	sorties	fuel needed	prob of accident: 5 year avg	10 year avg	lifetime
Burnt Mountain	CH-47	198	10	1.07E+03	7.59E-05	0.00E+00	0.00E+00
Ft Yukon	CH-47	186	10	7.49E+02	5.23E-05	0.00E+00	0.00E+00
Ft Yukon	C-130		2	3.26E+02	1.07E-06	9.39E-07	3.54E-06
Ft Yukon	C-17		1	8.07E+02	1.57E-06	2.04E-06	3.83E-06
Circle	CH-47	124	10	6.73E+02	4.70E-05	0.00E+00	0.00E+00
Circle	C-130		2	2.62E+02	9.59E-07	8.44E-07	3.19E-06
Circle	semi		2	2.07E+01	0.00E+00		

To: Eielson

From	Aircraft	distance	sorties	fuel needed	prob of accident: 5 year avg	10 year avg	lifetime
Burnt Mountain	CH-47	203	10	1.10E+03	7.69E-05	0.00E+00	########
Ft Yukon	CH-47	142	10	7.71E+02	5.38E-05	0.00E+00	########
Ft Yukon	C-130		2	3.35E+02	1.10E-06	9.66E-07	3.64E-06
Ft Yukon	C-17		1	8.30E+02	1.61E-06	3.03E-06	3.11E-06
Circle	CH-47	119	10	6.46E+02	4.51E-05	0.00E+00	########
Circle	C-130		2	2.81E+02	9.20E-07	8.10E-07	3.06E-06
Circle	semi		2	1.98E+01	0.00E+00		

To: JBER

From	Aircraft	distance	sorties	fuel needed	prob of accident: 5 year avg	10 year avg	lifetime
Burnt Mountain		401					
Ft Yukon	C-130	408	2	9.40E+02	3.08E-06	2.72E-06	1.02E-05
Ft Yukon	C-17		1	2.34E+03	4.56E-06	8.53E-06	8.77E-06
Circle	C-130	371	2	8.75E+02	2.87E-06	2.52E-06	9.52E-06
Ft Wainwright	C-130	265	2	6.25E+02	2.05E-06	1.80E-06	6.80E-06
Ft Wainwright	C-5		1	1.80E+03	2.56E-06	7.61E-06	5.27E-06
Ft Wainwright	C-17		1	1.65E+03	3.01E-06	5.65E-06	5.81E-06
Eielson	C-130	258	2	6.08E+02	1.99E-06	1.75E-06	6.62E-06
Eielson	C-5		1	1.75E+03	2.44E-06	7.41E-06	5.23E-06
Eielson	C-17		1	1.51E+03	2.93E-06	5.50E-06	5.68E-06

To: Tonopah

From	Aircraft	distance	sorties	fuel needed	prob of accident: 5 year avg	10 year avg	lifetime
Ft Yukon	C-17	2384	1	1.33E+04	2.60E-05	4.87E-05	5.01E-05
Ft Wainwright	C-5	2250	1	1.53E+04	2.13E-05	6.48E-05	4.58E-05
Ft Wainwright	C-17		1	1.32E+04	2.56E-05	4.83E-05	4.93E-05
Eielson	C-5	2331	1	1.52E+04	2.11E-05	6.41E-05	4.52E-05
Eielson	C-17		1	1.30E+04	2.54E-05	4.75E-05	4.88E-05
JBER	C-5	2157	1	1.47E+04	2.04E-05	6.20E-05	4.37E-05
JBER	C-17		1	1.26E+04	2.45E-05	4.60E-05	4.73E-05

To: Desert Rock

From	Aircraft	distance	sorties	fuel needed	prob of accident: 5 year avg	10 year avg	lifetime
Ft Yukon	C-17	2375	1	1.39E+04	2.70E-05	5.07E-05	5.21E-05
Ft Wainwright	C-5	2340	1	1.59E+04	2.21E-05	6.72E-05	4.74E-05
Ft Wainwright	C-17		1	1.37E+04	2.66E-05	4.99E-05	5.13E-05
Eielson	C-5	2322	1	1.58E+04	2.19E-05	6.67E-05	4.71E-05
Eielson	C-17		1	1.33E+04	2.64E-05	4.95E-05	5.09E-05
JBER	C-5	2248	1	1.53E+04	2.13E-05	6.46E-05	4.56E-05
JBER	C-17		1	1.31E+04	2.55E-05	4.88E-05	4.93E-05

To: Creech

From	Aircraft	distance	sorties	fuel needed	prob of accident: 5 year avg	10 year avg	lifetime
Ft Yukon	C-17	2384	1	1.39E+04	2.71E-05	5.08E-05	5.22E-05
Ft Wainwright	C-5	2350	1	1.60E+04	2.22E-05	6.75E-05	4.76E-05
Ft Wainwright	C-17		1	1.37E+04	2.67E-05	5.01E-05	5.15E-05
Eielson	C-5	2330	1	1.59E+04	2.20E-05	6.70E-05	4.73E-05
Eielson	C-17		1	1.36E+04	2.65E-05	4.97E-05	5.11E-05
JBER	C-5	2260	1	1.54E+04	2.13E-05	6.49E-05	4.58E-05
JBER	C-17		1	1.32E+04	2.57E-05	4.82E-05	4.96E-05

To: Nellis

From	Aircraft	distance	sorties	fuel needed	prob of accident: 5 year avg	10 year avg	lifetime
Ft Yukon	C-17	2418	1	1.47E+04	2.75E-05	[illegible]	[illegible]
Ft Wainwright	C-5	2368	1	1.60E+04	2.38E-05	[illegible]	[illegible]
Ft Wainwright	C-17		1	1.40E+04	2.71E-05	[illegible]	[illegible]
Eielson	C-5	2364	1	1.61E+04	2.24E-05	[illegible]	[illegible]
Eielson	C-17		1	1.38E+04	2.69E-05	[illegible]	[illegible]
JBER	C-5	2298	1	1.56E+04	2.17E-05	[illegible]	[illegible]
JBER	C-17		1	1.34E+04	2.61E-05	[illegible]	[illegible]

Attachment #4 Accident Risk Statistics

	Accidents/100,000 hours		
	Class A		
Asset	5 year avg	10 year avg	lifetime
CH-47	2.5	0	0
C-130	0.25	0.22	0.83
C-5	0.48	1.46	1.03
C-17	0.57	1.07	1.1

Class A: Direct mishap cost totaling ≥ $1,000,000 or fatality/permanent total disability
Class B: $200,000 ≤ Direct mishap cost total ≤ $1,000,000 OR a permanent partial disability OR inpatient hospitalization of ≥ 3 personnel
from: http://www.afsc.af.mil/index.asp from: Robert (Jon) Dickinson

All H-47 Variants							
FY	Flying Hours	Class A Accidents	Class B Accidents	Army Military Fatalities	DOD Civ Fatalities	Non DOD Fatalities	
2009	101690	0	6	0	0	0	
2010	114570	4	1	0	0	0	
2011	112869	3	5	0	0	0	
2012	96402	5	1	0	0	0	
2013	91807	1	0	0	0	0	RISK
Total	517338	13					2.512864

MH47						
FY	Flying Hours	Class A Accidents	Class B Accidents	Army Military Fatalities	DOD Civ Fatalities	Non DOD Fatalities
2009	13968	0	0	0	0	0
2010	15641	0	0	0	0	0
2011	16512	1	1	0	0	0
2012	3794	0	0	0	0	0
2013	14476	0	0	0	0	0

Attachment #4 Accident Risk Statistics

CH47F						
FY	Flying Hours	Class A Accidents	Class B Accidents	Army Military Fatalities	DOD Civ Fatalities	Non DOD Fataliti es
2009	20692	0	1	0	0	0
2010	22896	3	0	0	0	0
2011	32201	1	1	0	0	0
2012	35293	1	0	0	0	0
2013	39693	0	0	0	0	0
	150775	5				

RISK
3.3162

CH47D						
FY	Flying Hours	Class A Accidents	Class B Accidents	Army Military Fatalities	DOD Civ Fatalities	Non DOD Fataliti es
2009	67030	0	5	0	0	0
2010	76033	1	1	0	0	0
2011	64156	1	3	0	0	0
2012	57315	4	1	0	0	0
2013	37638	1	0	0	0	0

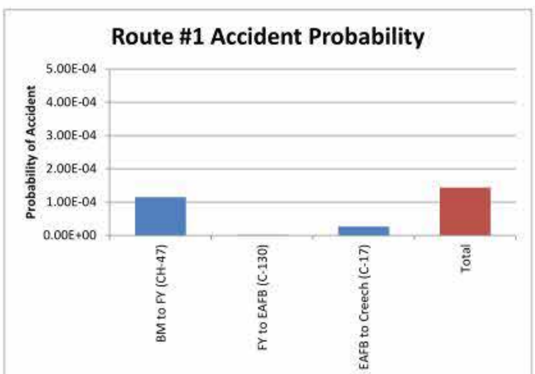
Risk Assessment

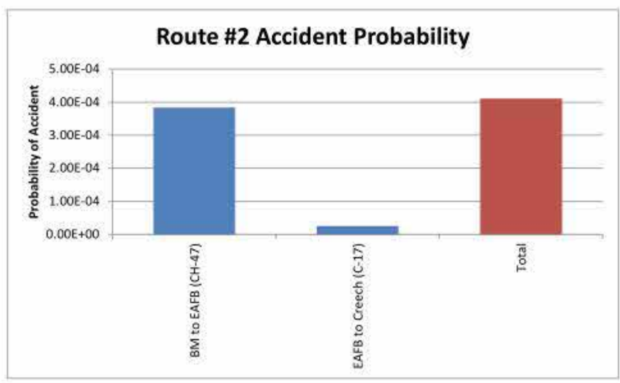
Alaska Transport Risk

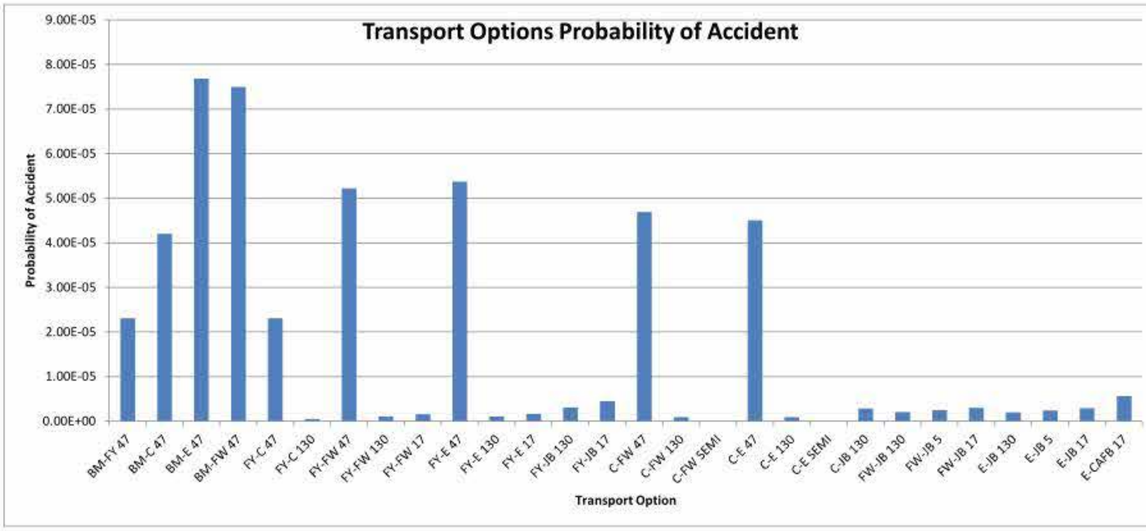
Embark	Destination	KEY	Mode of Travel	Distance	Class 1 Accident Risk		
					5 year avg	10 year avg	lifetime
Burnt Mountain	Fort Yukon	BM-FY 47	CH-47	61.00	2.31E-05	0.00E+00	0.00E+00
Burnt Mountain	Circle	BM-C 47	CH-47	111.00	4.20E-05	0.00E+00	0.00E+00
Burnt Mountain	Eielson	BM-E 47	CH-47	203.00	7.69E-05	0.00E+00	0.00E+00
Burnt Mountain	Fort Wainwright	BM-FW 47	CH-47	198.00	7.50E-05	0.00E+00	0.00E+00
Fort Yukon	Circle	FY-C 47	CH-47	61.00	2.31E-05	0.00E+00	0.00E+00
Fort Yukon	Circle	FY-C 130	C-130	61.00	4.72E-07	4.15E-07	1.57E-06
Fort Yukon	Fort Wainwright	FY-FW 47	CH-47	138	5.23E-05	0.00E+00	0.00E+00
Fort Yukon	Fort Wainwright	FY-FW 130	C-130	138	1.07E-06	9.39E-07	3.54E-06
Fort Yukon	Fort Wainwright	FY-FW 17	C-17	138	1.57E-06	2.94E-06	3.03E-06
Fort Yukon	Eilson	FY-E 47	CH-47	142	5.38E-05	0.00E+00	0.00E+00
Fort Yukon	Eilson	FY-E 130	C-130	142	1.10E-06	9.66E-07	3.64E-06
Fort Yukon	Eilson	FY-E 17	C-17	142	1.61E-06	3.03E-06	3.11E-06
Fort Yukon	JBER	FY-JB 130	C-130	400	3.09E-06	2.72E-06	1.03E-05
Fort Yukon	JBER	FY-JB 17	C-17	400	4.55E-06	8.53E-06	8.77E-06
Circle	Fort Wainwright	C-FW 47	CH-47	124	4.70E-05	0.00E+00	0.00E+00
Circle	Fort Wainwright	C-FW 130	C-130	124	9.59E-07	8.44E-07	3.18E-06
Circle	Fort Wainwright	C-FW SEMI	semi	124	0.00E+00		
Circle	Eielson	C-E 47	CH-47	119	4.51E-05	0.00E+00	0.00E+00
Circle	Eielson	C-E 130	C-130	119	9.20E-07	8.10E-07	3.05E-06
Circle	Eielson	C-E SEMI	semi	119	0.00E+00		
Circle	JBER	C-JB 130	C-130	371	2.87E-06	2.52E-06	9.52E-06
FortWainright	JBER	FW-JB 130	C-130	265	2.05E-06	1.80E-06	6.80E-06
FortWainright	JBER	FW-JB 5	C-5	265	2.50E-06	7.61E-06	5.37E-06
FortWainright	JBER	FW-JB 17	C-17	265	3.01E-06	5.65E-06	5.81E-06
Eielson	JBER	E-JB 130	C-130	258	1.99E-06	1.76E-06	6.62E-06
Eielson	JBER	E-JB 5	C-5	258	2.44E-06	7.41E-06	5.23E-06
Eielson	JBER	E-JB 17	C-17	258	2.93E-06	5.50E-06	5.66E-06
Eielson	Creech	E-CAFB 17	C-17	2332	5.70E-06	1.07E-05	1.10E-05

	Probability
Prob of RTG breech (fixed)	0.05
Prob of RTG breech (rotary)	0.01

	Risk (5yr Avg)/Flight Hour	Sorties	Total Distance (miles)	Flight Time (hrs)	Probability		Adjusted Probability
ROUTE #1							
BM to FY (CH-47)	2.50E-05	5	305	4.6	1.16E-04	80.1%	**1.16E-06**
FY to EAFB (C-130)	2.50E-06	2	284	0.88	2.20E-06	1.5%	**1.10E-07**
EAFB to Creech (C-17)	5.70E-06	1	2332	4.65	2.65E-05	18.4%	**1.33E-06**
Total					**1.44E-04**		**2.59E-06**
Inverse					**6934**		386089.32
ROUTE #2							
BM to EAFB (CH-47)	2.50E-05	5	1015	15.4	3.84E-04	93.6%	3.84E-06
EAFB to Creech (C-17)	5.70E-06	1	2332	4.65	2.65E-05	6.4%	1.33E-06
Total					**4.11E-04**		**5.17E-06**
Inverse					**2433**		193434.94






Transport Options Probability of Accident
Probability of Accident
9.00E-05
8.00E-05
7.00E-05
6.00E-05
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
BM-FY 47
BM-C 47
BM-E 47
BM-FW 47
FY-C 47
FY-C 130
FY-FW 47
FY-FW 130
FY-FW 17
FY-E 47
FY-E 130
FY-E 17
FY-JB 130
FY-JB 17
C-FW 47
C-FW 130
C-FW SEMI
C-E 47
C-E 130
C-E SEMI
C-JB 130
FW-JB 130
FW-JB 5
FW-JB 17
E-JB 130
E-JB 5
E-JB 17
E-CAFB 17
Transport Option

RTG Air Transport Dose Rate Calculations Route #1

BM->FY->EAFB->Creech

Baseline Taxi/Climb/Land/Delay		1	hours
	Distance (miles)	Flight Time (hrs)	Total Hours
BM->FY	61	0.92	1.92
FY->EAFB	142	0.44	1.44
EAFB->Creech	2332	4.65	5.65

			Distance RTG to Crew (feet)			Dose Rate to Crew (mrem/hr)			Maximum Flight Time (hr)			Total Dose per Crew Member (mrem)			Crew#			Total Dose (person-rem)			Latent Cancer Fatalities (risk)		
RTG#	**Dose Rate @ 1 Meter (July 2013) mrem/hr**	**Current Activity (Ci)**	**CH-47**	**C-130**	**C-17**	**CH-47**	**C-130**	**C-17**	**CH-47**	**C-130**	**C-17**	**CH-47**	**C-130**	**C-17**	**CH-47**	**C-130**	**C-17**	**CH-47**	**C-130**	**C-17**	**CH-47**	**C-130**	**C-17**
14	4.1	39156	10	15	15	0.441	0.196	0.196	1.92	1.44	5.65	0.849	0.282	1.107	5	5	5	4.2E-03	1.4E-03	5.5E-03	1.7E-06	5.6E-07	2.2E-06
4	1.97	32021	10	15	15	0.212	0.094	0.094	1.92	1.44	5.65	0.408	0.136	0.532	5	5	5	2.0E-03	6.8E-04	2.7E-03	8.2E-07	2.7E-07	1.1E-06
10	1.7	36810	10	19.66	19.66	0.183	0.047	0.047	1.92	1.44	5.65	0.352	0.068	0.267	5	5	5	1.8E-03	3.4E-04	1.3E-03	7.0E-07	1.4E-07	5.3E-07
18	1.59	38993	10	19.66	19.66	0.171	0.044	0.044	1.92	1.44	5.65	0.329	0.064	0.250	5	5	5	1.6E-03	3.2E-04	1.3E-03	6.6E-07	1.3E-07	5.0E-07
1	1.5	122922	10	24.32	24.32	0.161	0.027	0.027	1.92	1.44	5.65	0.311	0.039	0.154	5	5	5	1.6E-03	2.0E-04	7.7E-04	6.2E-07	7.9E-08	3.1E-07
9	1.26	37644	14.66	24.32	24.32	0.063	0.023	0.023	1.92	1.44	5.65	0.121	0.033	0.129	5	5	5	6.1E-04	1.6E-04	6.5E-04	2.4E-07	6.6E-08	2.6E-07
8	1.1	36566	14.66	28.98	28.98	0.055	0.014	0.014	1.92	1.44	5.65	0.106	0.020	0.080	5	5	5	5.3E-04	1.0E-04	4.0E-04	2.1E-07	4.1E-08	1.6E-07
20	0.878	38664	14.66	28.98	28.98	0.044	0.011	0.011	1.92	1.44	5.65	0.085	0.016	0.064	5	5	5	4.2E-04	8.1E-05	3.2E-04	1.7E-07	3.2E-08	1.3E-07
19	0.779	38700	14.66	33.64	33.64	0.039	0.007	0.007	1.92	1.44	5.65	0.075	0.011	0.042	5	5	5	3.8E-04	5.3E-05	2.1E-04	1.5E-07	2.1E-08	8.4E-08
17	0.704	40018	14.66	33.64	33.64	0.035	0.007	0.007	1.92	1.44	5.65	0.068	0.010	0.038	5	5	5	3.4E-04	4.8E-05	1.9E-04	1.4E-07	1.9E-08	7.6E-08
	Totals per aircraft type					1.40	0.47	0.47	19.24	14.39	56.49	2.70	0.68	2.66				1.35E-02	3.39E-03	1.33E-02	5.41E-06	1.36E-06	5.33E-06
	Overall Totals																	3.02E-02			1.21E-05		
	Maximum per Load					0.504168	0.292141419	0.471453															
	Inverse																				82716.86		

RTG Air Transport Dose Rate Calculations Route #2

5.04E-04

BM->FY->EAFB->Creech

Baseline Taxi/Climb/Land/Delay		1	hours
	Distance (miles)	Flight Time (hrs)	Total Hours
BM->FY	142	2.15	3.15
EAFB->Creech	2332	4.65	5.65

			Distance RTG to Crew (feet)			Dose Rate to Crew (mrem/hr)			Maximum Flight Time (hr)			Total Dose per Crew Member (mrem)			Crew#			Total Dose (person-rem)			Latent Cancer Fatalities (risk)		
RTG#	**Dose Rate @ 1 Meter (July 2013) mrem/hr**	**Current Activity (Ci)**	**CH-47**	**C-130**	**C-17**	**CH-47**	**C-130**	**C-17**	**CH-47**	**C-130**	**C-17**	**CH-47**	**C-130**	**C-17**	**CH-47**	**C-130**	**C-17**	**CH-47**	**C-130**	**C-17**	**CH-47**	**C-130**	**C-17**
14	4.1	39156	10		15	0.441		0.196	3.15		5.65	1.390		1.107	5		5	7.0E-03		5.5E-03	2.8E-06		2.2E-06
4	1.97	32021	10		15	0.212		0.094	3.15		5.65	0.668		0.532	5		5	3.3E-03		2.7E-03	1.3E-06		1.1E-06
10	1.7	36810	10		19.66	0.183		0.047	3.15		5.65	0.576		0.267	5		5	2.9E-03		1.3E-03	1.2E-06		5.3E-07
18	1.59	38993	10		19.66	0.171		0.044	3.15		5.65	0.539		0.250	5		5	2.7E-03		1.3E-03	1.1E-06		5.0E-07
1	1.5	122922	10		24.32	0.161		0.027	3.15		5.65	0.509		0.154	5		5	2.5E-03		7.7E-04	1.0E-06		3.1E-07
9	1.26	37644	14.66		24.32	0.063		0.023	3.15		5.65	0.199		0.129	5		5	9.9E-04		6.5E-04	4.0E-07		2.6E-07
8	1.1	36566	14.66		28.98	0.055		0.014	3.15		5.65	0.174		0.080	5		5	8.7E-04		4.0E-04	3.5E-07		1.6E-07
20	0.878	38664	14.66		28.98	0.044		0.011	3.15		5.65	0.139		0.064	5		5	6.9E-04		3.2E-04	2.8E-07		1.3E-07
19	0.779	38700	14.66		33.64	0.039		0.007	3.15		5.65	0.123		0.042	5		5	6.1E-04		2.1E-04	2.5E-07		8.4E-08
17	0.704	40018	14.66		33.64	0.035		0.007	3.15		5.65	0.111		0.038	5		5	5.6E-04		1.9E-04	2.2E-07		7.6E-08
	Totals per aircraft type					1.40		0.47	31.52		56.49	4.43		2.66				2.21E-02		1.33E-02	8.85E-06		5.33E-06
	Overall Totals																	3.55E-02			1.42E-05		
	Maximum per Load					0.504168		0.471453															
	Inverse																				70519.94		

Attachment #6 Incident Free Air Transport Dose Assessment

Cargo Handling Dose Assessment Route #1

Location	Number of Personnel	Time to Manauever (h)	Dose Rate (mrem/h)	RTG Unit	Total Dose (person-rem)
Burnt Mountain	4	1	0.70	17	0.003
	4	1	1.10	8	0.004
	4	1	0.88	20	0.004
	4	1	1.26	9	0.005
	4	1	1.50	1	0.006
	4	1	4.10	14	0.016
	4	1	1.70	10	0.007
	4	1	1.59	18	0.006
	4	1	0.78	19	0.003
Average			1.51		
Total					**0.054**
Fort Yukon	4	2	1.50	all	0.012
Eielson AFB	4	2	1.50	all	0.012
Creech AFB	4	4	1.50	all	0.024
Total Dose					**0.048**

Location	Operations	Number of Personnel	Dose Rate (mrem/h)	Exposure Time	Total Exposure (person-rem)
Burnt Mountain, AK	Removal and loading of RTG units	4	Dose at 1 meter for each unit	4 hours per unit	0.054
Fort Yukon, AK	Unloading and Loading of RTG units	4	1.51	4 hours	0.024
Eielson AFB, AK				(2 hours at each location)	
Fort Yukon, AK	Temporary Storage of RTG Units (Security)	2	0.04	360 hours (5 days at each site)	0.029
Eielson AFB, AK					
Creech AFB, NV					
Creech AFB, NV	Unloading and Loading on Ground Vehicles	4	1.51	4	0.024
TOTAL					0.13
LCF					**5.27E-05**
Inverse					**18991.38**

Cargo Handling Dose Assessment Route #2

Location	Number of Personnel	Time to Manauever (h)	Dose Rate (mrem/h)	RTG Unit	Total Dose (person-rem)
Burnt Mountain	4	1	0.70	17	0.003
	4	1	1.10	8	0.004
	4	1	0.88	20	0.004
	4	1	1.26	9	0.005
	4	1	1.50	1	0.006
	4	1	4.10	14	0.016
	4	1	1.70	10	0.007
	4	1	1.59	18	0.006
	4	1	0.78	19	0.003
Average			1.51		
Total					**0.054**
Eielson AFB	4	2	1.51	all	0.012
Creech AFB	4	4	1.51	all	0.024
Total Dose					**0.036**

Location	Operations	Number of Personnel	Dose Rate (mrem/h)	Exposure Time	Total Exposure (person-rem)
Burnt Mountain, AK	Removal and loading of RTG units	4	Dose at 1 meter for each unit	4 hours per unit	0.054
Eielson AFB, AK	Unloading and Loading of RTG units	4	1.51	2 hours	0.012
Eielson AFB, AK	Temporary Storage of RTG Units (Security)	2	0.04	240 hours (5 days at site)	0.019
Creech AFB, NV					
Creech AFB, NV	Unloading and Loading on Ground Vehicles	4	1.51	4	0.024
TOTAL					0.11
LCF					**4.40E-05**
Inverse					**22739.68**

ITEM NO. 1

October 28, 1965

MARTIN MARIETTA CORPORATION
APPLICATION FOR BYPRODUCT LICENSE FOR MARTIN
LOW COST THERMOELECTRIC GENERATOR

NON-PROPRIETARY INFORMATION

(1) Cover letter

(2) Form AEC-313 submitted on 8/13/65

(3) Martin Radiological Safety Program

(4) Resumes for Theodore R. Barker II; H. E. Bexford: Richad J. Brisson

(5) Specification for SR-90 Heat Source MN-10139

(6) Safety Evaluation for a 25 watt Sr-90 Low Cost Generator MNSP-RE-5073.

MARTIN PROPRIETARY INFORMATION

(1) Appendices for Safety Evaluation for a 25 watt Sr-90 Low Cost Generator MNSP-RE-5073

(2) Shield Plug and Shield Body

(3) Fuel Capsule Assembly N0013108

(4) Fueling Instructions and Module Installation

(5) Generator Assembly N0013100

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R2
12/91

however, procedures that must be followed to properly handle and transport an RTG and these procedures are outlined in new Appendix E: "Operating Procedures."

ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

Again, the NRC Regulatory Guide, under the heading of "acceptance tests" requests that the applicant discuss those tests to be performed prior to the first use of a package. All of the Sentinel-25 series packages were fabricated and inspected many years ago. Even though tests were performed to assure that the radioisotopic heat sources were leak tight and that the radiation shielding is adequate to meet the requirements of 10 CFR Part 71, no additional units may be built and therefore this section is not applicable. Additionally, an RTG is designed to be maintenance free such that the only maintenance required is related to the shipping pallet and the associated attaching hardware, these items are discussed in new Appenedix F: "Acceptance Test and Maintenance Program."

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* U.S. NRC letter SGTB:MGB 71-4888 dated 04 November 1991 from Charles E. MacDonald to John F. Vogt (TES) with enclosure.

R2
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PREFACE TO REVISION 2

Revision 2 is in response to a NRC request* to supply additional information to include specific specific sections on operating procedures and maintenance program. The applicability of these two sections is addressed below. Drawing No. 001-70057, Rev. D, also specifically requested is attached to this report. (This drawing was included with Rev. 1 - see Pg. v.)

OPERATING PROCEDURES

The intent of this chapter in the NRC Regulatory Guide 7.9 "Standard Format and Content of Part 71 Applications for Approval of Packaging of Type B, Large Quantity and Fissile Radioactive Material" is apparently to provide procedures for use in the loading and unloading of a typical "package" such as a shipping cask used to transport radioactive materials. A radioisotope fueled thermoelectric generator (RTG), however, is designed to convert the energy given up by the radioisotope's decay directly to electricity and hence, is useful only when loaded.

The Sentinel-25 series packages (RTGs) have been loaded or "fueled" at Oak Ridge National Laboratory (ORNL) and each RTG will remain "fueled" or loaded throughout its useful lifetime. If, and when, at the end of the RTG's useful life, the decision is made to "de-fuel" or unload the RTG, procedures will be developed based on the facilities to be used. Obviously, it is not possible to ship and "empty" package for these same reasons. The procedures for loading, unloading and transport of an empty package as described in the Regulatory Guide, therefore, are not applicable to an RTG. There are,

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With regard to the generator housing (shield vessel), the Top Assembly Dwg. for SN-001 cites Dwg. N-0013113 whereas the Top Assembly Dwg. for SN-004 cites Dwg. N0013213. Whether or not there were actually two drawings is unknown - the difference could have been a drawing error or a change in the part numbering system. Neither N0013113 nor N0013213 could be located. However, we believe that all cast iron housings were cast in accordance with Dwg. 001-70036 and were then machined to final dimensions to Dwg. 001-70033 with one exception. The lifting lug shown on 001-70033 to be removed applies for 25D units only (see note - "remove this ear"). These lugs were retained for both the 25A and 25B units. All castings were in accordance with the shield body casting specification 001-80005 (included herein in Appendix D).

The generator housing (shield vessel) lid for SN-004 was constructed to Dwg. 001-40000. The lid assembly drawing for SN-001 cited as N-13107-009 (Module Assembly) on Top Assembly Dwg. N0013100 could not be located.

SENTINEL (LCG) -25A (Continued)

SN-004: R1 10/86

COMPONENT/ASSEMBLY	DRAWING NO.	REMARKS
Top Assembly	001-10000	Included w/Rev. 1
Shield Body	001-70024	Included w/Rev. 1
Shield Plug	001-70025, Detail 001	Included w/Rev. 1
Shielding Specification (Tungsten Alloy)	001-80003	Included w/Rev. 1, (Appendix D)
Generator Housing (Shield Vessel)	001-70036 001-70033	Included w/Rev. 1, see text regarding removal of lifting lug
Generator Housing Lid	001-40000	Not Available, see text
Cast Generator Housing Specification	001-80005	Included w/Rev. 1, (Appendix D)

Our current investigations indicate that SN-001 was constructed in accordance with Top Assembly Dwg. N00113100. This drawing was the one submitted with the original license application (circa 1965). A distinctive feature of this first unit is that the T/E elements were installed into the generator housing lid assembly (as shown on N0013100). For SN-004, the design was revised such that the T/E elements were installed in a separate assembly with a bellows seal. The lid assembly was then modified to accept the new module assembly (T/E elements within bellows). The module assembly fit within a recessed portion of the lid assembly - see Top Assembly Dwg. No. 001-10000.

In August 1968, the Martin Marietta Nuclear Division was acquired by Teledyne. Subsequently, many of the Martin Marietta series N and PN drawings for the Sentinel (LCG-25) units were reissued as Teledyne series 001- drawings. Not all drawings were reissued; one example being the Top Assembly Dwg. for SN-001 (N0013100). However, our current investigations indicate that the tungsten alloy shield body and shield plug for both 25A units were constructed to (reissued) Dwgs. 001-70024 and 001-70025, Detail 001, respectively. The shield material is in accordance with shielding specification 001-80003 (included herein in Appendix D).

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SENTINEL (LCG) - 25A

ORIGINAL UNIT SERIAL NO.	OWNER	CURRENT LOCATION	CONSTRUCTION DATE
001	U.S. Navy	Fairway Rock, Alaska	Early 1966
004	U.S. Air Force	Burnt Mountain, Alaska	Mid 1968

SN-001:

COMPONENT/ASSEMBLY	DRAWING NO.	REMARKS
Top Assembly	N0013100	Included w/August 1986 submittal
Shield Body	001-70024	Included w/Rev. 1
Shield Plug	001-70025, Detail 001	Included w/Rev. 1
Shielding Specification (Tungsten Alloy)	001-80003	Included w/Rev. 1 (Appendix D)
Generator Housing (Shield Vessel)	001-70036 001-70033	Included w/Rev. 1, see text regarding removal of lifting lug.
Generator Housing Lid (Shield Vessel Lid)	N-13107-009	Not available - see text
Cast Generator Housing Specification	001-80005	Included w/Rev. 1, (Appendix D)

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PREFACE TO REVISION 1

Revision 1 is in response to a NRC request* to supply component drawings for each of the Sentinel 25 series generators for the following components:

Shield Body
Shield Plug
Generator Housing (Shield Vessel)
Generator Housing Lid (Shield Vessel Lid)

There were only two Sentinel (LCG) - 25A units constructed. The first, SN-001, was built in early 1966 for the Navy and was installed on Fairway Rock, Alaska. The unit is still at this location. The second, SN-004, was built in mid 1968 and is currently located at Burnt Mountain, Alaska. It is currently owned by the U.S. Air Force. For SN-004, the construction details of the thermoelectric (T/E) module were modified (as described below). In response to the NRC request, a summary of the information provided herein follows:

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* U.S. NRC Letter FCTC:CEW 71-4888, dated 23 September 1986 from Charles E. MacDonald to John W. McGrew (TES) with enclosure.

The application dated September 15, 1969 by Isotopes, Inc. provided the response to specific inquiries from AEC: Irradiated Fuels Branch regarding certain properties, hydrostatic testing and Quality Control procedures for the Hastelloy fuel capsule of the Sentinel 25 units. This submittal, along with explanatory notes prepared in April 1985 is provided in Appendix B.

ITEM NO. 2

SAFETY EVALUATION
FOR A
TWENTY-FIVE WATT STRONTIUM 90
LOW COST GENERATOR
MODEL LCG-25A

MNSP-RE-5073

April 15, 1965

Prepared by:

R. D. Emrick
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Approved by:

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MARTIN MARIETTA CORPORATION
NUCLEAR DIVISION
BALTIMORE, MARYLAND 21203

TABLE OF CONTENTS

I. INTRODUCTION

This report presents a description and nuclear safety evaluation of the LCG-25A model of a low cost radioisotope thermoelectric generator. It establishes the Low Cost Generator as an inherently safe device and further, that its radioisotope heat source can be treated essentially as a sealed source during handling, shipping and operation.

The environmental conditions, for which the sealed source is designed, are presented to establish the minimum acceptable site conditions for any operational site. Therefore in the future it should be possible to establish the acceptability of the generator for use at any particular site by a limited investigation of possible site effects on the radioisotope containment.

It is further shown that the radioisotope source is uneffected by modifications in the energy conversion subsystem.

II. SAFETY PHILOSOPHY AND DESIGN CRITERIA

In complying with the nuclear safety philosophy of protecting the general public from any undue hazards, the most desirable approach is to achieve a design providing absolute fuel containment under all normal and accidental shipping, handling, and operating conditions.

Coincident with this general philosophy, the LCG-25A heat source has been designed as a sealed source that is highly resistant to:

(a) mechanical loads and shocks,

(b) elevated temperatures,

(c) tampering.

Specifically the LCG-25A has been designed to the following requirements:

1. Fuel compatibility with containment structure.
2. Sufficient biological shielding to comply with current ICC and AEC shipping and handling regulations.
3. Negligible radiation effects on the structural integrity of the generator materials.
4. Fuel containment under the following conditions without increasing the dose rate at one meter from the surface of the source by more than a factor of 100:
   a. Free fall from a height of 30 feet onto a rigid non-yielding surface,
   b. Drop from 40 inches onto a steel cylinder,
   c. Exposure to an accident fire of 1475°F for a period of 30 minutes,
   d. Immersion in water for a 24 hour period.

To insure integrity of the safety features designed into the fuel containment, strict quality control and assurance of materials and workmanship during manufacturing and assembly will be maintained.

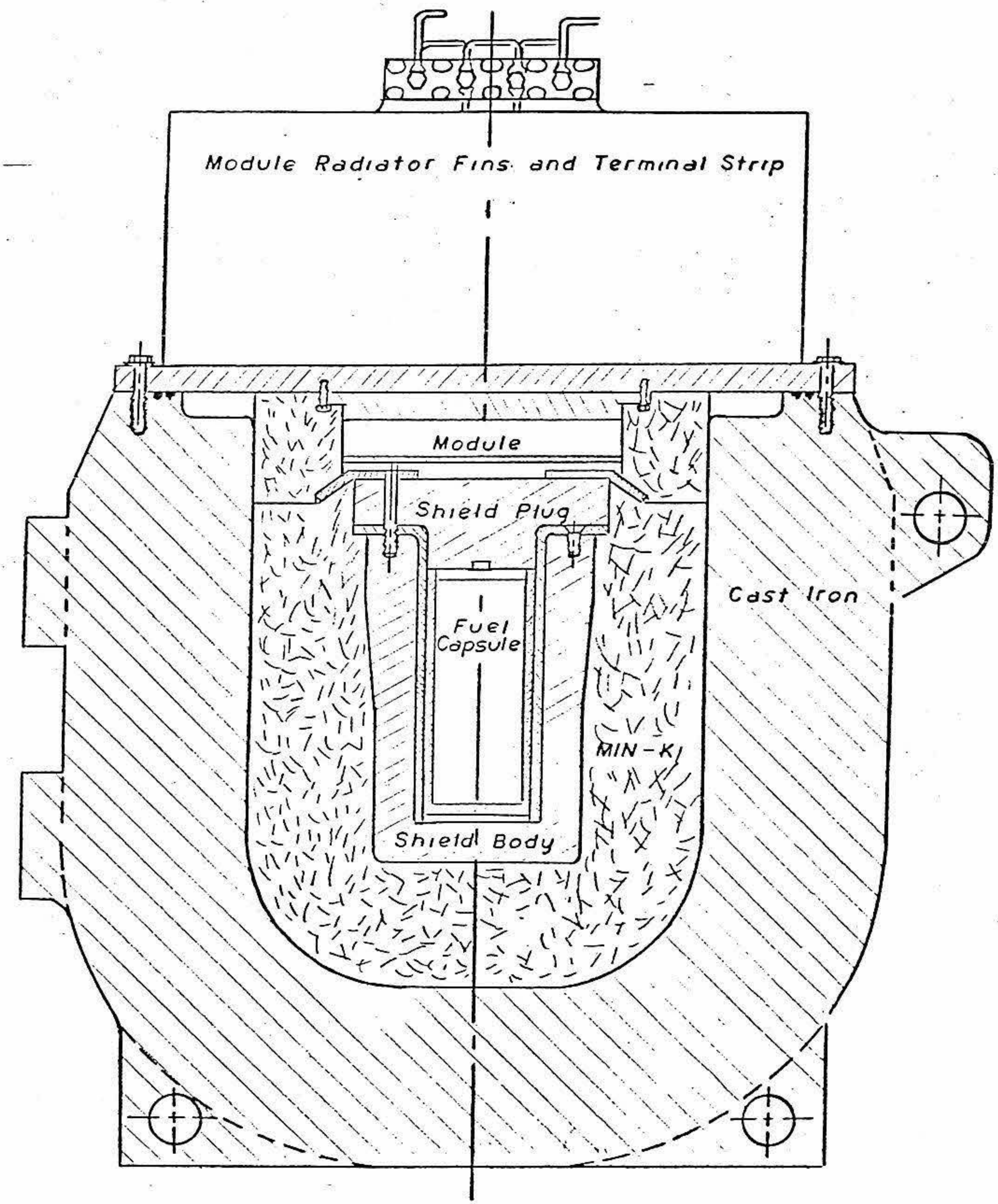
Module Radiator Fins and Terminal Strip
Module
Shield Plug
Fuel Capsule
Cast Iron
MIN-K
Shield Body

FIGURE 1

III. SYSTEM DESCRIPTION

The Low Cost Generator is a radioisotope thermoelectric generator designed for terrestrial applications. The model LCG-25A will be fabricated and tested as a prototype of this class of generators. The ton and a half generator, utilizing strontium titanate as a heat source, is designed to produce 25 electrical watts after 7.5 years.

Basically, the LCG consists of a nuclear heat source, energy conversion unit, and biological shielding. The entire assembly comprises a sealed source container which guarantees fuel containment under the adverse mechanical and thermal conditions which might be experienced in a transportation accident (Reference 1).

A. GENERATOR ASSEMBLY

From the center out, the generator consists of a heat source contained in a cylindrical Hastelloy-C capsule which is in turn surrounded by a tungsten alloy shield block providing part of the biological shielding (see Figure 1). This shield block is encased on its sides and bottom with Johns-Manville "Min-K" thermal insulation. The assembly is further contained in an outer shell of cast iron providing the remainder of the biological shielding. The thermoelectric module is attached to an aluminum lid which positions it directly over the fuel block. This lid is bolted to the cast iron shell with "O" rings between to minimize interchange of the internal argon atmosphere with the air outside. Fins on top of the lid serve to reject the waste heat from the thermoelectric system to the ambient air. Although assembled and fueled in an upright position (axis of the cylinder perpendicular to the ground), the generator is operated and shipped on its side to promote good convective flow over the cooling fins on the lid. This necessitates a

set of legs on the side as well as on the bottom of the generator.

The approximate total weight of the generator will be 3000 pounds, the bulk of this weight being accounted for by the cast iron shell weighing approximately 2500 pounds, with the lid, fins, module, and insulation adding about 200 pounds. The balance of the weight is attributable to the tungsten shield block.

1. Fuel Block Support

The fuel block (fuel capsule and internal tungsten alloy shield) is supported through the surrounding Min-K insulation. This insulation fits closely around the fuel block bottom and sides, but there is a gap between the top of the block and the module to permit heat transfer between the two and to allow easy removal of the module. To support the fuel block against upward directed loads and to keep it from slamming into the module and injuring it, a steel ring is attached to the top of the block. This ring extends into the side insulation and is canted to direct upward loads on the fuel block through the Min-K toward the "corner" formed by the lid and the outer shell of the generator. This is necessary since the "free" surface of the Min-K along the side wall of the module might flake and crack if the load were directed along the generator axis. The lid performs the function of fuel block hold down in this configuration.

2. Thermoelectric Module

The disc-shaped thermoelectric module, which will convert the heat of decay of the Strontium-90 fuel into electricity, is located directly above the fuel block plug. Using lead telluride as the conversion material, the module incorporates 28 thermocouples which are surrounded by Min-K insulations to reduce thermal losses.

Final installation of the module will be performed either at the fueling facility or at the Martin Company facility in Baltimore.

3. Lid and Fins

The fins and lid are made of aluminum to obtain high thermal conductivity at reasonable cost and weight. A terminal strip is attached to the top of one of the fins to allow electrical connections without disturbing the module output feed-throughs. This serves as a quick disconnect feature to facilitate replacement during maintenance activities.

4. Insulation

All thermal insulation is Johns-Manville Min-K 1301, except for a strip at the bottom of the fuel block. The module insulation and the ring of insulation that supports the fuel block against upward loads will be fabricated as separate pieces. The insulation around the sides and bottom of the generator will be formed into the outer vessel or fabricated in layers from sheets. The insulation in immediate contact with the bottom of the fuel block must have a higher temperature capability than Min-K 1301 to satisfy the high beginning-of-life fuel block temperatures which will be in the 1500-1600°F range. Johns-Manville Superex has been selected to satisfy this requirement.

B. BIOLOGICAL SHIELD

1. Inner Shield Block

The tungsten alloy internal shield consists of a cylindrical shield body to which a top plug is bolted and locked in place. This casing is designed to provide sufficient biological shielding under credible accident conditions. For instance, if the generator were subjected to the 1475°F accident fire, the aluminum lid could melt and the fuel block conceivably fall out. It also may be possible for the cast iron shell to crack or break away under adverse shock or impact conditions. A tungsten base alloy, exhibiting desirable mechanical properties under elevated temperatures, will

provide the necessary reserve containment should the cast iron shell fail. Some of the physical properties of this type of material are listed below.

TABLE 1

Typical Properties of
Tungsten-Copper-Nickel Alloys

Density, gm/cc		17.00 (min.)
Corrosion rate in 20% H C at 95°C, $gm/cm^2/hr$		0.00053
Oxidation resistance in still air, weight gain mg/cm^2 after 100 hr	750°F	nil
	930°F	0.65
	1110°F	7.60
Ultimate tensile strength, psi		120,000
Yield strength (.2% offset), psi		88,000
Elongation (% in 2")		2-15
Short time tensile at elevated temperature, psi	1200°F	70,500
	1500°F	55,000
	1800°F	31,000
Ultimate compressive strength, psi		167,000

Due to the excellent gamma absorption characteristics of this alloy, under an accident condition the shield will limit the dose rate to a tolerable level (low enough for a man to approach sufficiently close to perform emergency operations).

2. Cast Iron Shell

The outer shell of the shielded generator is a class 40 gray cast iron bowl-shaped vessel which provides a large portion of the necessary biological shielding and has integrally cast legs and lifting brackets necessary to handle the generator. Galvanic corrosion between the cast iron and the aluminum lid is avoided by several procedures in the manufacturing and assembly of the generator. These include priming the aluminum and iron with zinc chromate, filling interfaces with epoxy sealer, and using cadmium plated steel bolts.

C. HEAT SOURCE

The prime fuel containment for the titanate fuel is provided by a cylindrical Hastelloy-C capsule similar to the fuel capsules of the SNAP 7 series. The fuel will be further encased in a stainless steel liner(s) within the capsule to facilitate fuel loading and decontamination of the capsule. Approximately 120,000 curies of this strontium fuel will be loaded into the capsule to meet the beginning-of-life power requirement of 700 thermal watts.

Table 2 presents a list of the physical dimensions of the capsule and Table 3 is a summary of the material properties.

TABLE 2

Fuel Capsule Dimensions

Inside Diameter, in.	3.120
Outside Diameter, in.	3.620
Wall Thickness, in.	0.250
Overall Length, in.	9.484
Top Cap Thickness, in.	.375
Bottom Cap Thickness, in.	.250

The selection of Hastelloy-C as the capsule material was prompted primarily because of its compatibility with the titanate fuels (Reference 2). In addition, it exhibits excellent sea water corrosion resistance. Studies conducted by International Nickel Company and Martin Company (References 2 and 3) obtained average corrosion rates of .0001 in/year and 3-100 micro-inches/year, respectively. These characteristics, plus the high tensile strengths in the temperature range of the operating generator, guarantee fuel containment to a point well beyond the present design requirements for the LCG-25A.

For a more extensive treatment of the use of Hastelloy-C material with strontium titanate fuels, and of its ability to satisfy design requirements more stringent than those defined for the LCG, refer to the final safety reports of the SNAP 7 series (References 4, 5, and 6).

TABLE 3

Physical Properties of Fuel Capsule Material

	Hastelloy C
Density, lb/in^3	0.323
Melting Point Range, °F	2318-2381
Thermal Conductivity, BTU/hr-ft-°F	9.9(1100°F)
Coefficient of Thermal Expansion, per °F (32-212°F)	8.2x10^{-6}
Specific Heat, BTU/lb-°F (32-212°F)	0.09
Modules of Elasticity in Tension, psi	24.8x10^6(1000°F) 19.5x10^6(1500°F)
Tensile Strength (annealed), 1000 psi	99.3 (1000°F) 56.4 (1600°F)
Yield Strength (annealed), 1000 psi	43.9 (1000°F) 37.5 (1600°F)
Impact Strength (Izod, annealed), ft-lb	21-23
Creep Strength (1% ext. in 10,000 hr), psi	18,000 (1000°F) 4,500 (1300°F) 850 (1500°F)
Rupture Strength (1500°F), 1000 psi	26 (10 hr) 18 (100 hr) 12.5 (1000 hr)

D. RADIOISOTOPE FUEL

Strontium was selected as the fuel for the LCG-25 system because of its long half-life, availability, and ability to be processed into a highly insoluble compound. The fuel form will be of the strontium titanate series of compounds, of which $SrTiO_3$ or Sr_2TiO_4 is the most probable choice. The titanate fuel will be either step pressed or pelletized at the Martin processing plant at Quehanna, Pennsylvania. The fuel form selected will be dependent primarily upon the thermal energy and physical characteristics most desirable for the LCG system.

Strontium titanate is a chemically stable compound effectively insoluble in natural reagents. The titanate forms an eutectic with titania and solid solutions with the titanates of barium and calcium. The predominate form is the meta-titanate although an orthotitanate can be prepared.

In the radioactive disintegration of Sr-90 the daughters Yttrium-90 and Zirconium-90 are formed. Since the valence of the cation increases, there is an oxygen deficiency. Consequently, Yttrium and Zirconium may exist in the fuel in an uncombined state. At the present time there are no available data concerning the effect of fuel composition variation on solubility. This should be of no consequence to the generator system, however, since the fuel is, in effect, a sealed source of unquestionable containment integrity.

The physical properties for $SrTiO_3$ are well established while those for the Sr_2TiO_4 form are not as complete. Principal properties of the $SrTiO_3$ form are listed below.

TABLE 4

Properties of Strontium Titanate

Molecular Weight	- 183.5
Melting Point	- 1920°C
Crystal Structure	- Cubic (persovskite)
Theoretical Density	- 5.11 g/cc
Actual Density	- 3.0 g/cc
Thermal Conductivity, BTU/hr-ft-°F	- 4 at 550°F 1.5 at 730°R
Specific Heat BTU/lb-°R	- .080 at 250°R .166 at 2500°F
Coefficient of Thermal Expansion	- 9.4×10^{-8} per °C (21°C) 11.2×10^{-6} per °C (700°C)

E. QUALITY CONTROL

To insure containment integrity of the generator unit, adherence will be made to rigid quality control procedures during and after assembly of the various components. Generally, quality control system requirements as defined in Military Specification MIL-Q-9858a are followed as procedure guidelines.

Martin quality control procedures applicable to such system as the LCG are as follows:

1. Periodically inspect and calibrate all gages and precision measuring instruments used in manufacturing.
2. Materials are ordered as specified in the drawings. Alternate materials are specified, when feasible, to reduce costs and improve delivery schedules and all substitutions must be approved by Engineering. All incoming materials, parts, or units are checked for dimensions, physical conformity, workmanship, and shipping damage.

3. Visual and dimensional inspection as well as chemical and physical tests are performed where necessary. Dye penetrant tests per Process MIL-I-6866 and MIL-I-6868 and radiograms are performed as required. Special consideration is given to welded assemblies requiring absolute containments and seal welds are helium leak tested according to specifications.

4. Quality Inspection Log Control is maintained to document in-plant inspection steps during manufacturing, assembly, and tests.

The specific quality control and assurance procedures defined for the fuel capsule and shield block are conducted according to specifications of the applicable drawings.

IV. HAZARDS CONSIDERATIONS

For the transfer of the LCG generator, and for storage and operation, it is necessary to insure compliance with regulations of the appropriate agencies for the shipment and storage of radioactive materials. This necessitates that various analyses be performed of the thermal, structural, and containment integrity of the generator system subjected to potential transportation hazards.

A. LICENSING REGULATIONS

U. S. Atomic Energy Commission and Interstate Commerce Commission requirements include the following design criteria for the transportation of a package containing Strontium 90 fuel:

1. Radioactive materials that present special hazards must be packed inside metal containers approved by the Bureau of Explosives (BOE) in addition to prescribed Interstate Commerce Commission packing.
2. The cask must be designed such that the gamma radiation will not exceed 200 mr/hr at the surface of the cask or 10 mr/hr at a distance of one meter perpendicular to the long axis of the source.
3. At all times during transport, the surface of the cask must be less than 180°F.
4. No material within the system must approach within 300°F of its failure temperature during transport.
5. Lead shielding or other equally effective shielding material must be encased in steel or other suitable material such that shielding will neither flow away nor lose its efficiency if in a fire. The casing material must be 1/8 inch thick for 6 inches or less of shielding and 1/4 inch thick for more than 6 inches of shielding.

6. Material which might be damaged by a standard fire must be insulated from fire effects, if used.
7. A means, either direct or indirect, for measuring internal cask wall temperature at all times during transport must be provided.
8. Outer containers, where practicable, must have joints 100% welded or brased, with closure secured by a positive fastening device capable of withstanding severe impact without failure.
9. Sections of the shield must be designed such that the radiation cannot be beamed at joined points.
10. The shielding must be internally supported such that it can neither change position nor open under any ordinary conditions.
11. The container must be designed to withstand any vibration normally incident to transportation. This is defined by the Association of American Radilroads to be equivalent to a four-foot fall.
12. The cask, as a simple beam, must support 10 times its own loaded weight without exceeding its ultimate tensile strength.
13. Any lifting device must be of sufficient strength to lift 6 times the loaded cask weight without exceeding the yield strength of the lifting device material.
14. Containers of more than 500 lbs must be fitted with skids or designed so as not to create excessive pressure on small areas of carrier decks. Gross weight must be marked on containers destined for water shipment if loaded weight exceeds 500 lbs.

The generator system has been designed to meet these criteria.

B. HAZARD ENVIRONMENTS

In satisfying the mechanical and thermal requirements of part A above, four accident conditions simulating the most severe environmental threats to the LCG system have been recommended by the AEC for examination.

1. Flat Drop - A free fall through a distance of 30 feet onto a flat essentially unyielding horizontal surface, striking the surface in such a position as to suffer maximum damage.
2. Puncture - A free fall through a distance of 40 inches striking, in such a position as to suffer maximum damage, the flat horizontal end, with edges rounded to a radius of not more than one-quarter inch, of a vertical cylindrical mild steel bar, 6 inches in diameter. The bar shall be of such a length as to cause maximum damage to the package and shall in any event be not less than 8 inches long. It shall be mounted on a flat essentially unyielding horizontal surface.
3. Thermal - Exposure for 30 minutes within a source of radiant heat having a temperature of 1475°F and an emissivity coefficient of 0.9, assuming that the package has an absorption coefficient of 0.8, the package shall not be cooled artificially until after the 30 minute test period has expired and the internal temperature has begun to fall.
4. Immersion - Immersion in water so that the package (i.e. generator) is at least three feet below the surface for 24 hours.

Subsequent to these conditions, the system must retain sufficient shielding properties such that the radiation level at 1 meter from the surface of the generator will not exceed 1000 mr/hr (Reference 7).

The following paragraphs examine the ability of the Low Cost Generator design to meet these specific requirements.

Structural - Should the cast iron outer shell crack or break away in an accident, the tungsten shield block is designed to keep the radiation at an acceptable accident level of 100 times the normal permissible level. Analyses of the structural integrity of the internal shield in the 30 ft. free fall and the drop from 40 inches onto a steel cylinder have been performed. It is shown that the potential energy of an end drop from 30 feet is approximately 10,000 ft-lb, while the energy necessary to rupture the tungsten-alloy shield block is over 22,000 ft-lb, a margin of safety of 1.225.

In examining the shield block for the puncture drop, the 6 inch diameter of the steel cylinder is comparable to the dimensions of the shield block. Thus the shock load is similar to that of a drop onto a flat horizontal surface, and it is found that the potential energy available from a 40 inch height is only 11% of that from a 30 ft. height. Thus the shield block will survive this condition with an even greater degree of safety than that for the 30 ft. drop.

It may therefore be concluded that even if the outer cast iron housing were to break away, offering no structural support to the generator, the inner shield block would withstand the shock forces of the accident mechanical environments.

Thermal - An examination of the generator in the 1475°F accident fire has been performed. Conservative results indicate that, should the generator be subjected to the fire while in an upright position, the melting point of the aluminum lid would be reached in 15 minutes and a partial meltdown and subsequent collapse of the lid could occur. With the normal heat rejection path destroyed, it has been determined that the energy from the heat source can still be rejected while keeping the temperature well below the melting temperatures of the critical components, namely; the fuel, the fuel capsule, and the internal shield block.

Immersion - The excellent corrosion resistance of the outer cast iron shell, inner shield block, and fuel capsule has been discussed in sections III-B and C. Furthermore, the fuel capsule alone is designed to withstand hydrostatic pressures characteristic of ocean burial at depths greater than 3000 feet. Therefore, the design of the system precludes any possibility of leakage or fuel release due to water immersion.

C. RADIATION ANALYSIS

A radiation analysis was made of the LCG-25A generator in which the inner shield material was considered to be mallory 1000*. The inner shield, on the side and bottom of the cylindrical fuel capsule, was sized to prevent the radiation at one meter from exceeding 1 r/hr in case the capsule and inner shield were detached from the cast iron outer shield during an accident. This conforms to the standard recommended in Reference 7, which requires the radiation as a result of an accident not to exceed 100 times the normal dose. The plug covering the top of the capsule was sized to have the surface dose rate to be less than 500 mr/hr. This low dose rate is required in order to permit the thermoelectric module to be changed in the field. The analysis showed that 1 - 3/4 inches of shielding is required on the side and 1 - 1/2 inches of shielding is required on the bottom of the capsule to reduce radiation to 1 r/hr at one meter from the capsule center. The required top plug thickness is 3-1/2 inches.

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* At the time of this analysis, Mallory 1000 had been the choice for the inner shield. However, little difference in the shielding characteristics of the tungsten alloys is expected due to the similar composition and densities.

An outer shield of cast iron is included in the Low Cost Generator to reduce raidation levels to acceptable limits during normal handling. These levels correspond to the ICC regulations for shipping radioactive materials - 10 mr/hr or less one meter from the center of the source or 200 mr/hr or less at the surface of the cask. A 5-1/2 inch thickness of cast iron is required on the side and bottom of the cask to reduce the radiation level to 10 mr/hr at one meter from the fuel center. This thickness of cast iron produces a surface dose rate of 80 mr/hr.

D. TAMPERING

Although the LCG will be in a controlled access area during operation, this alone can not prevent access by persons intending to tamper with the generator. Should the tinker be a saboteur, little defense is available. Should he be motivated by curiosity or mischief, however, it is nearly impossible to endanger himself or others by radiation exposure.

Assuming that he is equipped with the proper tools to facilitate removal of the heavy aluminum lid and module, and can work without being affected by the heat radiated from the hot generator surface - this in itself is quite a feat for the average tinker - attempts to get any closer than this to the fuel block will be futile. To get to the heat source would require burning through the locked shield block plug. Only a person bent on sabotage would pursue the matter to this extent.

Since the radiation at the top surface of the inner shield block plug is less than 500 mr/hr, one would have to keep his hand on the hot surface for more than 37 hours before reaching the maximum permissible normal quarterly dose of 18.75 rem for the hands.

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5. Final Safety Evaluation of a Sixty Watt Strontium-90 Fueled Generator for a U.S. Navy Boat - Type Weather Station - SNAP 7D, MND-P-2664-A, Martin Company, May 1962.
6. Final Safety Evaluation of a Ten Watt Strontium-90 Fueled Generator for a Deep Sea Application - SNAP 7E, MND-P-2761, Martin Company, May, 1962.
7. Draft Revision of the regulations for the Safe Transport of Radioactive Materials, November 1, 1964, International Atomic Energy Agency.

ITEM NO. 3

APPENDICES
MNSP-RE-5073
SAFETY EVALUATION
FOR A
TWENTY-FIVE WATT STRONTIUM 90
LOW COST GENERATOR
MODEL LCG-25A

MARTIN MARIETTA CORPORATION

VI. APPENDICES

A. INNER SHIELD STRUCTURAL ANALYSIS*

1. Free Fall From 30 Feet

The generator internal shield is designed to meet the emergency radiation requirements without the use of additional shield material. That is, this material only will provide adequate shielding to limit the radiation level to less than the maximum allowable specified after a 30-foot free fall drop. Thus, the 30-foot drop criteria shall have been met if the fuel block internal shield can survive the resultant impact without suffering gross deformation and/or fracture.

Assumptions for Analysis:

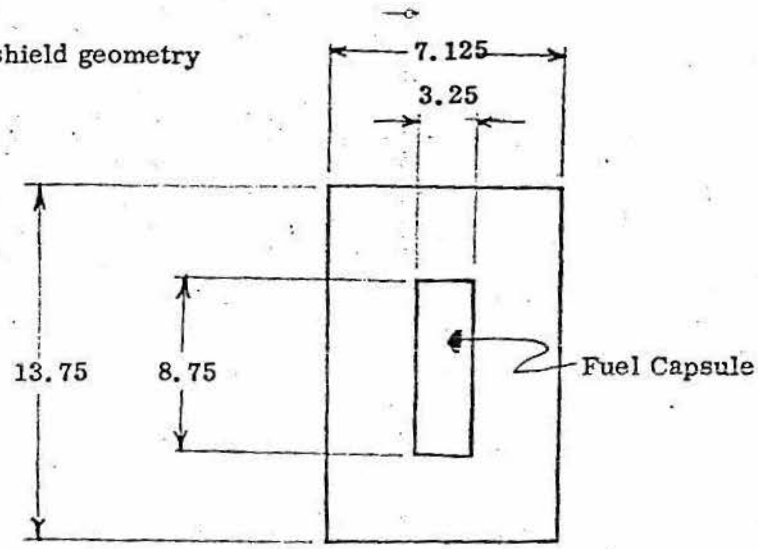
a. No energy dissipation shall be accounted for though deformation of: the cast iron outer shell, cask fittings and projecting components, internal Min-K insulating material, and target material.

b. The internal shield shall be treated as a solid body. This assumes that the capsule and fuel fill the shield center void such that for purposes of analysis the shield may be treated as a solid cylinder subject to dynamic compression only and no local bending.

c. The cast iron outer shell and Min-K insulating material provide support for the fuel block such that only uniformly distributed loads, acting on the shield projected area perpendicular to the target plane, are imposed due to the shield's own inertia forces.

*By R. Gjertsen

Internal shield geometry



It is conservatively assumed that the shield is a solid cylinder made from Mallory - 3000 material.

W = shield weight = ρV

where

ρ = density = $.6125\ lb/in^3$

V = volume = $\frac{\pi}{4}(7.125)^2(13.75) = 550\ in^3$

thus

$W = 337$ lb

U_a = available energy = Wh

where

h = drop height = 30 ft

thus

$U_a = 10,100$ ft-lb

Properties of Mallory - 3000 material (Reference P.R. Mallory & Co. Booklet, "High Density Metals", 1962

Room Temperature Properties:

S_{cu} = ultimate compressive strength = 167,000 psi

S_{cy} = yield compressive strength = 105,000 psi

S_{tu} = ultimate tensile strength = 120,000 psi

S_{ty} = yield tensile strength = 88,000 psi

Thus the room temperature stress ratios are:

$$\frac{S_{cu}}{S_{tu}} = 1.39, \quad \frac{S_{cy}}{S_{ty}} = 1.19, \quad \frac{S_{ty}}{S_{tu}} = .733$$

Properties at 1500°F:

S_{tu} = 55,000 psi

Using the room temperature stress ratios.

$S_{ty} = .733 \times S_{tu} = 40,300$ psi

$S_{cy} = 1.19 \times S_{ty} = 48,000$ psi

$S_{cu} = 1.39 \times S_{tu} = 76,500$ psi

Also,

e_u[1] = tensile or compressive deformational ultimate

= .03 in./in.

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(1) In reference only the tensile elongation is given at temperature. But comparison of the room temperature tensile strain for Mallory - 1000 with the room temperature ultimate bearing compressure strain shows the compressive strain to approximately equal the tensile strain. Hence, it is assumed that the compressive strain and tensile strain are equal at operating temperature.

Determination of energy available in the shield material:

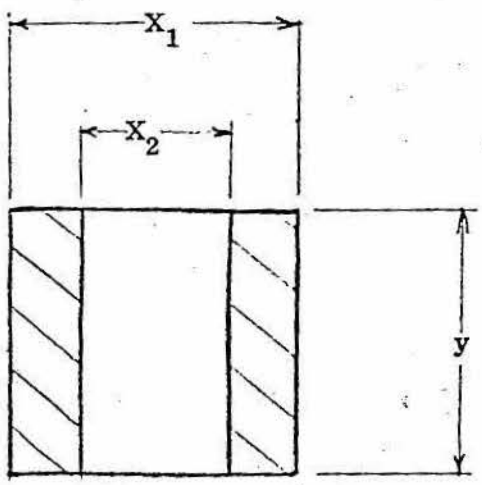
A. End drop:

For an end drop it is assumed that a uniformly varying load distribution will occur along the shield length as shown below:

The energy per unit volume $\left(\frac{U}{V}\right)$ up to the material's ultimate strength is:

$$\left(\frac{U}{V}\right)_u = \frac{e_u^*}{6} \left(S_y + S_u\right)$$

for a conservative approximation the volume of a hallow cylinder, as below, shall be used as the effective volume to resist the impact load.



X_1 = 7.125 in.

X_2 = 3.25 in.

y = 13.75 in.

$$V = \frac{\pi}{4} (X_1^2 - X_2^2) y$$

$$V = 432.5 \text{ in.}^3$$

hence, using the properties given for Mallory-3000 yields

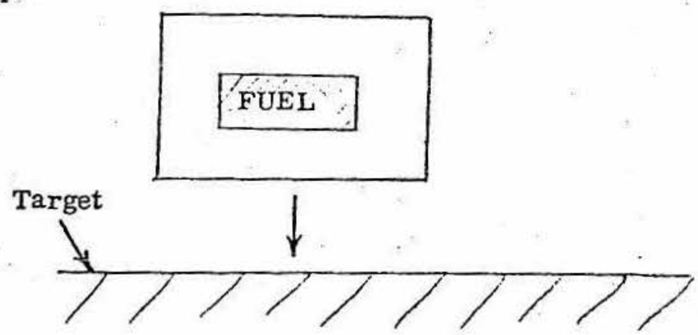
U_u = ultimate energy = 22,450 ft - lb

*The value 1/6 e_u as opposed to 1/2 e_u comes from the fact that the energy per unit volume when the maximum stress is equal to or less than the material yield stress for the uniformly distributed load is 1/3 that produced by a concentrated load.

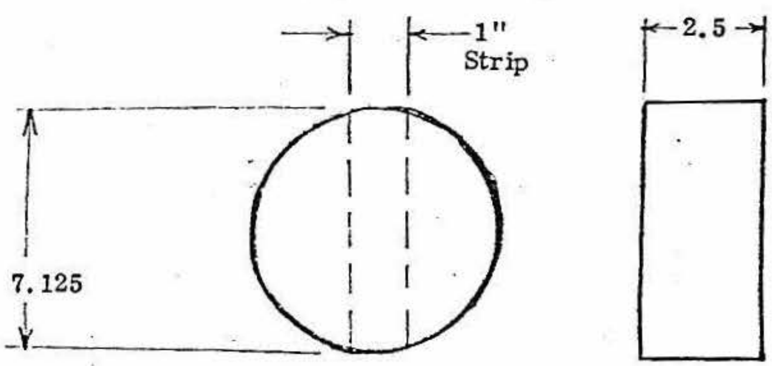
Comparison with the energy available (U_a) produces the following margin of safety (M.S.):

$$M.S. = \frac{U_u}{U_a} - 1 = 1.225$$

B. Side drop:



For this evaluation a one-inch wide strip of the end cover shall be considered.



V = volume = $1(7.125)(2.5) = 17.8 \text{ in}^3$

W = weight $2 \rho V = .6125 (17.8) = 10.9$ lb

U_a = actual energy = $Wh = 10.9(30) = 328$ ft - lb

Considering now the material ultimate energy and the properties of Mallory-3000 at 1500°F,

$$U_u = \text{ultimate energy} = \frac{V}{6} e_u (S_y + S_u)$$

$$U_u = 11080 \text{ in - lb} = 925 \text{ ft - lb}$$

which yields the following margin of safety

$$M.S. = \frac{U_u}{U_a} - 1 = 1.81$$

2. Puncture Free Fall

For the 40-inch drop onto a 6-inch diameter rod it is very likely that the rod will not fracture the 6 1/2-inch thick cast iron outer shell. But, in the event that failure of the casting does occur this failure should be in the form of cracking and not a clean shear puncture due to the brittle nature of the material. Hence it is felt that penetration of the rod into the cask is very unlikely.

The energy developed by the inner shield block for the 40-inch drop will be 11.1% of that developed by the 30-foot free fall and since, in previous calculations, the shield block was shown to survive the free fall impact it is concluded that the 40-inch drop, being much less severe, shall not damage the shield block.

B. SYSTEM INTEGRITY IN AN ACCIDENT FIRE*

Two conditions were studied to determine the behavior of the LCG system when subjected to a fire. The first case was the transient heat up of the fuel capsule during the fire. The second case was the determination of the equilibrium temperature of the fuel capsule after destruction of the normal heat path.

1. Transient Heat Up Of Fuel Capsule

Because of the enormous weight of this system, sufficient heat capacity is present to prevent large increases in temperature when subjected to a fire at 1475°F. A preliminary analysis showed that if the outer surface of the cast iron shield was kept at 1475°F for 30 minutes, the inner surface (next to the insulation) would

*By V. Truscello

increase from 200°F up to 800°F. Despite this fact, an even more conservative approach was taken to investigate the transient heat up of the fuel capsule.

The assumption was made that the fire had forced the inner surface of the cast iron shield immediately to 1475°F (the maximum possible temperature). Also, it is assumed that the inner shield which is made of Mallory-3000 was also at the temperature of 1475 (under normal conditions it would operate between 1300 and 1570°F). With this assumption made, heat generated within the fuel capsule can no longer be transferred to the surroundings. This means that the fuel capsule and surrounding Mallory shield will undergo an adiabatic rise in temperature for a period of 30 minutes. It will now be shown that because of the large heat capacity of the capsule and shield assembly, the temperature rise in 30 minutes is about 150°F.

The fuel capsule generates heat at the rate of 700 watts or 2380 Btu/Hr. The appropriate equation to determine the temperature increase of the capsule is given by

$$Q = MC_P \frac{\Delta T}{\Delta t}$$

where

Q = total heat input = 2380 Btu/Hr

M = weight of the capsule - shield assembly = 234 lb

Cp = specific heat of shield material

= 0.034 Btu/lb-°F

ΔT = associated temperature rise °F in time Δt

The rise in temperature in 30 minutes (maximum duration of fire) is then

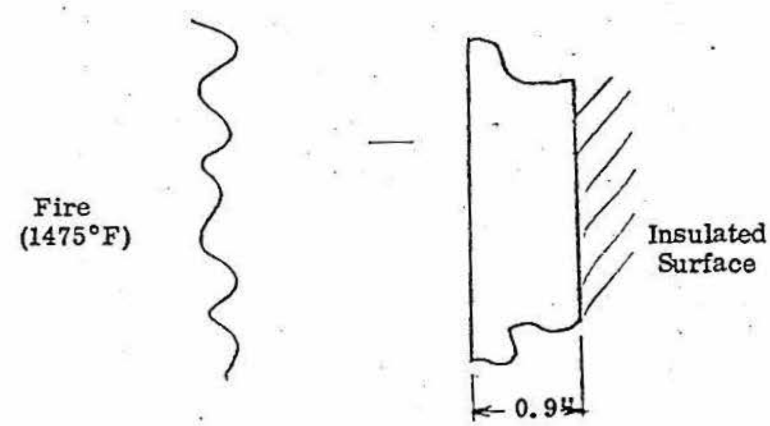
$T = 150°F$

The critical component of the shield assembly (lowest melting point) is the Hastelloy-C capsule with a melting point of 2318°F. Under the above conditions,

the capsule will rise in temperature from its maximum normal operating temperature of 1740°F up to 1890°F, well below its melting point.

2. Equilibrium Temperature Of The Fuel Capsule After Destruction Of Normal Heat Path

The previous case considered the maximum possible increase in temperature of the fuel capsule during which the fire prevented heat from being rejected in the normal manner. In this section, we study the case in which the fire has stopped, but has permanently damaged the normal heat path from capsule to surroundings. Specifically, the heat is normally transferred by radiation from the inner top shield to the aluminum plate and subsequently dissipated to the surrounding atmosphere. It will now be shown that under the conditions of the fire, that the aluminum plate will reach its melting point within 15 minutes. The following model is used:



A heat balance is made at the surface of the plate over a time increment Δt and unit area, (heat input) = (heat rejected) + (heat stored).

$$q_{in} \Delta t = q_{out} \Delta t + MC_p \Delta T$$

The rate of heat input by the fire is given as

$$q_{in} = \sigma \epsilon \alpha T_g^4 \quad \text{Btu/Hr-Ft}^2 \qquad (1)$$

where

σ = Stefan Boltzman Constant = 0.17×10^{-8} Btu/Hr-Ft^2 - F^4

ϵ = emissivity of the flame wall = 0.9

α = absorptivity of aluminum surface for the flame radiation = 0.8

T_g = gas temperature = 1935°F

The rate at which heat is rejected by the aluminum plate is dependent upon its temperature and is given by

$$q_{out} = \sigma \epsilon \alpha T_s^{\,4} \quad \text{Btu/Hr-Ft}^2 \tag{2}$$

T_s = plate temperature (a function of time)

ϵ = plate emissivity = 0.8

The amount of heat stored within the plate is given by

$$Q = MC_p \quad \Delta T = \text{Btu/Ft}^2 \tag{3}$$

M = weight of aluminum plate/Ft^2 = 14.5 lb

C_p = specific heat of aluminum = 0.23 Btu/lb-°F

Δ T = temperature rise of aluminum plate

Using expressions (1), (2) and (3) we obtain the following expression,

$$\Delta t\,(1.71 \times 10^4 - 0.136 \times 10^{-8}\; T_s^{\,4}) = 3.35 \quad \Delta T$$

With this expression, the rise in temperature as a function of time can be determined. Assuming that the initial temperature is 187°F (normal operating temperature of aluminum plate) the aluminum plate will reach its melting point after 15 minutes in the fire. Once the melting point has been achieved, the plate will remain at 1195°F until it completely absorbs its latent heat of fusion. The time required to do this is found from the relation

$$Q = q_{net} \quad \Delta t$$

where

q_{net} = the net rate of heat transfer into the plate. This is equal to the difference between the heat transferred into the plate from the 1475°F flame and rejected by the plate at a temperature of 1195°F.

Q = heat absorbed at constant temperature = Mh_F.

M = mass of plate = 14.5 lb/Ft^2

h_f = heat of fusion = 178 Btu/lb

$$q_{net} = \sigma\epsilon\alpha T_g^{\ 4} - \sigma\epsilon T_s^{\ 4}$$

T_g is the flame temperature (1475°F) and T_s the plate temperature (1195°F). All other nomenclature have been previously defined.

This analysis indicates that an additional 22 minutes will be required to completely melt down the plate once it has reached its melting point. Therefore, a total time of (15 + 22) = 37 minutes is required to completely melt down the plate. Since the fire will last only 30 minutes, this indicates that the plate will not completely melt down. However, it is possible that the plate will not hold together at 1195°F and may flow under its own weight and thus be completely destroyed. This case has therefore been assumed in order to determine the maximum possible capsule temperature.

With the removal of the aluminum radiator, the heat generated by the fuel capsule (under steady state conditions) must now be rejected by a now reduced surface area. Two conditions are now possible. The first assumes that the T/E module falls out of the generator after destruction of the aluminum plate which holds it in place. In this case (least severe) the heat is rejected directly from the inner shield top surface. The steady state temperature will then be found by the relation:

$$q = \sigma \epsilon A T_B^{\;4}$$

q = 555 watts (the remainder of the 700 watts is rejected through the sides)

$\epsilon = 0.8$

$A = 0.36 \text{ Ft}^2$ (total area of the top surface of the fuel block)

This results in a surface temperature of 940°F which is well below its normal operating point of 1290°F.

The second case assumes that the module does not fall out of generator but remains within the generator thus preventing the heat from radiating directly from the top surface to the environment. In this case, it is very likely that the elements will melt and flow out of the module. The heat can then be radiated directly from the fuel block to the hot plate and then directly to the environment through the holes left in the insulation. This case was found to give steady state temperatures well below the melting point of any material within the fuel block.

The most critical condition arises if one considers that the T/E elements, even though molten, still remain within the holes. The heat must now be conducted through the elements and the insulation. The properties of the Min K 1301 are such that when exposed to a 1700°F environment there is a material shrinkage of 20% while the thermal conductivity of the insulation increases due to the higher temperatures. Since the inside surface of the generator case has been assumed to be at 1475°F, the temperature of the Min-K will range between this value and 2000°F ± 100°F. It can therefore be certain that at least 5% shrinkage will be experienced by the insulation. This implies that a radiation gap will be opened up between the tungsten shield and the insulation, the tungsten shield and the module, and the insulation and the generator case. In addition, there will be a gap between the layers of insulation so that the tungsten shield can radiate directly to the 1475°F cold wall (Figure 1). The mathematical model for this

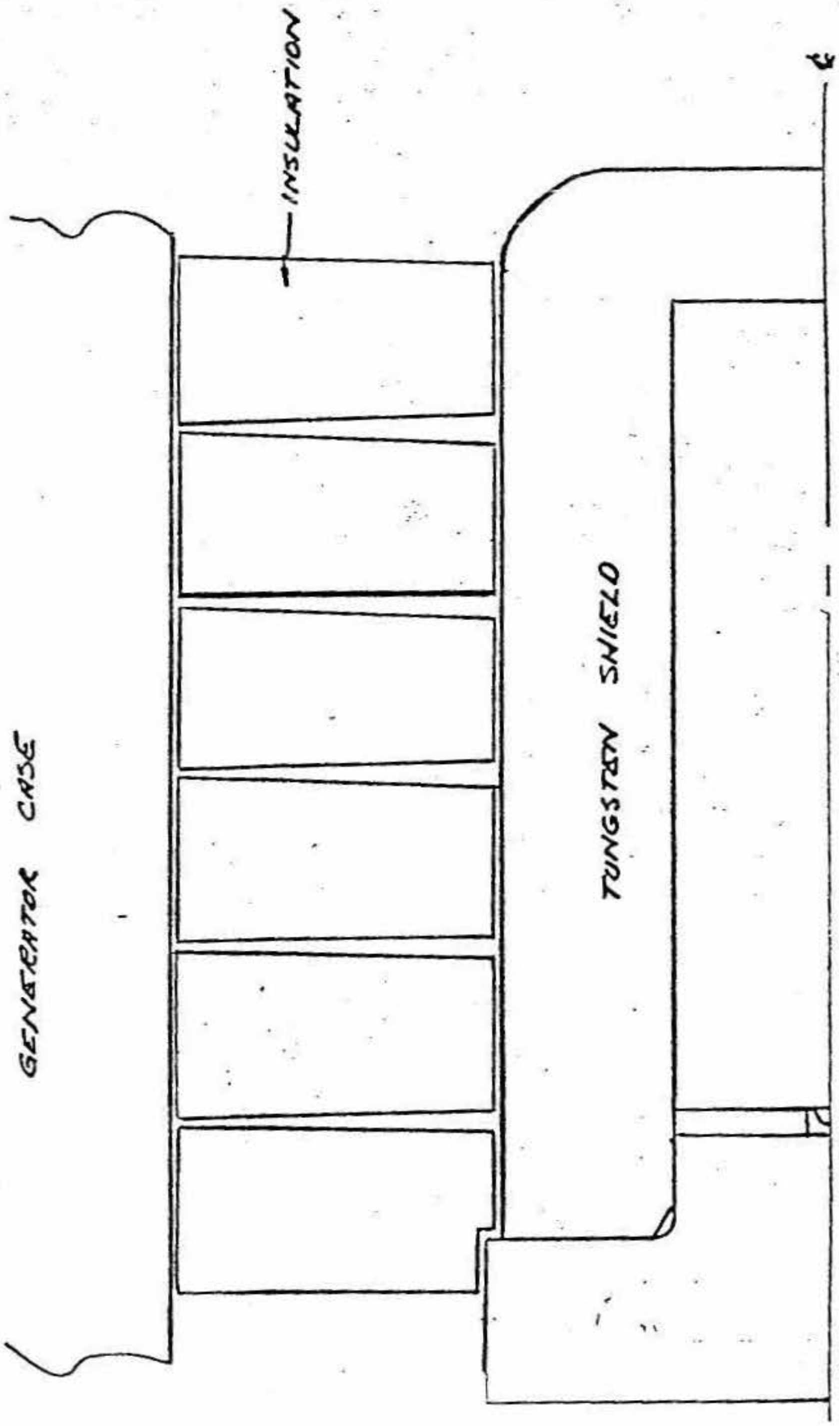


FIGURE 1

LCG-25A AFTER OVERTEMPERATURE CONDITION

condition becomes:

$$q = k\frac{A}{L} \quad \Delta T) \text{ insulation} + K\frac{A}{L} \quad \Delta T) \text{ module} + \quad \sigma\epsilon FA_G(T_{HS}^4 - \bar{T}^4 \text{ wall})$$

q - Heat to be dissipated from fuel capsule, 700 watts

k - Thermal conductivity, .0088 watts/ft -°F for insulations and .4103 watts/ft -°F for melted T/E elements

A/L - Heat conduction area divided by heat path length, 10.22 ft for insulation and 1.83 ft for T/E elements

Δ T - Temperature differential, cold side temperature, T_{wall}, is 1935°R and hot side, T_H, to be determined

σ - Constant, $.0503 \times 10^{-8}$ watts/ft^2 -°R^4

ϵ - Combined emissivity of shield and case, 0.3

F - View factor, tungsten to steel case, 0.1

A_G - Area of insulation gap, 0.129 sq. ft.

T_{HS} - Temperature of shield, °R

while the heat radiation between the shield and the insulation and the insulation and the generator case follows.

$$q' = \sigma\epsilon FA (T_{HS}^4 - T_H^4)$$

q' - Heat radiated to insulation, watts

ϵ - Emissivity, 0.4

F - View factor, 1.0

A - Surface area, tungsten, 2.93 sq. ft ; generator case, 5.07 sq. ft

The radiation view factors were determined from the NACA Technical Note 2836, "Radiant-Interchange Configuration Factors."

The solution of these equations yields a temperature of the tungsten shield of 2244°F while the hot side of the insulation and module becomes 2230°F. This temperature is well below the 2318°F melting temperature of the Hastalloy-C. This analysis has not considered heat flow from the bottom of the tungsten shield through that insulation, and it is therefore conservative by that amount.

The LCG-25A is normally designed to sit in the horizontal position since the cooling fins are designed to operate most effectively in this position. If, however, the generator were stored in the vertical position before a fire began, then some of the melting aluminum would run into the generator which can only increase the thermal conductivity of the insulation and hence reduce the maximum temperature of the fuel block which was previously discussed. The fuel block would be supported on the bottom insulation which would give excellent contact with the insulation and in combination with the insulation shrinkage it would give a good heat path for heat dissipation which has not previously been accounted for. Even if a gap didn't open up around the perimeter of the fuel capsule, this factor alone would only allow the tungsten shield temperature to reach 2305°F.

Since it has already been pointed out that the maximum temperature which the cast iron inner surface would reach is 800°F, and here the insulation could not shrink so that no gap exists between the layers of Min-K-1301, the resulting tungsten temperature would only be 1700°F. This assumes that the insulation is not in contact with the tungsten.

Therefore, it is certain that a fire will not result in a catastrophe which will destroy the integrity of the fuel capsule nor will the fuel, which melts at 1900°C (3452°F), be in any danger of melting.

C. RADIATION ANALYSIS *

A radiation analysis was made of the Low Cost Generator in which the inner shield is to be made of Mallory-1000. Mallory-1000 is a compacted and sintered composition consisting of approximately 90% tungsten with copper and nickel used as binding material.

The heat is supplied by two pellets of strontium dititanate each containing 350 watts. The pellets are pressed in stainless steel liners 0.060 inches thick and loaded into a single capsule. The capsule is made of Hastelloy-C and is approximately 1/4" thick.

The side and bottom of the cylindrical inner shield was first sized to allow the radiation at one meter from the fuel center to be 1 R/hr or less in case the capsule and inner shield were detached from the cast iron outer shield as a result of an accident. This criterion conforms to the standard recommended by the IAEA. The top thickness of the inner shield was sized to have the surface dose rate to be less than 500 mr/hr. This lower dose rate is required in case the thermoelectric module must be changed in the field. Figures 1 and 2 show the variation of dose rate with Mallory-1000 thickness at the surface of the shield and at one meter from the center of the fuel.

An outer shield of cast iron is included in the Low Cost Generator to reduce radiation levels to acceptable limits during normal handling of the generator. These levels correspond to the ICC regulations for shipping radioactive materials - 10 mr/hr

* By A. M. Spamer

or less from the center of the source or 200 mr/hr or less at the cask surface. Figures 3 and 4 show the variation of side and bottom dose rates with cast iron thickness for inner shield thicknesses of 1 and 1-3/4 inches of Mallory.

Figures 1 thru 4 were used to obtain tentative sizes for the inner and outer shields. The tentative and final thickness are given in Table 1.

TABLE 1

Tentative and Final Shield Thicknesses

	Tentative Thickness (inches)	Final Thicknesses
Mallory-1000		
Top	3-1/2	3-1/2
Side	1-3/4	2
Bottom	1-1/2	1-1/2
Cast Iron		
Side	5-1/4	5-1/4
Bottom	5-1/4	5-1/4

Dose point locations at one meter from the fuel center are shown in Figure 5 and surface dose point locations are shown in Figure 6. Dose rates are shown in Tables 2 and 3.

Examination of dose rates in the t_1 = 1-3/4 inch columns of Tables 2 and 3 shows that at angles between 35 and 50 degrees from the axis the dose rates at one meter are higher than the allowable 10 mr/hr. The surface dose rates however are well below the 200 mr/hr allowed. Additional material is thus required to reduce dose rates at one meter to allowable limits. Two approaches were investigated.

For the first, the side thickness of the Mallory was increased to two inches, and for the other approach, the height of the outer cast iron shield was increased (t_2 in Figure 6).

The additional 1/4" on the side thickness of the internal shield reduced the higher dose rates to acceptable limits (see column t_1 = 2" Tables 2 and 3). An increase of 3/4" (t_2 on Figure 6) in the height of the cast iron outer shield did not reduce the dose rates to acceptable limits (Table 2). This approach was therefore abandoned as additional increases in height required for further reduction would introduce complications in the installation of the thermoelectric module.

TABLE II DOSE RATES (MR/HR) ONE METER FROM CENTER OF FUEL (SEE FIG. 5)

DOSE POINT	$X_{(in)}$	$Z_{(in)}$	MALLORY 1000 ON SIDE t_1 = 1 3/4"	MALLORY 1000 ON SIDE t_1 = 2"	t_1 = 1 3/4" t_2 = 3/4" Cast Iron
1	0	39.37	6.6	6.6	6.6
2	6.84	38.77	5.5	5.5	5.5
3	10.19	38.03	4.2	4.2	4.2
4	13.46	37.00	2.8	2.8	2.8
5	16.64	35.68	2.0	1.7	2.0
6	19.68	34.09	4.0	1.8	3.8
7	25.58	32.25	11.1	4.6	9.8
8	23.14	31.85	12.9	5.4	11.2
9	23.69	31.44	14.8	6.2	12.6
10	24.22	31.02	16.5	7.1	13.6
11	24.77	30.57	18.2	8.0	14.4
12	25.31	30.16	19.6	8.7	15.1
13	25.83	29.69	20.8	9.4	15.2
14	26.34	29.25	21.6	9.88	14.9
15	26.85	28.80	21.92	9.90	14.0
16	27.35	28.32	21.87	10.0	12.4
17	27.84	27.84	21.3	9.9	11.0
18	28.32	17.35	20.2	9.7	9.2
19	28.79	26.85	17.9	8.7	7.5
20	29.25	26.34	15.9	7.9	6.2
21	29.71	25.83	13.5	6.7	5.0
22	30.16	25.31	10.7	5.5	3.9
23	34.09	19.68	2.4	1.3	2.4
24	37.00	13.46	5.3	3.0	5.3
25	39.37	0	9.5	5.0	9.5
26	0	-39.37	10.0	10.0	10.0

TABLE III DOSE RATES (MR/HR) AT GENERATOR SURFACE
(SEE FIG. 6)

DOSE POINT	$X_{(in)}$	$Z_{(in)}$	MALLORY 1000 ON SIDE t_1 = 1 3/4"	t_1 = 2"
30	0	18.54	34.3	34.3
31	2		31.5	31.5
32	3		28.2	28.2
33	4		23.8	23.8
34	5		19.0	19.0
35	6		14.5	14.5
36	7		10.5	10.5
37	8		7.6	7.4
38	9		7.0	5.3
39	10		10.4	5.1
40	11		18.0	7.3
41	12.8	18.54	40.3	16.6
42	32.6	17.54	57.6	24.4
43		16.54	79.5	34.8
44		15.54	103.0	46.8
45		14.54	120.0	56.5
46		13.54	107.0	52.1
47		12.54	68.3	34.1
48		11.54	36.9	18.9
49		10.54	15.6	8.2
50		9.54	9.5	5.1
51	32.6	0	77.1	44.2
52	0	-38.9	81.8	81.8
53	0	8.43	329.0	329.0
54	0	9.55	227.0	227.0
55	1.77		164.0	164.0
56	3.54		53.9	53.9
57	4.55		54.1	23.4
58	5.55		210.0	87.5
59	6.56		437.0	195.0
60	7.56		668.0	311.0
61	8.61		310.0	151.0
62	9.67		134.0	67.6
63	10.72		56.7	29.3
64	11.78	9.55	23.3	12.3

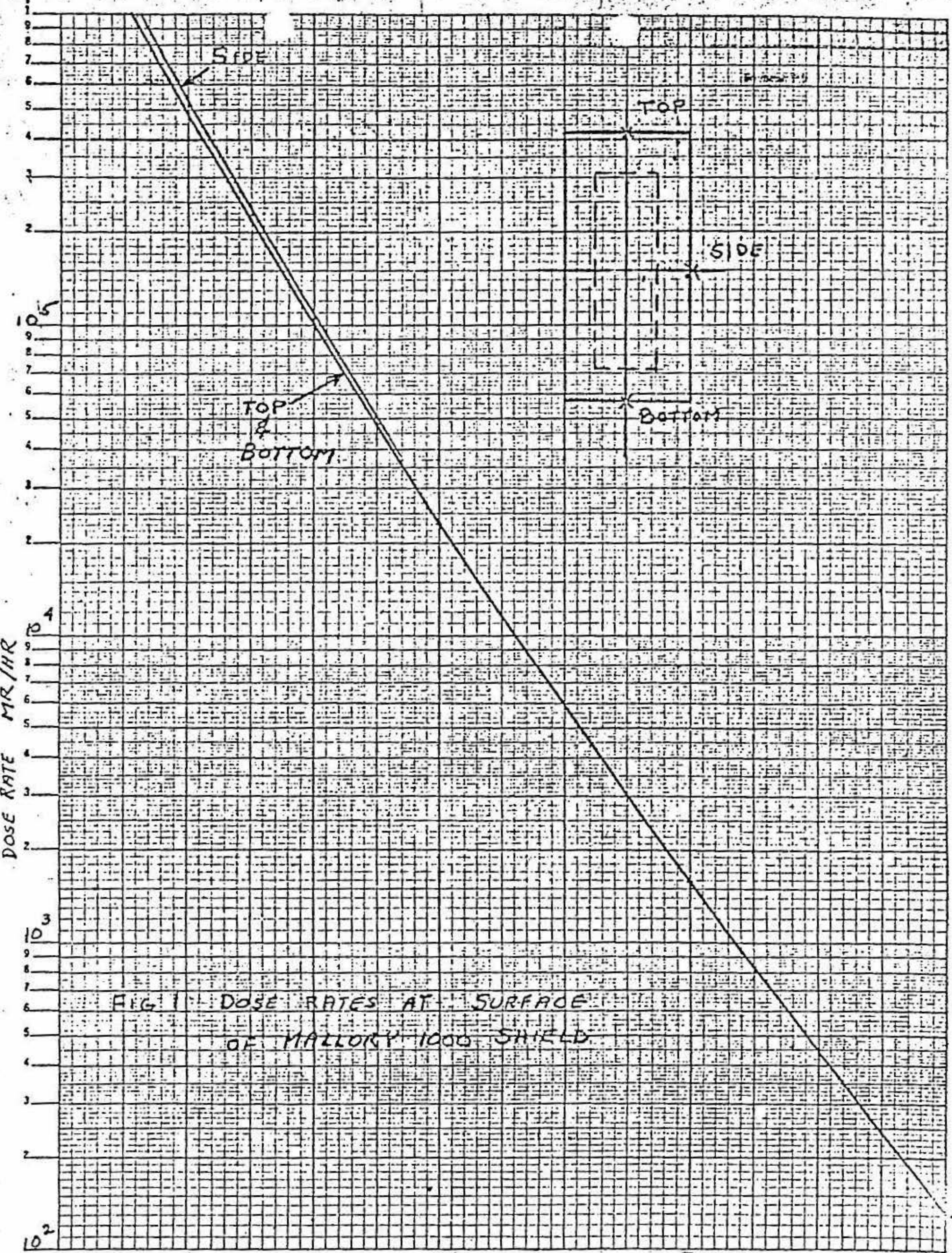
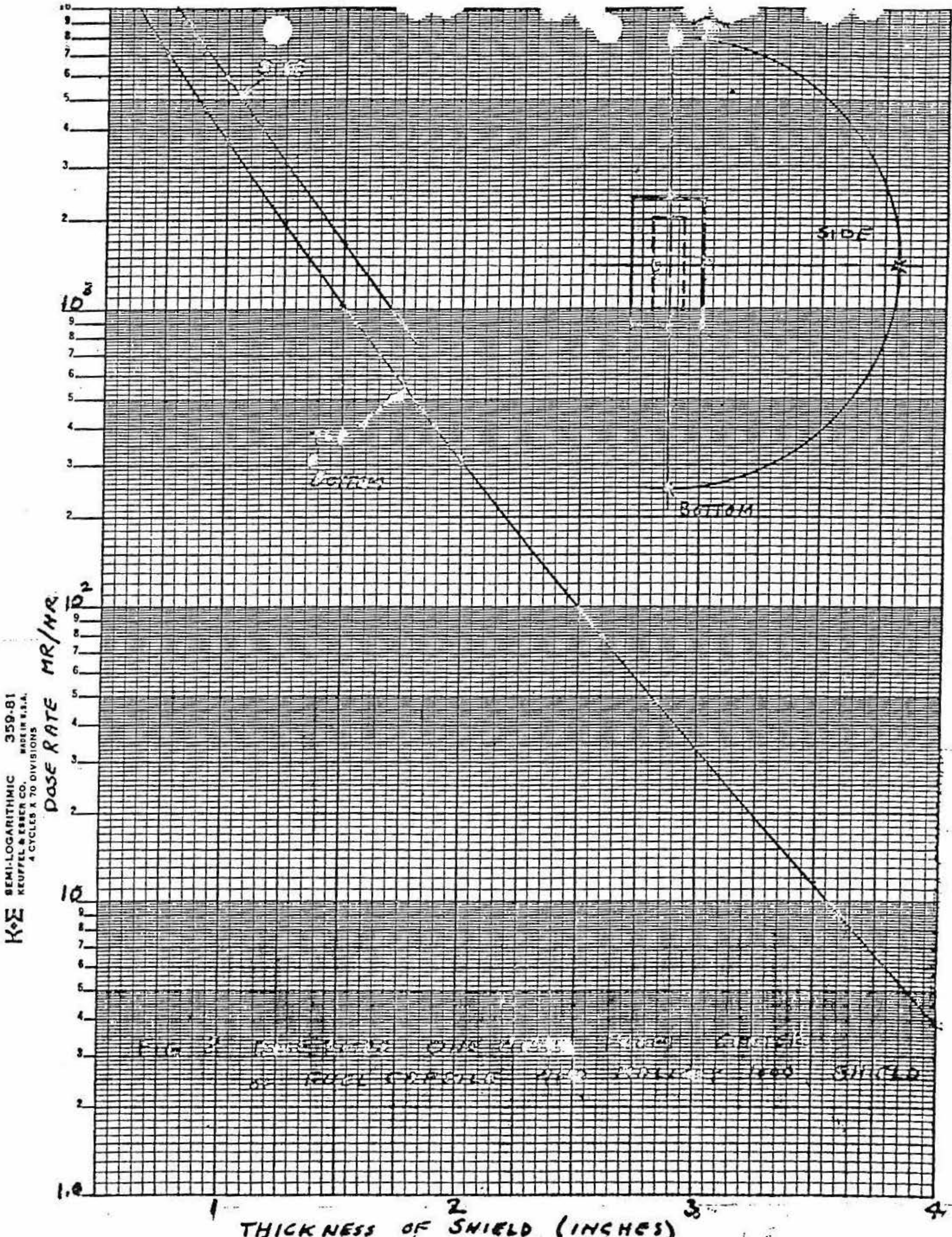


FIG 1 DOSE RATES AT SURFACE OF MALLORY 1000 SHIELD



K+E SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS
DOSE RATE MR/HR
SIDE
BOTTOM
FIG 3
FUEL CAPSULE
SHIELD
1.0
10
10^2
10^3
1
2
3
4
THICKNESS OF SHIELD (INCHES)

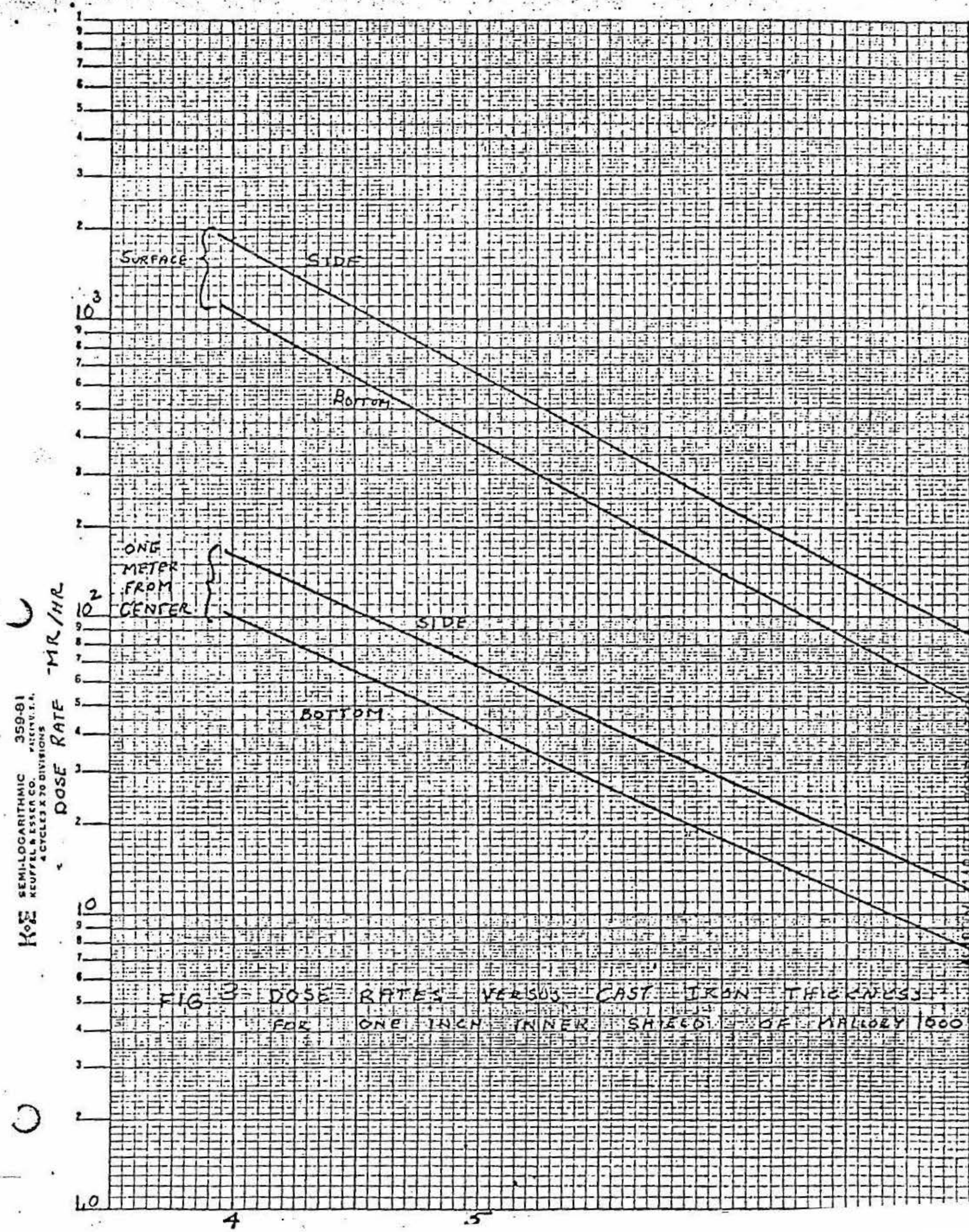


FIG 3 DOSE RATES VERSUS CAST IRON THICKNESS FOR ONE INCH INNER SHIELD OF MALLORY 1000

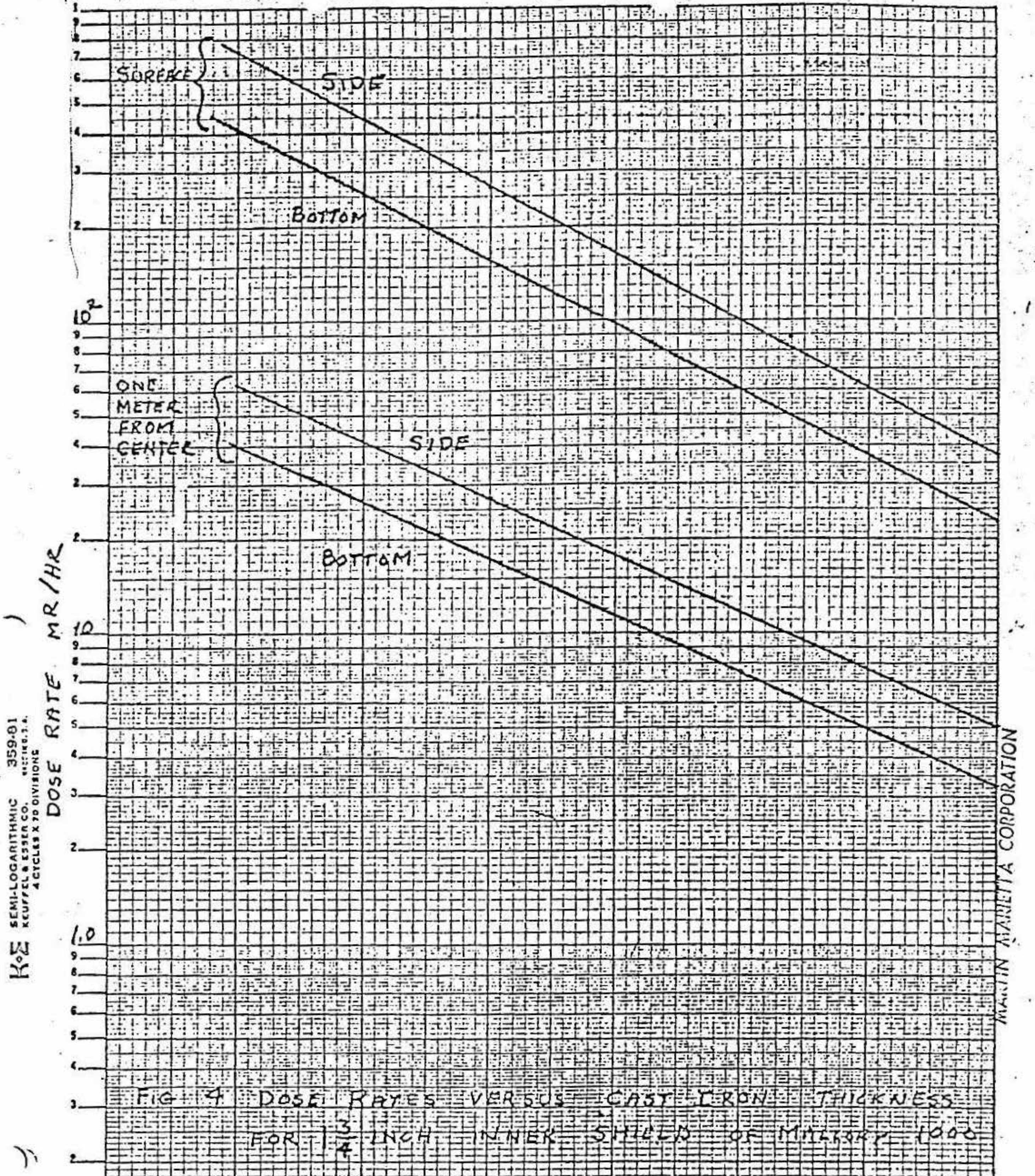


FIG 4 DOSE RATES VERSUS CAST IRON THICKNESS FOR $1\frac{3}{4}$ INCH INNER SHIELD OF MALLORY 1000

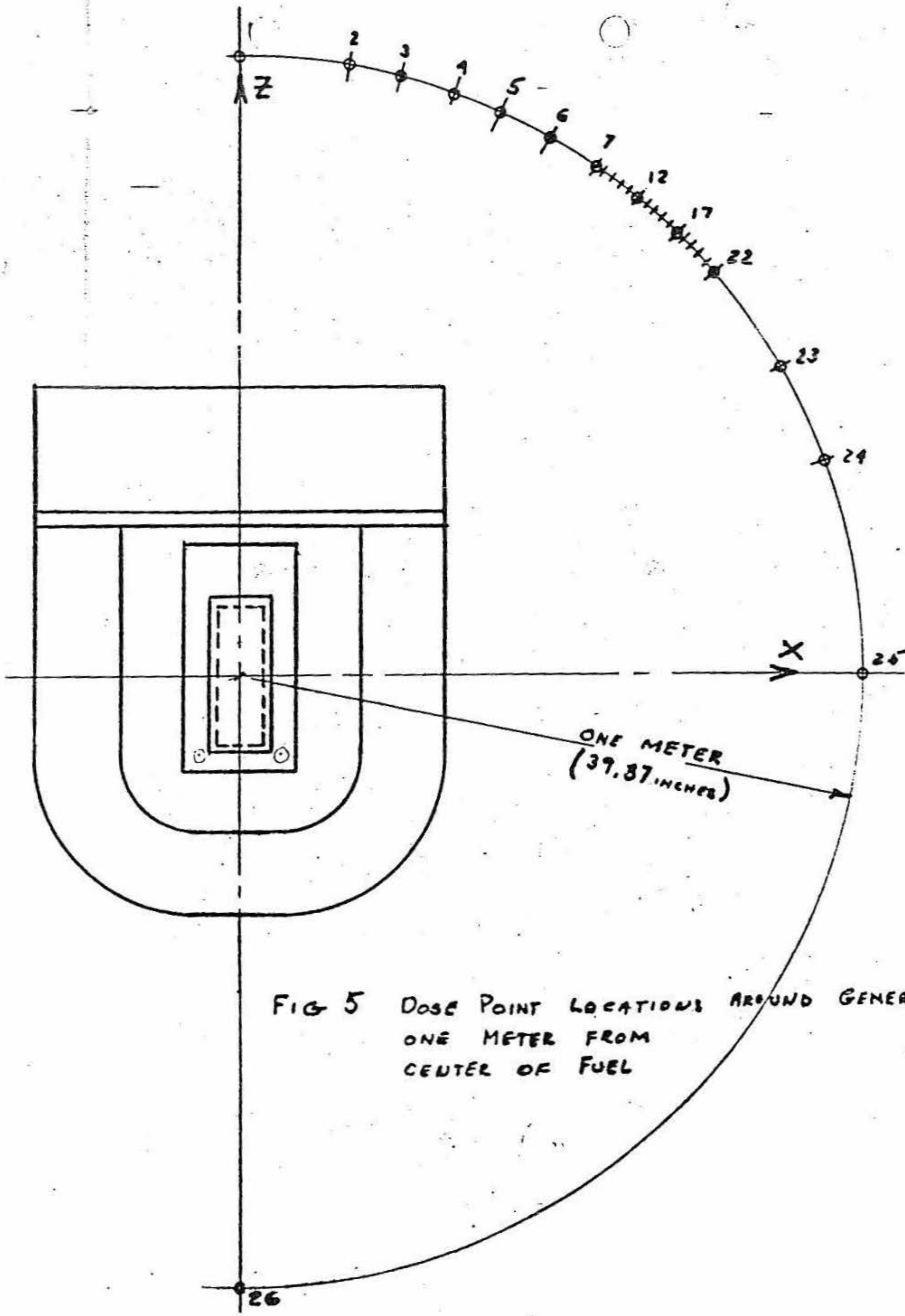


FIG 5 DOSE POINT LOCATIONS AROUND GENERATOR ONE METER FROM CENTER OF FUEL

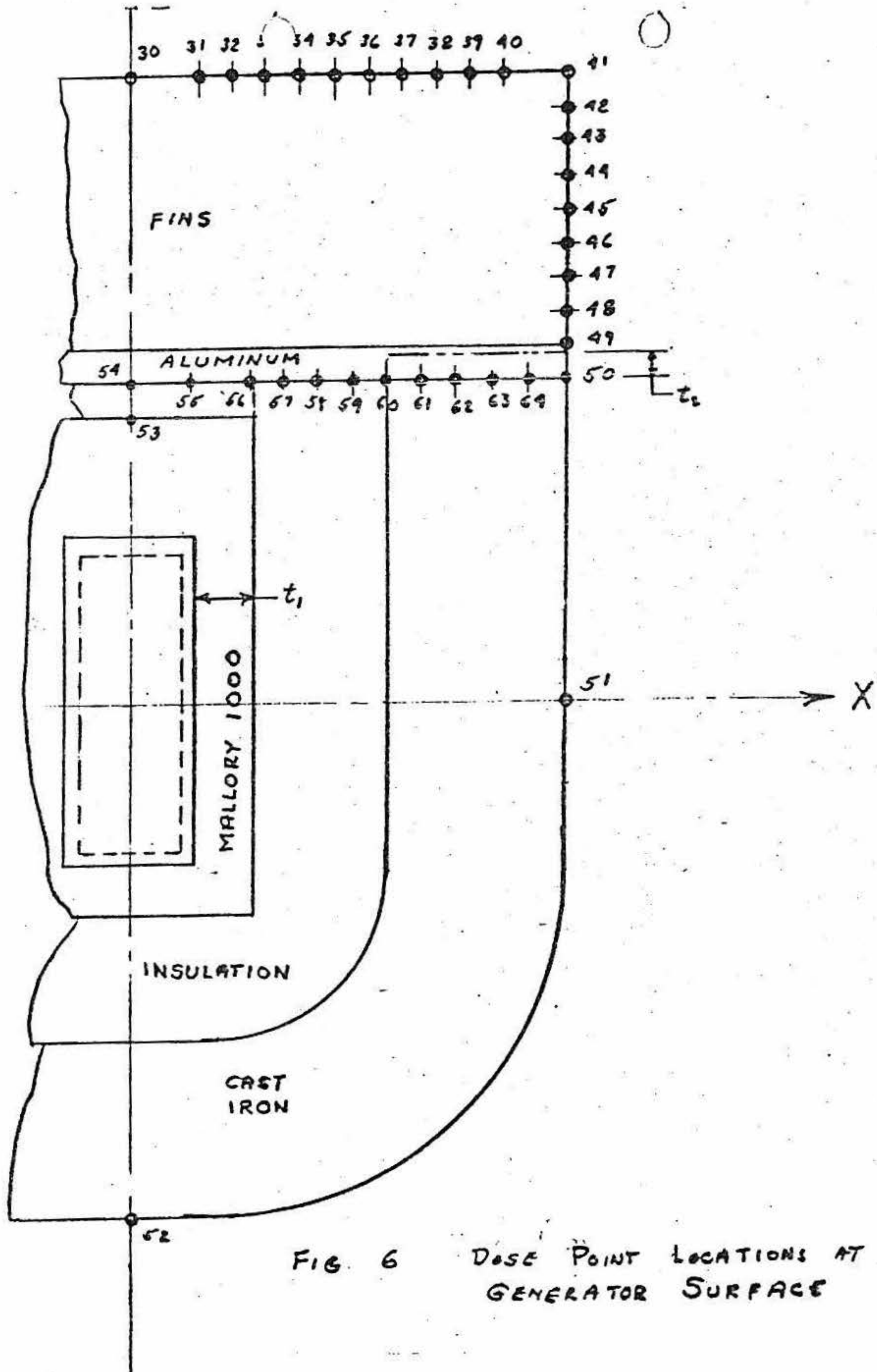


FIG 6 DOSE POINT LOCATIONS AT GENERATOR SURFACE

TES-3206

50.

ITEM NO. 4

SPECIFICATION

FOR

STRONTIUM-90 HEAT SOURCE FOR THE LCG-25A GENERATOR

MN-10139,

April 19, 1965

WRITTEN BY G. S. Stivers

APPROVED BY Safety

APPROVED BY Reliability

APPROVED BY Design-Analysis Unit

APPROVED BY

THE MARTIN-MARIETTA CORPORATION
BALTIMORE, MARYLAND 21203

SHEET 1 OF 2

(Insert opp. page 1)

SPECIFICATION CHANGE NOTICE

NO. 2

DATE 9/15/65

SPEC. NO. MN-10139 C.C.P. -

DATED April 19, 1965 PROJECT LCG

CONTRACT -

SUBJECT OF CHANGE

Deletion of fuel specification reference

NATURE OF CHANGE:

Para: 2.1 Delete the following
"MN-(to be issued)-Sr-90 Fuel for Terrestrial Applications"

Para. 3.1 Delete all after "...Titanate form".

Para. 3.2.1 Change "700 watts" to "688 watts" and "675 watts" to "662 watts"

REASON FOR CHANGE

The fuel cannot be specified at this time.

REFERENCE:

AUTHORIZATION: Not applicable MARTIN APPROVAL Earl B. West

THIS SCN AFFECTS PAGES

1 and 2

Manufacturer's Code 38597

N-147

SPEC. NO. MN-10139

SPECIFICATION

FOR

STRONTIUM-90 HEAT SOURCE FOR THE LCG-25A GENERATOR

1. SCOPE - This specification establishes the requirements for a Strontium-90 heat source (fuel capsule) for the LCG-25A radioisotope thermoelectric generator.

1.1 GENERAL - No modifications or deviations from either this specification or referenced documents shall be allowed unless authorized by Engineering in writing.

2. APPLICABLE DOCUMENTS - The following documents form a part of this specification to the extent specified herein.

2.1 MARTIN SPECIFICATIONS

MN-10137 - Hastalloy C Fuel Capsule Welds

MN-(To be issued) - Sr-90 Fuel For Terrestrial Applications

2.2 I.C.C TARIFF 2 - Dangerous Articles

2.3 ASTM-321 - Corrosion Resistant Steel

3.0 REQUIREMENTS

3.1 Sr-90 FUEL - The Strontium-90 fuel shall be in the Titanate form and shall meet the requirements of MN-(to be issued), Strontium 90 Fuel for Terrestrial Applications.

3.2 SOURCE THERMAL REQUIREMENTS

3.2.1 - A Time Of Encapsulation - At the time of fuel encapsulation, the thermal inventory in the fuel capsule shall be not more than 700 watts nor less than 675 watts.

THE MARTIN-MARIETTA CORPORATION
BALTIMORE, MARYLAND 21203

SHEET 2 OF 2

(Insert opp. page 2)

Spec. No. MN-10139

SPECIFICATION CHANGE NOTICE

NO. 2

DATE 9/15/65

Para. 3.2.2 Revise entire paragraph to read, "3.2.2 At 7.5 Years From Encapsulation - For the determination of Sr-89 content limitations, the thermal inventory seven and one half (7.5) years after encapsulation shall be not less than 543 watts nor more than 564 watts."

AUTHORIZATION SEE SHEET 1

THIS SCN AFFECTS PAGES
1 and 2

3.2.2 - At 7.5 Years From Encapsulation - For the determination of Sr-89 content limitations per MN-(to be issued), Strontium-90 Fuel for Terrestrial Applications, the thermal inventory seven and one half (7.5) years after encapsulation shall be not less than 560 watts nor more than 585 watts.

3.3 CAPSULE SURFACE CONTAMINATION - Exterior radioactive contamination of the completed fuel capsule, as measured by wipe test, shall not exceed 0.005 microcuries per one hundred (100) square centimeters.

3.4 SHIPPING CONTAINER CONTAMINATION - Following the loading of the fuel capsule into the shipping container (either a generator or a generator body with a shipping lid), the radioactive contamination of the exterior surfaces shall not exceed those specified in the Interstate Commerce Commission Regulations for shipping radioactive materials. (I.C.C. Tariff 2)

3.5 FUEL CAPSULE LINERS - Fuel capsule liners may be used at the discretion of the fueling facility to aid in the fuel processing and the fueling of the LCG-25A heat source. If such liners are used, they shall be fabricated from ASTM-321 stainless steel.

3.6 CAPSULE WELD REQUIREMENTS - All fuel capsule outer welds shall meet the requirements of MN-10137.

3.7 CAPSULE MATERIAL CERTIFICATION - A certified laboratory analysis shall be obtained for all materials used in the fabrication of capsule components and test specimens except the fuel. The analyses shall be obtained from the Supplier of the materials or alternately by chemical and/or spectrographic analysis performed by the Martin Company. Any deviation from governing specifications specified by procurement documents, and/or engineering drawings shall be cause for rejection.

3.8 FUEL CAPSULE OPERATING ENVIRONMENT - The Fuel Capsule shall be designed with the objective of operating in either of the following environments for the time specified without breaching of the fuel capsule.

3.8.1 NORMAL ENVIRONMENT - When the fuel capsule is installed in the generator the environmental parameters are:

Temperature - Fuel capsule surface 1400 to 1800°F.

Pressure - 1.0 to 1.5 atmosphere.

Atmosphere - 95% Argon, Balance N_2, O_2 CO_2.

Time - 300 years

3.8.2 EMERGENCY ENVIRONMENT - As an alternate to the environment of paragraph 3.8.1, the capsule may experience the following environment:

3.8.2.1 - Fire

Temperature	- 2000°F on fuel capsule surface.
Pressure	- 1 atmosphere
Atmosphere	- Air and hydrocarbon combustion products.
Time	- The above conditions will exist for a maximum of one hour.

Following the fire, the capsule will be subject to 300 years exposure to salt air at 125°F with the capsule surface temperature at 1000°F.

3.8.2.2 - Submergence - The capsule may be submerged in sea water at a depth of 3000 ft. (1500 psi) for 300 years.

3.9 IDENTIFICATION - All heat sources and test pieces shall be assigned an identifying number and shall be clearly marked with that number. Test pieces may be permanently marked, but heat sources shall be identified only by tags or other non-permanent methods.

4.0 QUALITY ASSURANCE

4.1 INSPECTION SYSTEM REQUIREMENTS - A system of quality control and inspection shall be set up to verify conformance with the requirements of this specification. A complete quality control record shall be maintained and one copy of all required documents shall be transmitted to the Martin Company. The records shall include as a minimum but not be limited to the following items:

4.1.1. CAPSULE MATERIALS CERTIFICATION - A certified chemical analysis of all materials used in the fuel capsule and fuel capsule liner, except the fuel.

4.1.2. FUEL - Qualification test data and equipment log books and individual run test data to demonstrate the conformance to paragraph 3.1 of this specification.

4.1.3. SEAL WELD PROCESS CERTIFICATION - Qualification test data, weld photo micrographs and equipment log books and quality control test data to demonstrate conformance with paragraphs 3.6 and 4.2 of this specification (that is, as required in MN-10137).

4.1.4. RADIOCONTAMINATION WIPE TESTS - Test data demonstrating conformance to paragraphs 3.3, 3.4 and 4.3 of this specification for each heat source.

4.1.5. CALORIMETRY TESTS - Test data demonstrating conformance with paragraph 3.2 and 4.4 of this specification for each heat source.

4.1.6. PART IDENTIFICATION - Each heat source and test piece shall be assigned an identifying number and shall be clearly marked with that number. Test pieces may be stamped with dye or ink or may be scratched grooved or otherwise marked. Heat sources shall not be marked in anyway but shall be identified by tag or other non-permanent method.

4.2 WELD QUALITY VERIFICATION - All capsule welds shall be tested according to the tests and inspections required in paragraph 3.6 of this specification (that is as required in MN-10137).

4.3 WIPE TESTS - Radiocontamination Wipe Tests shall be performed on the fuel capsule exterior after the final decontamination and on the shipping cask or generator exterior after heat source installation. In either case radioactive contamination shall not exceed 0.005 microcuries per 100 square centimenters. If contamination exceeds this level, the decontamination process will be repeated until the above level is reached. If the specified level is not obtained, the capsule or generator will be rejected.

4.4 CALORIMETER CHECK OF HEAT SOURCE - The fuel capsule, following the final seal weld and decontamination, shall be tested by means of a calorimeter for conformance to paragraph 3.2.1. If the fuel capsule thermal inventory exceeds 700 watts or is less than 675 watts, the capsule shall be rejected.

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SEE PAGE FOR REVISIONS
57.

ITEM NO. 5

N0013130

			N0013T00	LCG 25		
EFFECTIVE ON	CALC WT	DASH NUMBER	NEXT ASSY	USED ON	FINAL ASSY	TEST
			APPLICATION		QTY REQD	

DRAWN BY G.S. STIVERS DEPT. 1553 DATE 5/10/5	MARTIN COMPANY A DIVISION OF MARTIN MARIETTA CORPORATION FRIENDSHIP INTERNATIONAL AIRPORT, MARYLAND	
CHECKER Gordes 1550 5-19-65	FUELING INSTRUCTIONS AND MODULE INSTALLATION INSTRUCTIONS FOR LCG-25A	
STRESS ENGR		
WT ENGR		
MATL-ENGR		
RELIABILITY 1553 5/20/65		
R ENGR Wm J. Beutel 5/19/5		
PROGRAM REP. George S. Stivers 5/20/5	CODE IDENT NO. 38597	SIZE A — N0013130
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REVISIONS

SYM	PAGE	DESCRIPTION	DATE	APPROVED

CHG.	CODE IDENT NO. 38597	SIZE A	N0013130
	SCALE		PAGE 3

FUELING INSTRUCTIONS AND MODULE INSTALLATION

INSTRUCTIONS FOR LCG-25A

CONTENTS

I. GENERAL

The LCG-25A (N0013100) is to be fueled with approximately 120,000 * curies of Sr-90 in the titanate form. Prior to the insertion of the fuel in the generator, it will be sealed into a Hastelloy-C fuel capsule (N0013108). The insertion of this fuel capsule into the generator is the subject of this instruction. The fuel capsule is to be inserted into the heavy metal inner shield (PN 1000003-003) of the generator and the shield plug emplaced on top of the capsule (PN 1000003-001).

Following the insertion of the top plug it is safe to approach the generator because the biological shielding is complete. At this time, either a special shipping cover (N0013017-019) or a thermoelectric module (N0013107 or N0013116) is to be placed on the generator. If the shipping cover is used, the module will be installed later. Following any of these operations, the generator is to be outgassed to remove oxygen and water vapor from the interior and/or to outgas the thermal insulation.

Caution should always be taken to insure the minimization of oxidation of the heavy metal inner shield, in handling the thermoelectric modules so as not to injure them, and to insure that the interior of the generator is properly outgassed.

* See paragraph 3.2.1 of Reference (1).

II. APPLICABLE DOCUMENTS AND DRAWINGS

A. Martin Specifications

(1) Fuel, Fuel Encapsulation and Fuel Capsule Specification for LCG-25A. MN 10139

B. Martin Drawings

N0013100	LCG-25 Generator Assembly
N0013107	Module Assembly, Spring Loaded
N0013113	Shield Vessel
N0013116	Module Assembly, 28 Couple LCG
N0013108	Fuel Capsule Assembly
N0013125	Retaining Ring
N0013126	Insulation
N0013017-019	Radiator Assembly (Shipping Cover)
PN1000003	Shield Plug and Shield Body

III. GENERATOR ASSEMBLY STEPS PRIOR TO FUELING

A. General

Prior to fueling the generator and installing the module several operations must be performed to prepare the generator.

B. Prefueling Procedure

1. Coat all bolts required with Electrofilm #1000 per N0013100 Note 7.
2. Install generator insulation (N0013126) in the shield vessel (N0013113) per drawing N0013100.
3. Place the Inner Biological Shield (PN 1000003) into the generator and measure the distance from the top of PN 1000003 to the top of N0013113. (Surfaces A and B on Drawing N0013100)
4. Shim with 321 SS sheets under biological shield until distances and tolerances required by Drawing N0013100 are met.
5. Install thermocouples on Biological Shield Top plug per N0013131.
6. Install Fuel Block Retaining Ring (N0013125).
7. Install top ring of thermal insulation, N0013126-023 or -025, depending on whether the generator is to be sent to the fueling site with the shipping cover (N0013017-019) or a module.
8. Install shipping cover or module, being careful not to nick or mar "O" Rings or seal surfaces. At this time there is no need for the generator to be sealed. Therefore the cover (or module) need only be secure. No leak check is needed.

9. Install the generator on the shipping pallet for shipment to the fueling site.

IV. FUELING THE GENERATOR WITHOUT MODULE

A. General

The LCG-25A will be shipped unfueled to the fueling facility. As received at the fueling facility the heavy metal inner shield body and plug (see Dwg. PN 1000003) will be installed in the generator outer housing (see Dwg. N0013100). The generator cover, top insulation, retaining ring and the inner shield plug will be removed. The fuel capsule will be inserted and the shield plug replaced in a hot cell. The generator cover will then be installed and the generator purged (or the insulation outgassed if a module is installed). This section will describe the fueling operation for the generator with shipping cover only. The modifications introduced for generators with modules will be presented in subsequent sections. The procedures of Section III of this procedure should be completed before the generator is sent to the fueling facility.

B. Procedure for Fueling Generator

1. Place generator, as received, in hot cell to be used for the fueling operation.

2. Remove generator cover, being careful not to nick or mar the "O" Ring seals or seal surfaces. Lightly grease the "O" rings with

vacuum grease. Set "O" rings aside.

3. Remove inner shield bolts and lock washers and insert lifting eye bolts in the inner shield top plug. Set bolts aside in accessable location. Install locating studs in shield body (PN1000003-003).

4. Remove top ring of thermal insulation, retaining ring and shield top plug. (N0013126-023, N0013125, PN1000003-001).

5. Attach outgassing cart to cover outgassing port with sufficiently long vacuum hose to permit removal and re-installation of the lid. Leak check these connections. (Leak rate shall not be detectable with a sensitivity of 10^{-6} cc/sec of helium on leak detector.)

6. Install Fuel Capsule

7. Install shield top plug using locating studs.

8. Monitor cell radiation.

9. Enter cell and check radiation levels and contamination at top of generator. If they meet the requirements, proceed. If not, remove fuel capsule, return it to storage and notify the Project Engineer and Project Manager. (Requirements are that the radiation level be 10 mr/hr at a meter from the center of the generator and .05μ-curies per 100 cm^2)

10. Install fuel block retaining ring and top thermal insulation ring.

11. Install bolts and lock washers into inner shield that were removed in Step 3. Tighten with 45 ft. lbs torque.

12. Remove lifting eye bolts.

13. Place cover on generator. Be careful not to pinch, nick or mar "O" Rings or seal surfaces. Bolt lid down, per Note 2 on Dwg. N0013100.

14. Evacuate generator to 500μ pressure and backfill generator with cold trapped (dry ice and acetone) helium to 40$\pm$ 1 inches Hg pressure (absolute).

15. Leak check the generator. Leak rate shall not be detectable in 60 min. with sensitivity of 10^{-7} cc/sec. of helium on the leak detector.

CAUTION

Steps 6 through 13 should be performed as quickly as possible but in no case should more than 30 minutes be spent. If trouble is encountered, remove fuel capsule before correcting the difficulty. This is necessary to minimize oxidation of the heavy metal inner shield. If the fuel capsule must be left in the generator and the cover removed from the generator after fueling, a cold trapped argon purge tube will be inserted at the lowest available point in the generator to retard diffusion and eddying of air into the generator.

16. Evacuate and backfill the generator as follows:

a. evacuate for 10 minutes

b. backfill with cold trapped helium to 40 $\pm$ 1 inches Hg pressure absolute. Let stand for 10 minutes after attaining pressure.

c. repeat Steps a. and b. 5 times, leaving helium in generator after last gas fill.

17. Prepare the generator for shipping.

C. Required Equipment to Fuel Generator

a. generator body including vessel, inner shield, insulation, fuel block retaining ring, bolts washers, etc. per Dwg. N0013100.

b. locating studs

c. lifting eyebolts for shield top plug

d. evacuation cart

e. fuel capsule without fuel

f. helium bottled gas and regulators

g. fuel

h. dry ice and acetone

i. plumbing necessary to connect generator outgassing tube to vacuum cart

j. leak detector and calibtrated leak

k. suitable wrenches and other tools.

V. INSTALLING MODULE

A. General

The procedure for fueling a generator when a printed circuit module is to be installed is virtually identical to the procedure used when a shipping cover only is installed. However, after the installation of the module certain additional steps must be taken to check the module and outgas the generator insulation. The procedure given below will be followed in installing a module in the generator at a location other than the fueling facility, when the generator is shipped from the fueling facility with the special shipping cover, or at the fueling facility if a module is installed with the cover.

B. Procedure for Installing Module

At the Fueling Facility

Follow Fueling Procedure (Section III) through Step 12. Then proceed as follows:

13. Place finned radiator, with module attached, on generator. Be careful not to nick, mar or pinch "O" Ring or seal surfaces. Daub all hold down bolts with epoxy sealer EC801. Insert bolts and torque finger tight; pressurize generator to 35 in Hg Helium pressure; check for hiss of escaping Helium; this indicates a pinched "O" Ring. If the "O" Ring is seated properly, torque down bolts to 150 in. lbs per Note 2 on Dwg. N0013100.

14. Evacuate generator to 500 μ pressure and backfill generator with cold trapped (dry ice and acetone) helium to 40 ± 1 inches Hg pressure (absolute).

15. Leak check generator. Leak rate shall not be detectable in 60 min with sensitivity of 10^{-6} cc/sec of helium on leak detector.

16. Liberally cover all bolt heads with epoxy sealer EC801 so that no portion of the bolt is exposed and so that the epoxy touches the lid all around the bolt head. Liberally cover the joint between the lid and the shield vessel also.

17. Outgas generator insulation according to outgassing procedure described in Section VI of this procedure immediately.

18. Check module performance for conformance to the requirements of Section VII of this procedure. If module fails to meet requirements of Section VII notify the Project Engineer. The module will be replaced.

At a Site Other Than the Fueling Facility

1. Attach outgassing cart to outgassing port on finned radiator with module attached. Attach another line to outgassing port on shipping cover. Prepare an argon purge line.

2. Evacuate generator for 10 minutes. Backfill with cold trapped (dry ice and acetone) argon to 35 ± 1 inches Hg pressure (absolute).

3. Remove shipping cover and top insulation ring (used with special shipping cover).

4. Place argon purge line on top of fuel block (PN 1000003) ... generator.

5. Attach fuel block instrumentation, ..., to generator radiator feed throughs.

6. Install top insulation ring N0013126-025.

7. Remove purge line.

8. Place module and radiator on generator. Be careful not to nick, mar or pinch the "O" Ring or seal surfaces. Daub all hold down bolts with Epoxy Sealer EC 801. Insert bolts and torque finger tight. Pressurize generator to 35 in Hg. Helium pressure. Check for hiss of escaping helium. This indicates a pinched "O" Ring. If the "O" Ring is seated properly, torque down bolts to 150 in. lbs per Note 2 on Dwg. N0013100.

9. Evacuate generator for 5 minutes and backfill to 40 ± 1 inches Hg pressure with cold trapped helium.

10. Leak check the generator. Leak rate shall not be detectable in 60 min. with sensitivity of 10^{-6} cc/sec of helium on leak detector.

11. Liberally cover all bolt heads with Epoxy Sealer EC801, that no portion of the bolt is exposed, and so that the epoxy touches the lid all around the bolt head. Liberally cover the joint between the lid and the shield vessel also.

12. Outgas generator insulation according to outgassing procedure described in Section VI of this procedure.

13. Check module performance for conformance to the requirements of Section VII of this procedure. If the module fails to meet the requirements of Section VII notify the Engineering Manager. The module will be replaced.

CAUTION

Steps 3 through 9 should be performed as quickly as possible but in no case should it require more than 30 minutes. If trouble is encountered, re-install the shipping cover, evacuate and backfill with argon or helium and correct the deficiency without exposing the inside of the generator to the air any more than possible.

VI. GENERATOR OUTGASSING PROCEDURE

1. As the generator heats up, evacuate generator continuously for until the modules hot plate or diaphragm temperatures reaches 600°F.
2. Fill with argon or Helium (at the Project Engineer's direction) to +35 in. Hg absolute pressure. Cold trap the gas with dry ice and acetone before feeding it into the generator.
3. Pump down for 15 minute intervals every hour until the generator internal pressure reaches 100μ. After every 15 minute pump down, backfill with argon or helium. Repeat as often as necessary to get generator internal pressure down to 100μ after 15 minutes.

Note: If a module has been installed at a site other than the fueling facility, only Step 3 applies.

VII. MODULE PERFORMANCE DATA

To be written at a later date when module test data are available.

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PN100003

SECURITY REVIEW RD DI GP-1 GP-2 (UCS circled) TS GP-3 GP-4
CLASSIFIER Wm. J. Beutel 4/29/5
N-140

SPECIFICATION CONTROL DRAWING

EFFECTIVE ON	CALC WT	DASH NUMBER	NEXT ASSY	USED ON	FINAL ASSY	TEST
			APPLICATION		QTY REQD	

DRAWN BY / DEPT. / DATE: ..HUDDLE 1553 4-29-65	**MARTIN COMPANY** A DIVISION OF MARTIN MARIETTA CORPORATION FRIENDSHIP INTERNATIONAL AIRPORT, MARYLAND
CHECKER: [signature] 1550 4-29-65	
STRESS ENGR: [signature] 1554 4-29-65	SHIELD PLUG AND SHIELD BODY
T ENGR	
MATL ENGR: J. J. Fretheim 1552 4-30-65	
RELIABILITY: [signature] Brundage 4/30/65	
R ENGR: Wm. J. Beutel 4/29/5	
PROGRAM: George S. Stevens 4/29/5	CODE IDENT NO. 38597 / SIZE A / PN100003
ST.	
P.	SCALE / SHEET / PAGE 1 OF 11

REVISIONS

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	SCALE	SHEET		PAGE 3

1.0 SCOPE

1.1 Purpose - This specification establishes the requirement for the design and manufacture of the biological shield for a radioisotope fueled thermoelectric power generator. The shielding will be fabricated in two parts, -001 shield plug and -003 the shield body. The shielding is required to limit the radiation from the generator assembly.

2.0 APPLICABLE DOCUMENTS

NONE

3.0 REQUIREMENTS

The design and construction of the shield shall be in accordance with the requirements of this specification and any referenced specifications or other documents specified herein.

3.1 Configuration - The shield configuration shall agree with the dimensions shown in Figures 1 and 2 pages 10 and 11 for the shield plug and body respectively after application of the protective coating described in paragraph 3.4.

3.2 Material - The shield pieces shall be fabricated from a tungsten alloy consisting primarily of tungsten with small additions of copper and nickle, or other metals as binding agents. The material shall be formed by powder metallurgy techniques.

3.2.1 Density - The shield pieces shall have a density at room temperature of not less than 16.9 grams per cubic centimeter (.611 pounds per cubic inch).

3.2.2 Mechanical Properties. The material in the shield shall have the following mechanical properties.

3.2.2.1 0.2% Tensile and Compressive Yield Strength - The material shall have not less than 75,000 psi 0.2% tensile and compressive yield strength at 70°F and not less than 30,000 psi 0.2% tensile and compressive yield strength at 1500°F.

3.2.2.2 Ultimate Tensile and Compressive Strength - The material shall have not less than 105,000 psi ultimate tensile and compressive strength at 70°F and not less than 45,000 psi ultimate and compressive strength at 1500°F.

3.2.2.3 Elongation - The material shall have not less than 10% tensile or compressive elongation at fracture at 70°F and not less than 5% tensile or compressive elongation at fracture at 1500°F.

3.3 Tolerances - Tolerances not specified herein shall be held and limited to good commercial standards.

3.4 Oxidation Retarding Coating - The surfaces of the shield pieces shall be coated, plated or otherwise treated so that they will be able to withstand exposure to air at 1800°F for at least 200 hours with no more than 1% loss in weight after removal of loose oxides.

The air will be slowly moving over the shield in the assembled condition.

The protective coating will protect the shield pieces after normal handling during generator assembly. The shield pieces will not be required to meet the other requirements of this specification following exposure to air as described above.

3.5 Method of Assembly - Martin will provide Ni base super-alloy bolts to hold the shield plug onto the shield body and will assemble the shield in a hot cell following insertion of a radioisotope filled fuel capsule (Ni base super-alloy) into the shield body.

3.6 Environment - The normal operating environment of the shield pieces will be as follows

Temperature	-	1200°F to 1600°F
Atmosphere	-	Argon - 99%
		Balance - CO_2, O_2, H_2, N_2.

The shield pieces will be operated in a sealed chamber. Under emergency conditions the environment of paragraph 3.4 may be experienced.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Dimensions - The dimensions of the shield pieces will be checked for compliance with paragraph 3.1.

4.2 Integrity of Oxidation Retarding Coating - The shield pieces will be inspected to determine the freedom of the oxidation resistant coating from nicks, mars or other blemishes that may cause its failure.

4.3 The average density of both shield pieces shall be measured by water displacement and weighing and recorded. The average density of the pieces, individually, shall be not less than 16.9 grams per cubic centimeter. If the average density of the piece is less than 16.9 grams per cubic centimeter, the part shall be rejected. The data shall be transmitted to the Martin Company along with the shield pieces.

5.0 PREPARATION FOR DELIVERY - Preparation for delivery shall be in accordance with best commercial practices with particular care taken to insure that the oxidation retarding coating is not nicked or marred during transportation.

6.0 NOTES

6.1 Definitions

6.1.1 Manufacturer or Vendor - The manufacturer or vendor shall be the industrial organization awarded the procurement agreement of which this specification becomes a part.

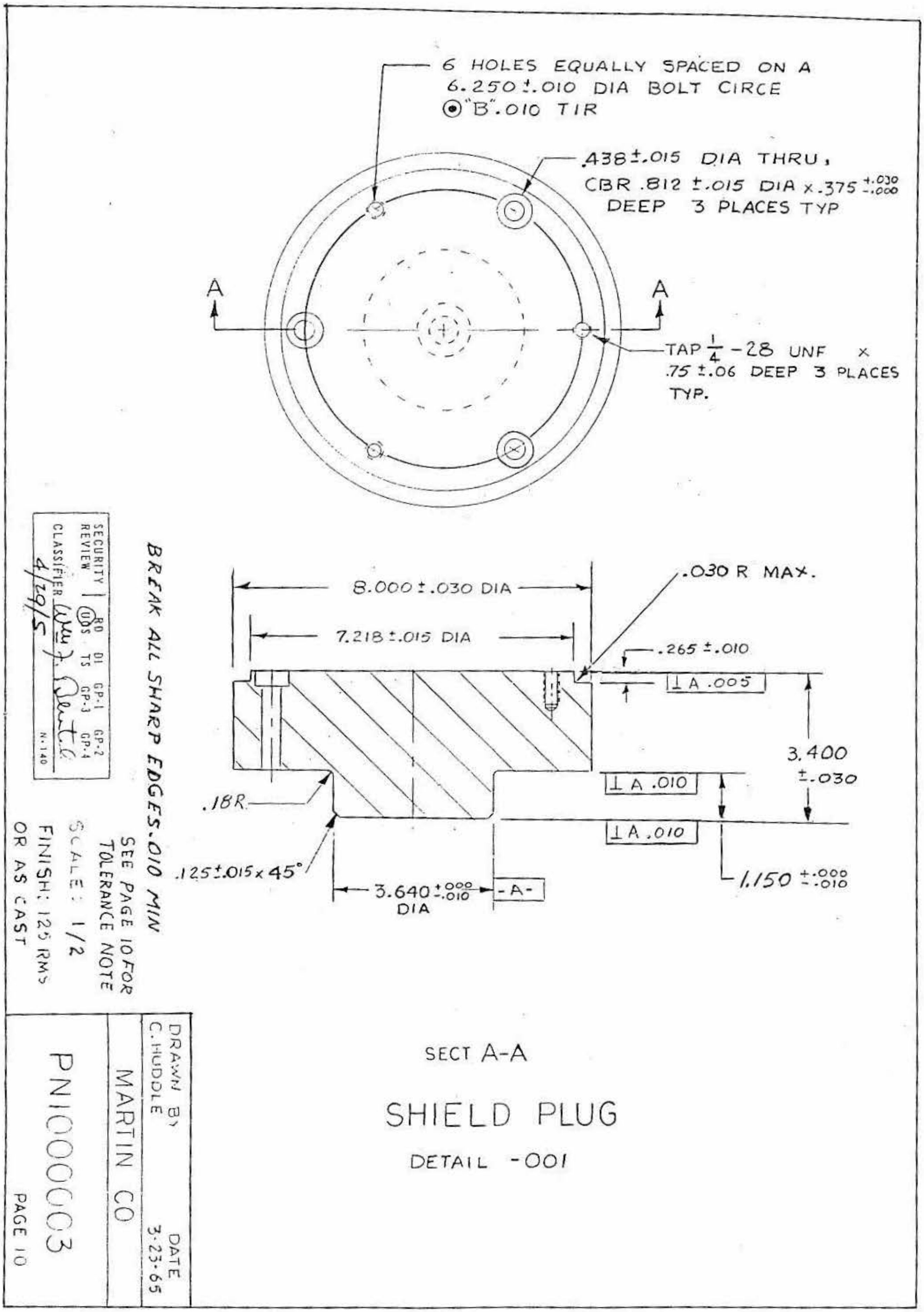
6.1.2 Martin - Martin shall be the Nuclear Division of the Martin Company, the Aerospace Division of the Martin Marietta Corp., Baltimore, Maryland 21203.

6.1.3 Shield Plug - That piece described by Figure 1 of this specification.

6.1.4 Shield Body - That piece described by Figure 2 of this specification.

6.1.5 Shield Pieces - The shield plug and the shield body.

6.1.6 Shield - The assembled shield pieces.


6 HOLES EQUALLY SPACED ON A
6.250 ±.010 DIA BOLT CIRCE
◉"B".010 TIR
.438±.015 DIA THRU,
CBR .812 ±.015 DIA x .375 +.030 -.000
DEEP 3 PLACES TYP
A
A
TAP 1/4 - 28 UNF x
.75 ±.06 DEEP 3 PLACES
TYP.
8.000±.030 DIA
.030 R MAX.
7.218±.015 DIA
.265 ±.010
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±.030
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⊥ A .010
.18R
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3.640 +.000 -.010
DIA
-A-
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SECT A-A
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DETAIL -001
BREAK ALL SHARP EDGES .010 MIN
SEE PAGE 10 FOR
TOLERANCE NOTE
SCALE: 1/2
FINISH: 125 RMS
OR AS CAST
SECURITY REVIEW
RD DI GP-1 GP-2
UOS TS GP-3 GP-4
CLASSIFIER
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C. HUDDLE
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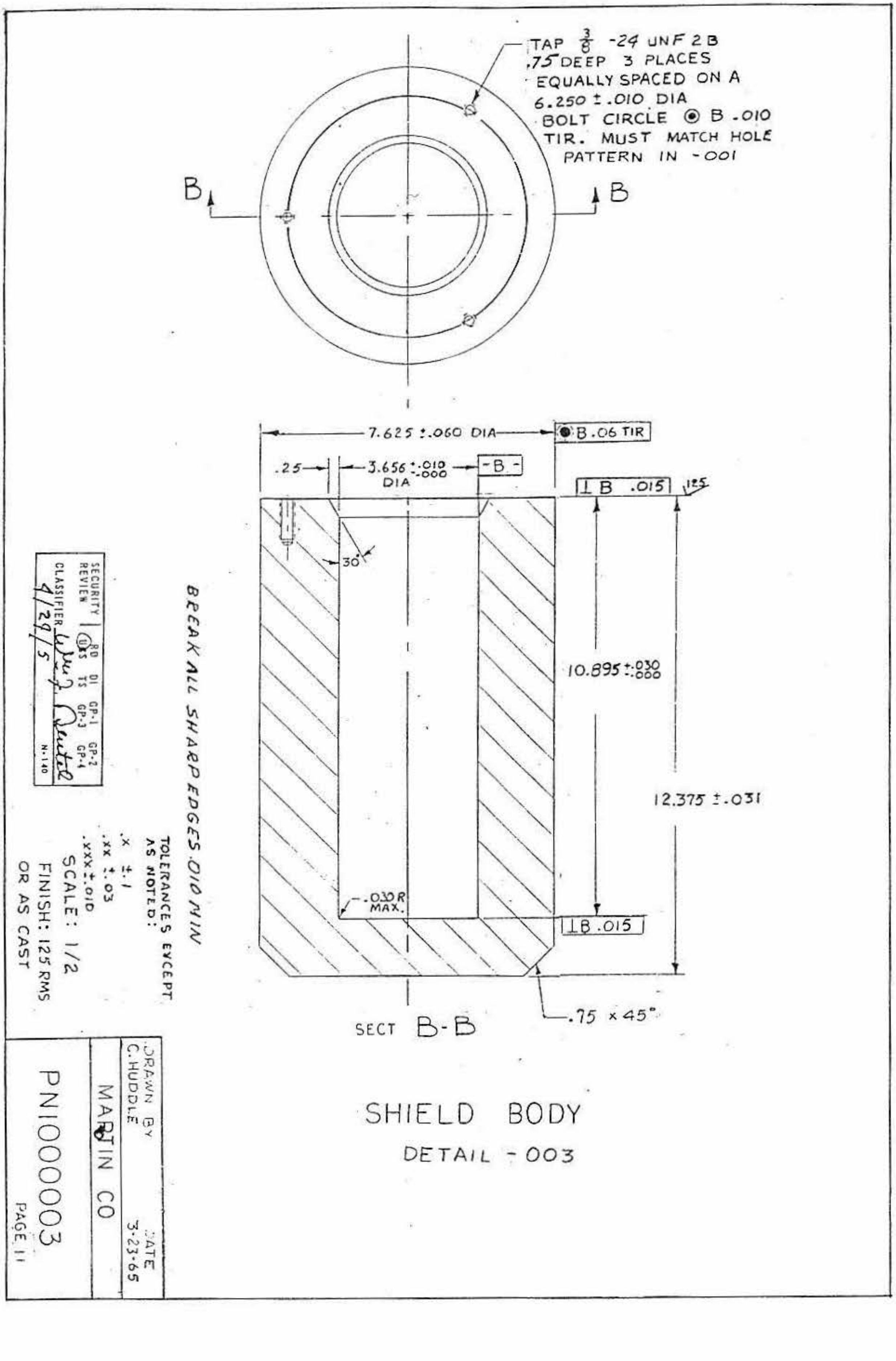
MARTIN CO
PN1000003
PAGE 10


TAP 3/8 -24 UNF 2B .75 DEEP 3 PLACES EQUALLY SPACED ON A 6.250 ±.010 DIA BOLT CIRCLE ◉ B .010 TIR. MUST MATCH HOLE PATTERN IN -001
B
B
7.625 ±.060 DIA
◉ B .06 TIR
.25
3.656 +.010 -.000 DIA
-B-
⊥ B .015
125
30°
10.895 +.030 -.000
12.375 ±.031
.030 R MAX.
⊥ B .015
.75 × 45°
SECT B-B
SHIELD BODY
DETAIL -003
BREAK ALL SHARP EDGES .010 MIN
TOLERANCES EXCEPT AS NOTED:
.x ±.1
.xx ±.03
.xxx ±.010
SCALE: 1/2
FINISH: 125 RMS OR AS CAST
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PAGE 11

TES-3206

LCG

ITEM NO. 7

Mail No. 845
January 14, 1966

Refer to:
ACC-455

U. S. Atomic Energy Commission
Division of Material Licensing
Washington, D. C.

Attention: Mr. W. Ray, Irradiated Fuels Branch

Subject: Byproduct License 19-1398-34 - Additional Information

Enclosure: (1) Additional Information for Byproduct License 19-1398-34 (3 copies)

Gentlemen:

As you are aware, it is our ultimate desire to obtain license coverage for the transport, display, and demonstration of the Martin Marietta Low Cost Generator in all areas of the U.S.A. in which AEC has jurisdiction. From discussions with you it has been indicated that additional information on the following topics is needed to permit you to continue evaluation of these aspects of the license.

1. The frangibility and compressibility characteristics of Min-K insulation at thetemperatures of interest.

2. The melting or failure temperature of the wolfram inner shield.

3. An evaluation of the temperature that will be reached by the wolfram inner shield under the accident conditions that will cause melting of the Hastelloy-C capsule.

4. Establishment of the stability of the strontium titanate fuel form at this maximum temperature.

5. Data on the strength of the bolts holding the cover on the wolfram inner shield at the normal operating temperature.

This submission supplies the additional information and we request that you continue your review in keeping with the newest proposed title 10, part 71, to permit the transport, display and demonstration of the Martin LCG in all areas within the U.S.A. in which the AEC has jurisdiction.

Thank you for your excellent cooperation in granting the original byproduct license No. 19-1398-34 and for your effort in the evaluation of this request.

Very truly yours,

MARTIN MARIETTA CORPORATION
MARTIN COMPANY, Baltimore Division

C W Keller

C. W. Keller
Nuclear Accountability and
Licensing Representative

CWK:mal

ITEM NO. 8

Additional Information

Byproduct License 19-1398-34
Martin Marietta Corporation

January 14, 1966

In answer to your questions on materials used in the LCG-25A generator the attached data and reports are submitted. The following comments should be considered along with the data.

1. The attached report MND-3169-45 on the strength of MIN-K at elevated temperatures should answer Question 1. Note that the data goes only to 1000°F. Note also conclusion (5) on Page 24 of the report. Operating experience with MIN-K at still higher temperatures indicates that this conclusion holds to at least 1300°F.

2. The attached report from the supplier of the tungsten shield is submitted in answer to Question 2. Note that the tests are such that they closely duplicate the actual tungsten shield conditions in that the material was subjected to a compressive load of 9 psi which is equivalent to the maximum pressure the material in the LCG-25 shield will see due to its own weight. No deformation was noted below 2350°F.

3. The attached calculation indicates that the tungsten shield will reach a maximum temperature less than 2285°F, which is well below the softening point of the shield material.

4. Little or no direct data is available on any of the strontium titanates at temperatures above 1000°F. The melting point of the fuel is well above the maximum fuel temperature expected, 2800°F, under maximum capsule temperature conditions. Mechanical stability at these temperatures has not been verified by experiment but the fuel is so far below its melting point (3490°F) that no problems are expected. It is known that a pressed pellet of strontium titanates will crack into several large pieces after long term exposure at 1000°F, apparently due to thermal stresses, but that is all that happens.

5. Data sheets on the bolt material are enclosed. The bolts meet specification AMS-5735E and are in the heat treat condition for which the mechanical properties on Page 2 of the A286 data sheet apply.

ITEM NO. 9

STRUCTURAL EVALUATION OF MIN-K 1301

MND-3169-45
January 1965

Prepared by:
D. R. Thomas

Approved by:
M. Norin
Program Engineer

C. R. Fink
Program Manager

Contract AT(30-1) 3169

MARTIN
BALTIMORE DIVISION
BALTIMORE, MARYLAND 21203

LEGAL NOTICE

FOREWORD

This report has been prepared for submittal to USAEC, as part of the work done under Contract AT (30-1)-3169. The work was completed by the Martin Nuclear Division.

CONTENTS

SUMMARY

Structural properties of Min-K 1301 with a 20-lb/ft^3 density were investigated. Compression tests were conducted on the material in unbaked and baked conditions at 75°, 500° and 1000° F to determine temperature effects; in restrained and unrestrained conditions to determine restraint effects; and dynamic tests conducted to determine dynamic properties such as modulus and damping.

Results of the test program indicate the following structural properties:

(1) Modulus of elasticity, $\overline{E}$, is estimated at 5400 psi in the X direction.

(2) The apparent yield point is approximately 200 psi in the X direction.

(3) The average ultimate strength is 290 psi in compression in the X axis; 135 psi in the Y axis; and 185 psi in the Z axis.

(4) Temperatures to 1000° F have no significant effect on the compression modulus.

(5) Unrestrained and restrained test results indicate no significant effect on the compression modulus.

(6) The material creep or load relaxation properties are stress dependent; high rates occur at high stress levels of 130 to 170 psi, insignificant rates at low stress levels of 70 psi.

(7) Static and dynamic moduli are essentially the same--within 8%; on the average, the material has a structural damping of 1%.

Based on these results, it is recommended that Min-K 1301 be used as a structural material within the limits shown in this report.

I. INTRODUCTION

Min-K 1301, manufactured by Johns Manville Corporation, is used in the SNAP 19 thermoelectric generators as a thermal insulator and as a structural element. Because of this, it was necessary to have data on the structural properties. The manufacturer's structural properties data were rather limited, particularly in the area of dynamic characteristics such as dynamic modulus and damping, and little was known regarding thermal effects on structural properties, either static or dynamic. In view of this, a test program was undertaken to generate structural properties data.

The test program was initiated as outlined in Ref. 1 and was revised as the testing progressed. The revisions were based on initial results and changes in technical requirements.

Results of the testing essentially determine the static and dynamic structural properties of Min-K 1301 as a function of temperature and restraint.

Ref. 1 Thomas, D. R. and Buxbaum, R. S., "Program Plan for Investigation of Structural Characteristics of Min-K Material Used in SNAP 19 Generators," Martin Company, June 1964.

II. DESCRIPTION OF TEST SPECIMENS AND FACILITIES

A. TEST SPECIMENS

The material tested was Min-K 1301 which has a density of 20 lb/ft^3. All test specimens were right circular cylinders, two inches high and approximately 2.5 inches in diameter. Most of the specimens were tested in the as-received condition, or unbaked. However, before the test program was revised, several of the specimens were baked at 1000° F for a period of 24 hours prior to testing. All of the specimens tested after the test program was revised were baked prior to testing.

Specimens were taken from a single 18 by 36 by 2 inch production sheet. This production sheet was given geometric designation as indicated in Fig. 1 so that the test specimen fiber orientation characteristics could be determined. The Z axis was along the 36-inch side, the Y axis along the 18-inch side and the X axis normal to the surface.

B. TEST FACILITIES

Compression testing during the initial phase of the test program was accomplished using a Baldwin-Lima-Hamilton Universal Test Machine. The deflection of the Min-K 1301 test sample was determined by using a dial gage with a resolution of 0.001 inch.

For elevated temperature conditions, the samples were heated using a Lepel Induction Heater.

Compression testing later in the program was accomplished by using lead weights. Each weight was 11 by 13 by 1 inch and the average weight was approximately 54 pounds. Compression stresses up to 110 psi were attained with this method of loading. Test sample deflection was determined with a dial gage with a resolution of 0.0001 inch.

Data for the dynamic tests were obtained using an Endevco Model 2212 accelerometer and Endevco Dynamonitor, Model 2702B. Data were recorded on a Consolidated Electrodynamics Corporation (CEC) Model 5-124 oscillograph.

The Lepel Induction Heater was used for the elevated temperature tests.

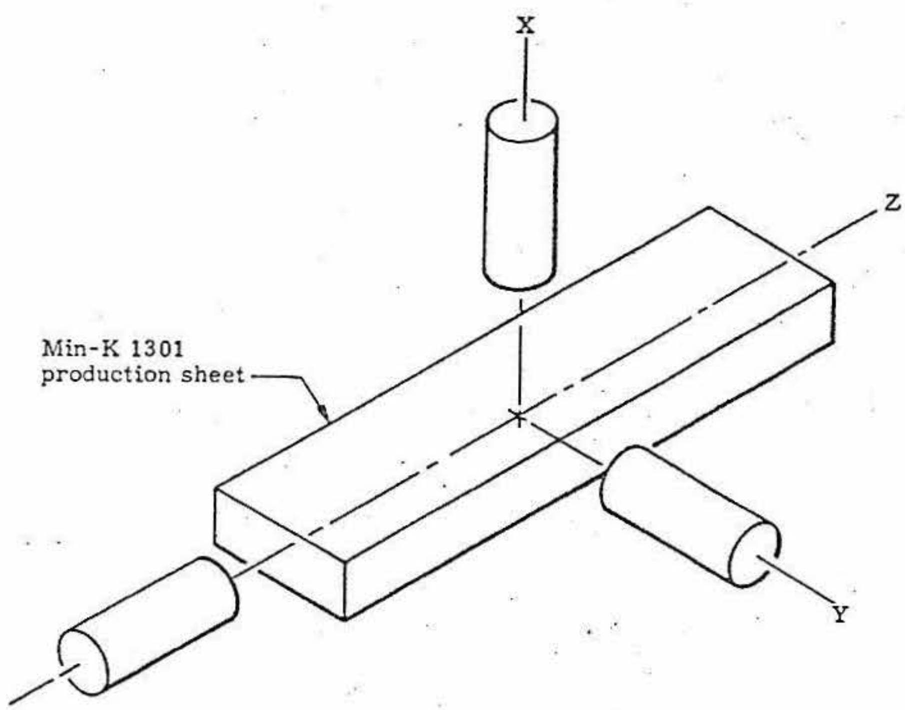


Fig. 1. Min-K 1301 Test Specimen Orientation Designation

III. TEST PROCEDURES

All testing was conducted with the test specimens mounted in a test fixture designed for use at temperatures up to 1000° F. The test fixture consists of a water-cooled, cast aluminum base (Fig. 2) with provisions to insert an induction heating coil and thermal insulation materials (Figs. 3 and 4). The specimen loading head is a 2.5-inch diameter aluminum cylinder with provisions for water cooling (Fig. 5).

A sectional view sketch showing how the test specimen is mounted in the fixture is shown in Fig. 6. The dotted lines in the sketch show the modifications necessary to convert the fixture for compression testing with the lead weights. This arrangement is shown pictorially in Fig. 7.

A. STATIC TESTS

The Min-K specimen was placed in the test fixture as indicated in Fig. 6. If the test environment required a restrained condition, the sample was inserted into a stainless steel cup or cylinder; load was applied by inserting the loading plate inside the cup. For an unrestrained condition, the sample was positioned on a stainless steel base plate and the loading plate positioned on top of the specimen.

The load was applied to the sample using a BLH-Universal Test Machine. The deflection of the sample was obtained by positioning a dial gage, capable of resolving 0.001 inch, between the loading head and the base of the test fixture.

For the elevated temperature tests, one thermocouple was positioned in the geometric center of the specimen to determine specimen temperature and one thermocouple was placed against the stainless steel cup or loading plate to monitor the specimen surface temperature.

Unbaked specimens of Min-K, of equal projected area, were subjected to temperatures of 75°, 500° and 1000° F. One sample was subjected to each temperature environment in the unrestrained condition and one sample was exposed to each temperature in the restrained condition. The unrestrained samples were loaded to failure (fracturing of the sample). The restrained samples did not fail as in the unrestrained case but the material packed together. These samples were loaded until a 25% sample deflection was obtained.

The sample was stabilized at the desired temperature within a tolerance of ± 5% for at least 15 minutes prior to the start of testing. The thermocouples positioned in the geometric center of the samples were used to determine temperature stabilization.

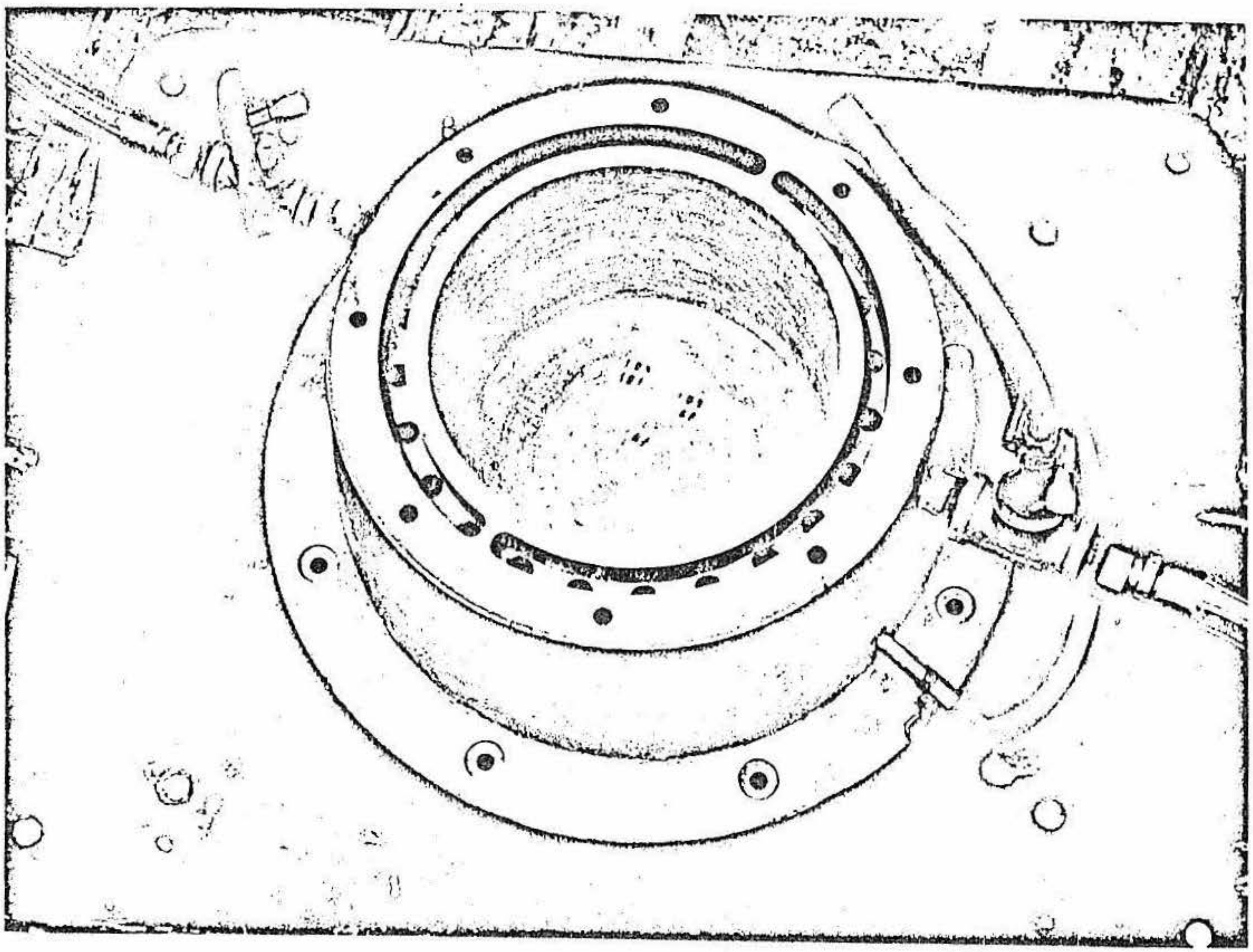


Fig. 2. Min-K 1301 Structural Test Fixture with Water-Cooled Aluminum Base

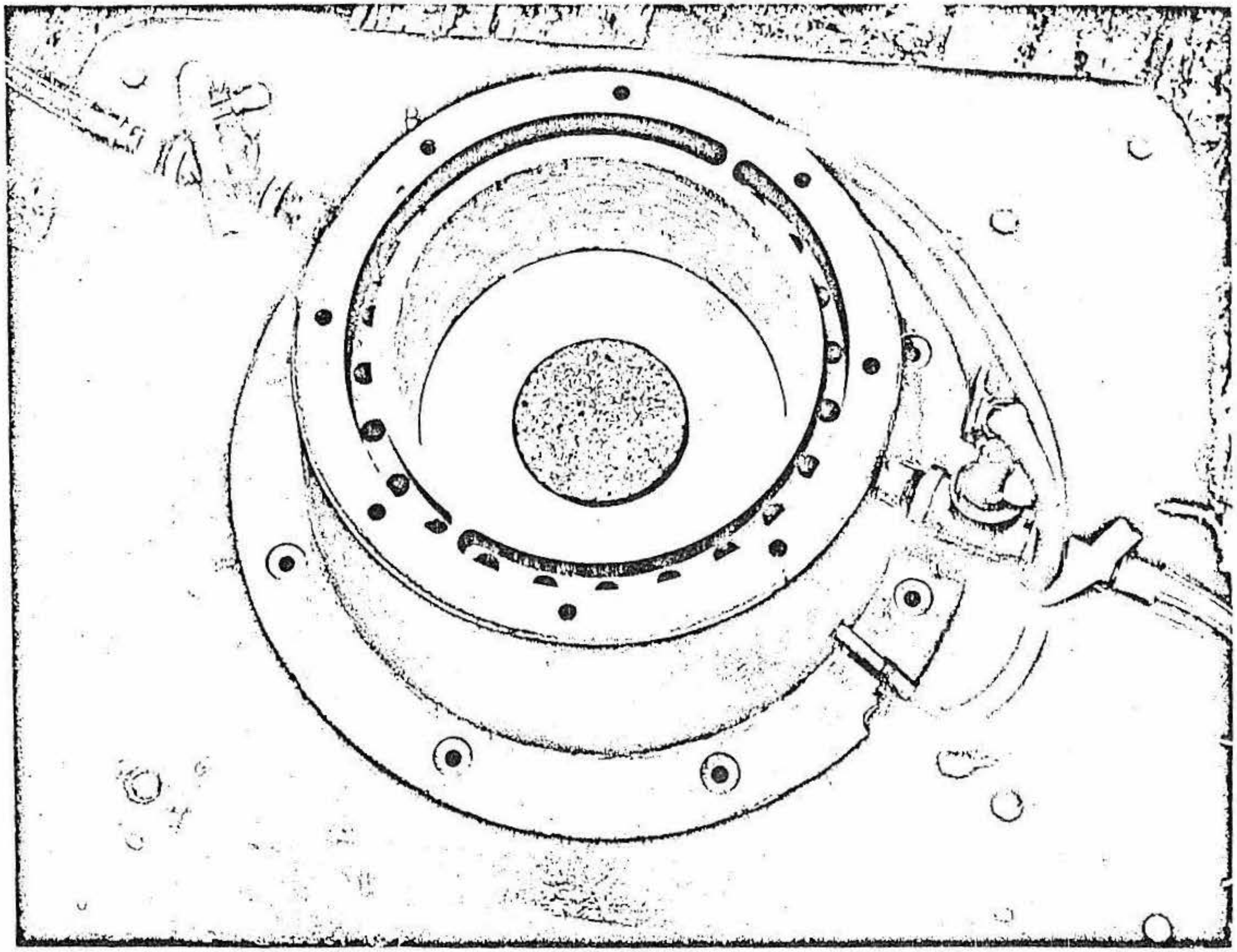


Fig. 3. Min-K 1301 Structural Test Fixture Base and Thermal Insulation Inserts

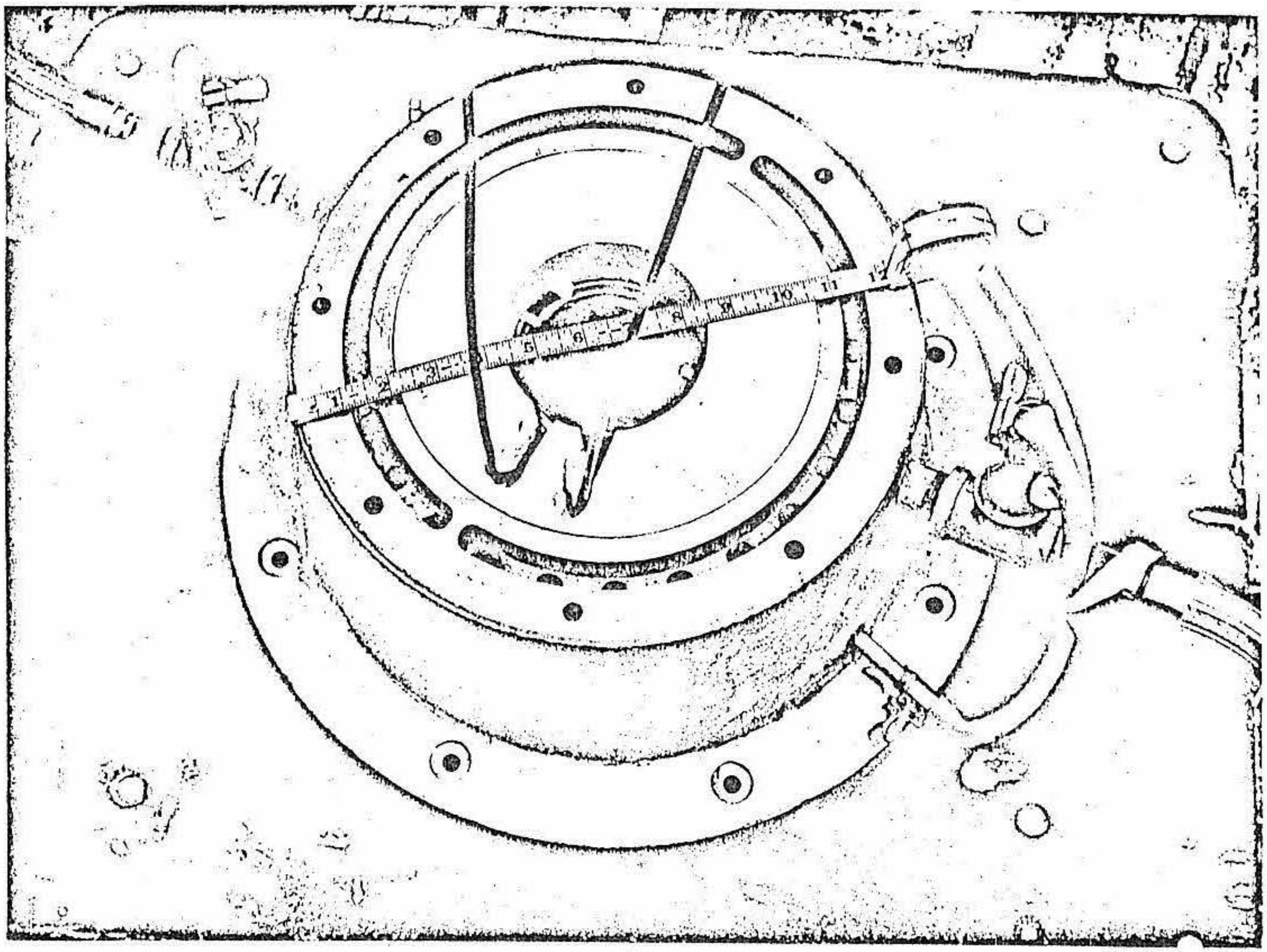


Fig. 4. Min-K 1301 Structural Test Fixture Base and Test Specimen with Induction Heating Coil and Thermal Insulation

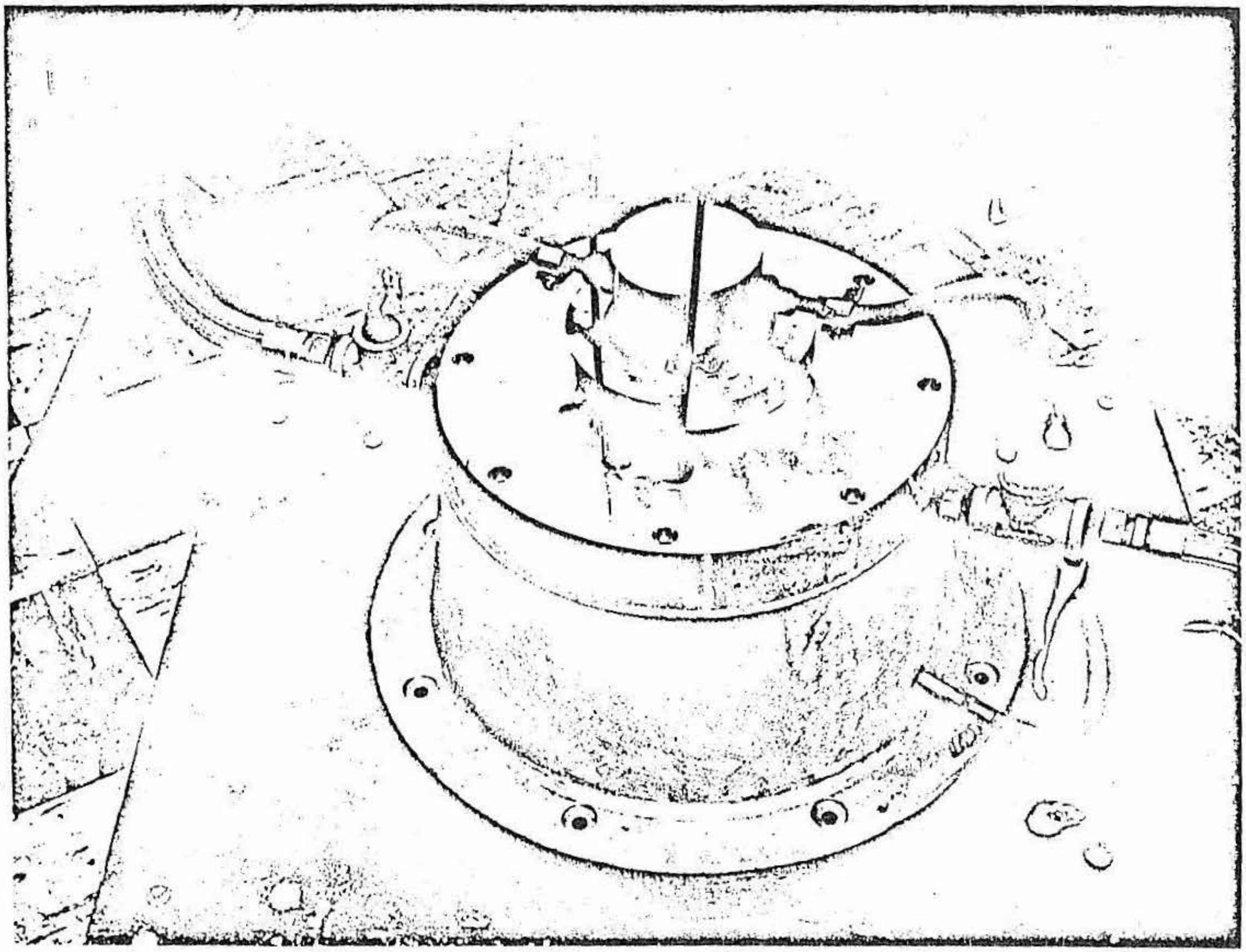
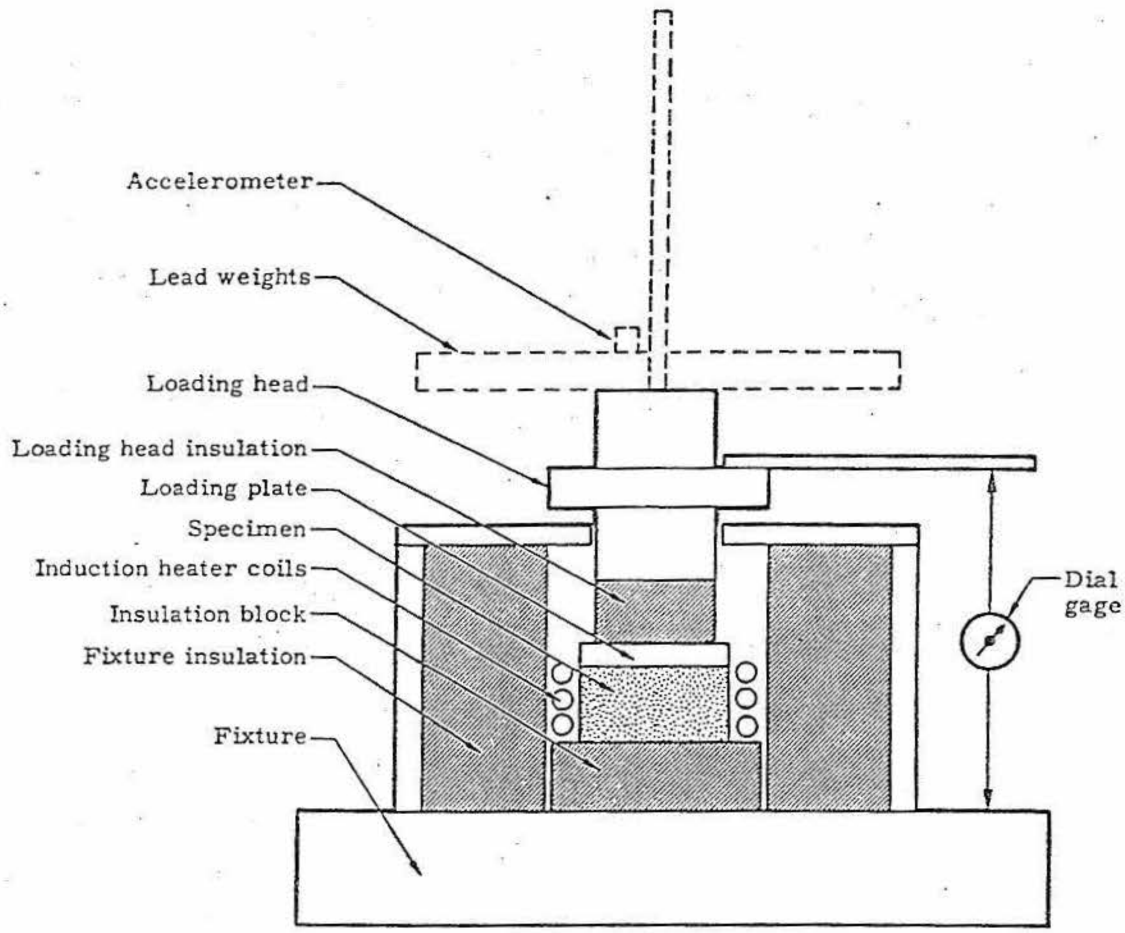


Fig. 5. Min-K 1301 Structural Test Fixture Base and Water-Cooled Loading Head Test Configuration



NOTE: For the restrained conditions, a steel cup is used to restrain the specimen.

For the unrestrained condition, a steel base plate is inserted between the insulation block and specimen.

Fig. 6. Static and Dynamic Load Test Setup

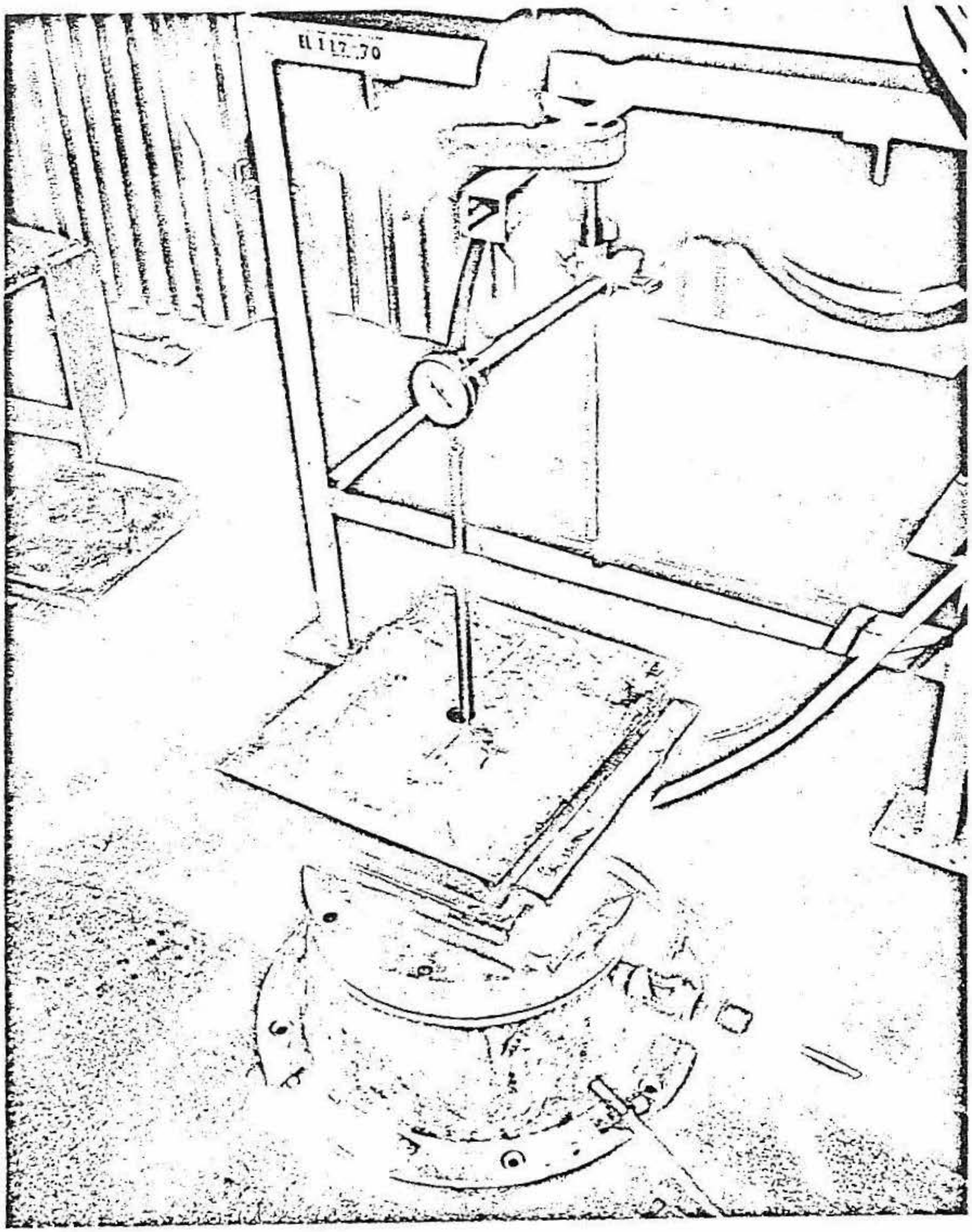


Fig. 7. Min-K 1301 Static and Dynamic Test Configuration Base and Lead Weight Loading

To determine the stress-strain characteristics of cross axis-oriented samples, three samples of unbaked Min-K were subjected to the unrestrained static test, at room temperature, in each of the Y- and Z-axes (see Fig. 7).

Each of the samples used for static testing was subjected to an initial preload of 5 psi. The deflection of the test fixture, up to a 5000-pound load, was determined as a tare reading.

1. Relaxation Tests

The relaxation rate of the Min-K specimen was determined by placing a fixed load (using a BLH-Universal Test Machine) on the specimen. The test machine was then stopped and held at a constant position. Load readings were taken at various time intervals throughout the test periods.

B. TESTS TO DETERMINE SCATTER EFFECTS

1. Static Loading

Six test specimens, baked at 1000° F for 24 hours, were subjected to compression loads up to 110 psi to determine variations in the stress-strain characteristics of unrestrained Min-K 1301. All test specimens came from the same production sheet.

Compression loads were applied in increments of 11 psi using the lead weights previously described. This testing arrangement is shown in Fig. 7. Differential displacement and load data were recorded. Preload for these tests was 12.57 psi.

2. Dynamic Loading

Loading for the dynamic testing was accomplished as described for the static loading except that the maximum load was 67 psi.

Dynamic testing consisted of exciting free vibration of a spring (Min-K 1301) mass (lead weights) system at each load increment. An accelerometer was bonded to the loading head with dental cement, and its output recorded on an oscillograph. From the recorded accelerometer output, frequency and damping were determined.

Free vibration was induced by striking the lead weights near the center of gravity with a rubber hammer.

C. RESTRAINT TESTS

Tests to determine the effect of restraining the Min-K were conducted on one sample. Tests were conducted on Test Sample 6 which had been first tested in an unrestrained condition. The test sample was placed in the restraining cup as described in Section III-A). Static and dynamic loading tests were again conducted as described in Sections B-1 and B-2.

D. TEMPERATURE TESTS

Temperature tests were also conducted on Test Sample 6 in the restrained condition. Static and dynamic loading was accomplished as described in Sections B-1 and B-2.

A Lepel Induction Heater was used to heat the test sample. The induction coil is shown in Fig. 4. Test temperature was 1000° F. The test fixture base and loading head were water-cooled during these tests.

E. MIN-K FIBER ORIENTATION TESTS

Dynamic tests were conducted on two test samples to determine fiber orientation effects on damping and spring constant. One test sample was Y-axis oriented and the other, Z-axis oriented. This designation is shown relative to a production sheet in Fig. 1.

Dynamic loading was accomplished as described in Section B-2.

IV. RESULTS AND DISCUSSION

A. STRESS-STRAIN VARIATION FROM SIX-SAMPLE TEST

Stress-strain data was taken from six baked, unrestrained Min-K 1301 test samples at room temperature (75° F) to determine variance from sample to sample. These data are shown in Fig. 8. By use of small sample statistics, an estimate of the mean strain at each stress level was made and the best fit curve drawn. This curve determines the modulus of elasticity, $\overline{E}$, to be 5400 psi. Also shown on the curve are the 90% confidence limits of the estimate of the mean. The upper confidence limit yields an $\overline{E}$ of 6000 psi and the lower limit of 5000 psi.

B. TEMPERATURE EFFECTS

To determine the effect of temperature, stress strain tests were conducted on baked Min-K at room temperature (75° F) and 1000° F. These tests were conducted on the same specimen over the linear range of $\overline{E}$. These data are shown in Fig. 9. As can be seen from the curves, temperature has no significant effect on the stress strain characteristics.

C. RESTRAINT EFFECTS

Stress-strain data were taken on the same baked Min-K specimen in an unrestrained condition and then in a restrained condition, using the restraining cup. This stainless steel cup completely restrains the test sample over the two-inch height. Results of these tests are shown in Fig. 10. As can be seen, there is no significant variation in the stress-strain characteristics over the range considered, i.e., up to 110 psi.

D. STATIC TESTS

Initial static testing included tests of unbaked Min-K, unrestrained at 75°, 500°, and 1000° F and restrained at 75°, 500°, and 1000° F. Since it was shown previously that temperature and restraint had no significant effect on the stress strain characteristics, these data were grouped and plotted as shown in Fig. 11. The mean strain was computed at each stress level and the best-fit curve drawn. The best-fit curve gives an $\overline{E}$ of 5500 psi over the linear range; i.e., between 30 and 200 psi. This, of course, if very close to the estimate of $\overline{E}$ from tests of baked Min-K. By deduction, it has been determined that it makes little difference in the compression modulus if the material is baked or unbaked.

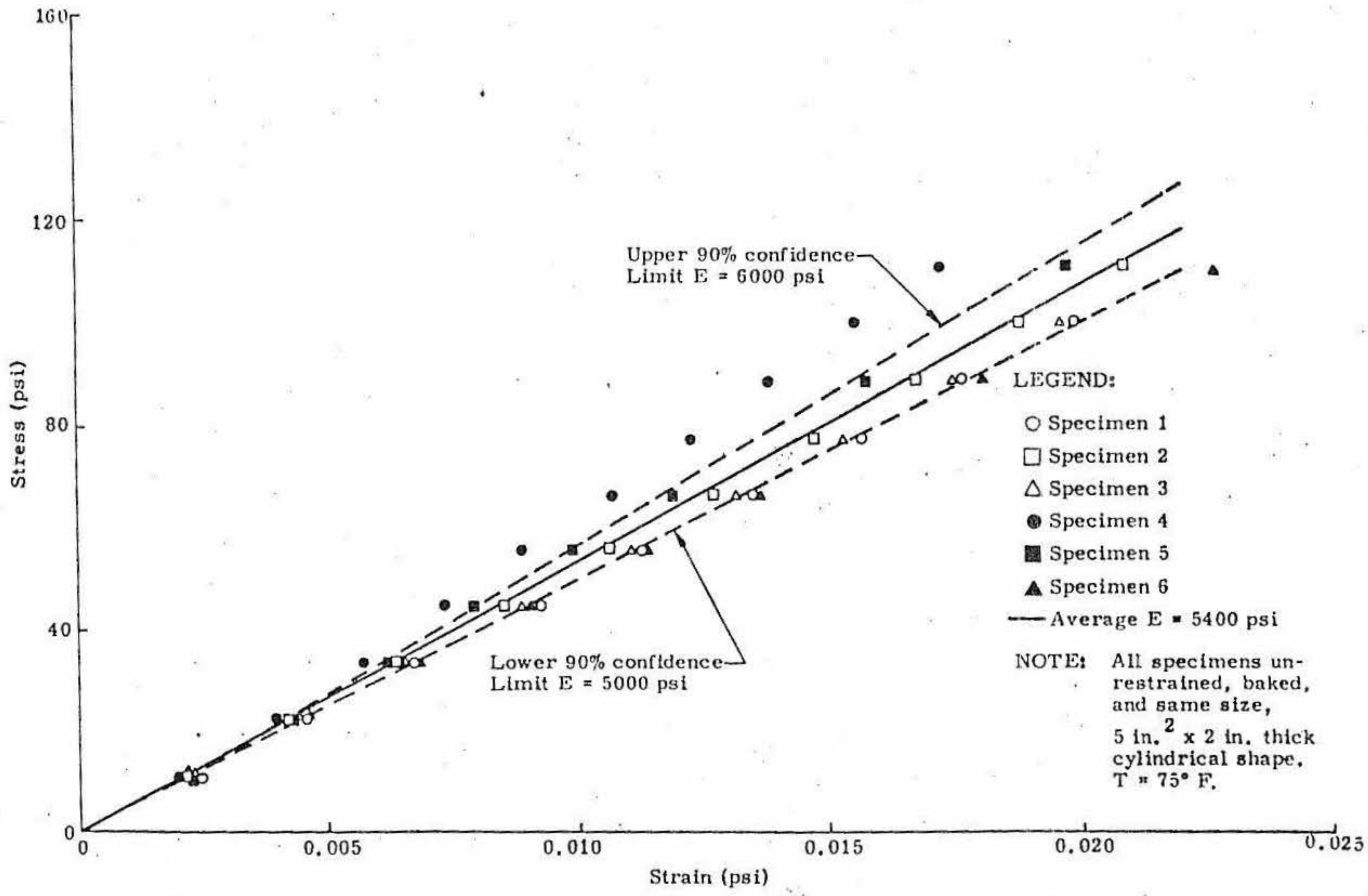


Fig. 8. Min-K 1301 Stress-Strain Characteristics Variation in Six Specimens

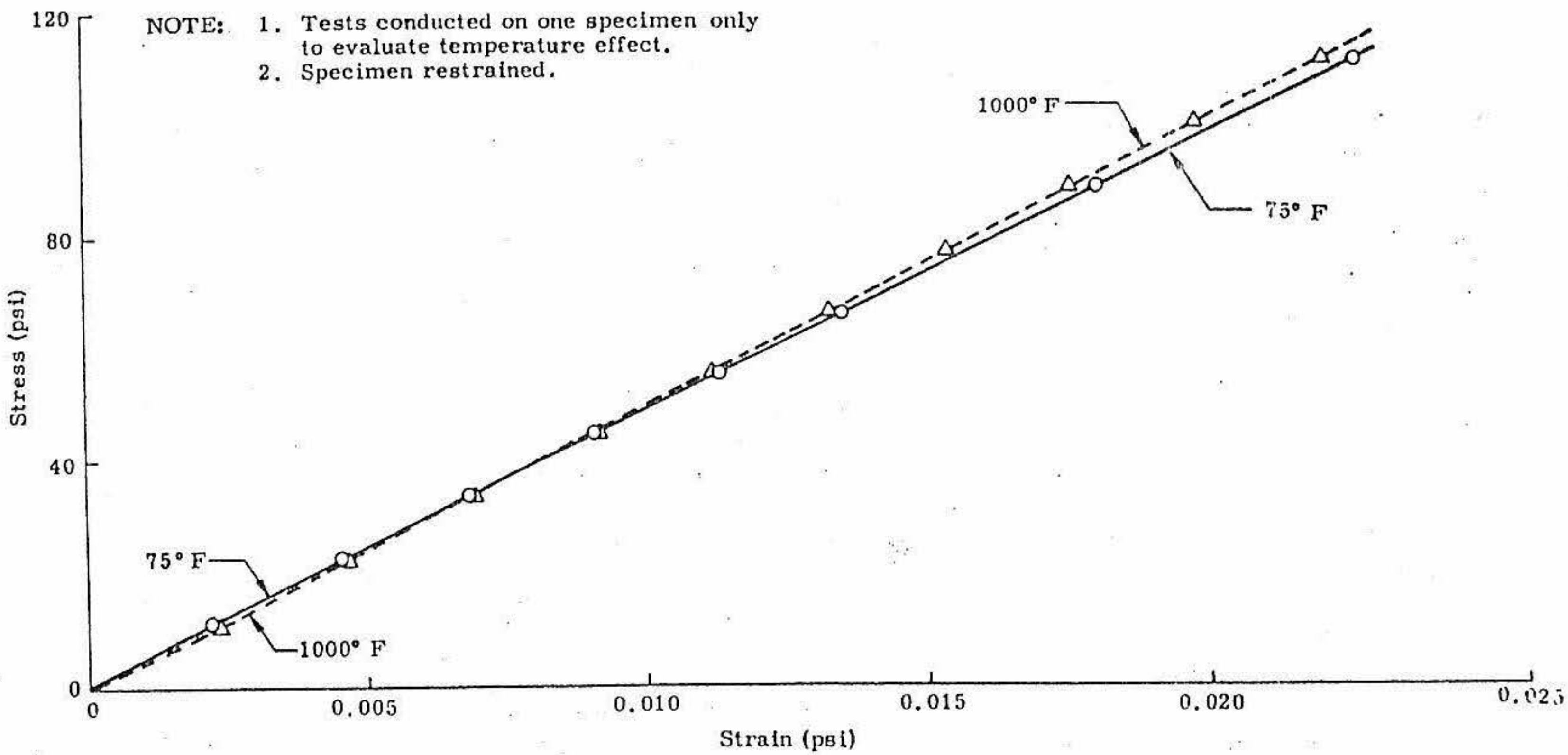


Fig. 9. Min-K 1301 Stress-Strain Characteristics as a Function of Temperature

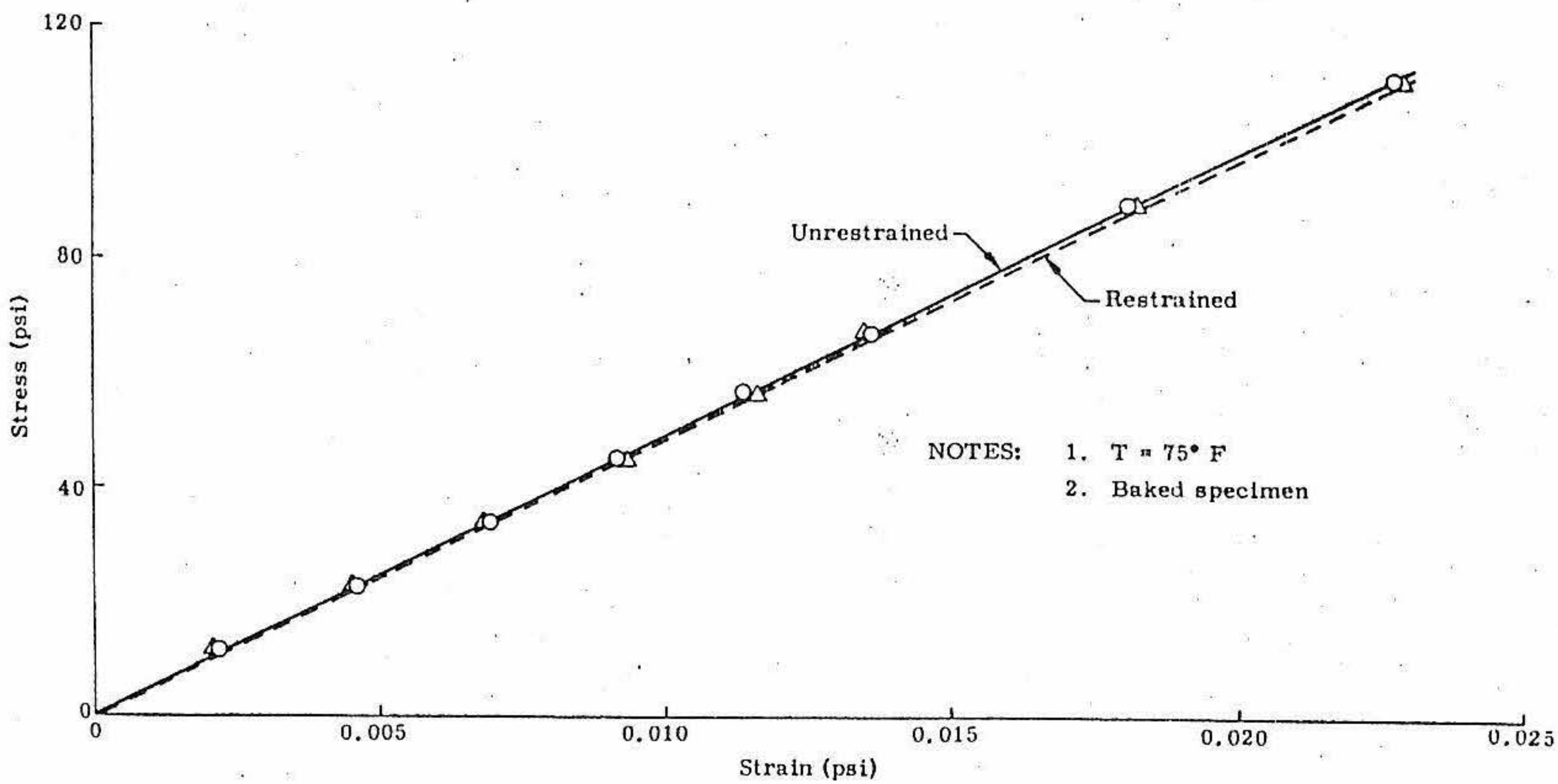


Fig. 10. Min-K 1301 Stress-Strain Characteristics as a Function of Restraint

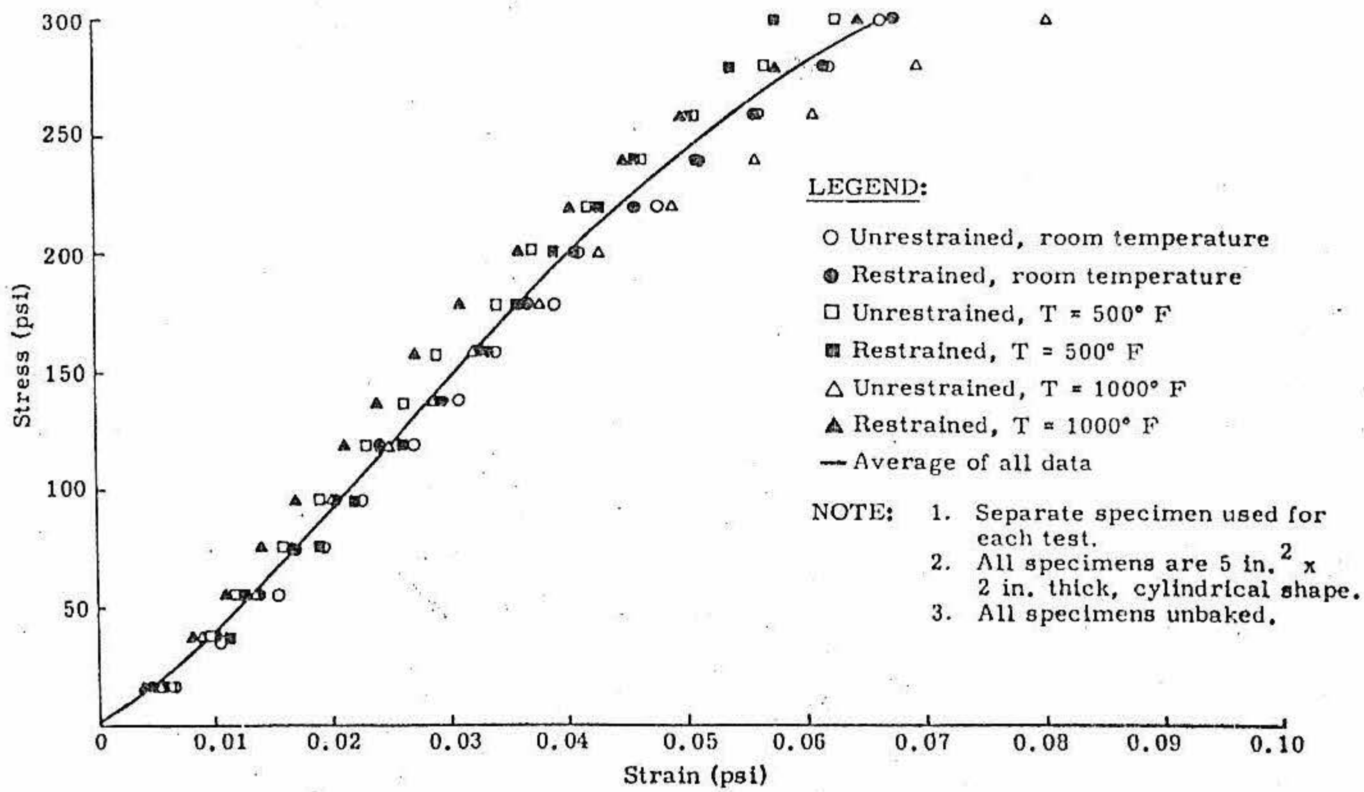


Fig. 11. Min-K 1301 Stress-Strain Characteristics

Further examination of Fig. 11 indicates that the modulus decreases above 200 psi. In all probability the material yield point is in the vicinity of 200 psi, based on the change in slope of the stress-strain curve.

All of the samples were taken to failure; these data indicate that the mean ultimate strength is 290 psi. The 90% confidence limits were also computed based on 18 samples tested to failure; these limits are 303 psi and 277 psi. It is noted here that the restrained specimens continued to show linear stress-strain data above 300 psi up to 1000 psi in some cases. The test samples were, in effect, being compressed into the restraining cup and did not recover their original shape. For example, at 1000 psi the test samples compressed 0.5 inch and 50% recovery was noted after the load was released.

The unrestrained specimens failed in shear in a plane nearly parallel to the cylinder faces. First, pieces popped out of the side and then the specimen fractured. Figure 12a depicts typical failures, encountered for X axis loading.

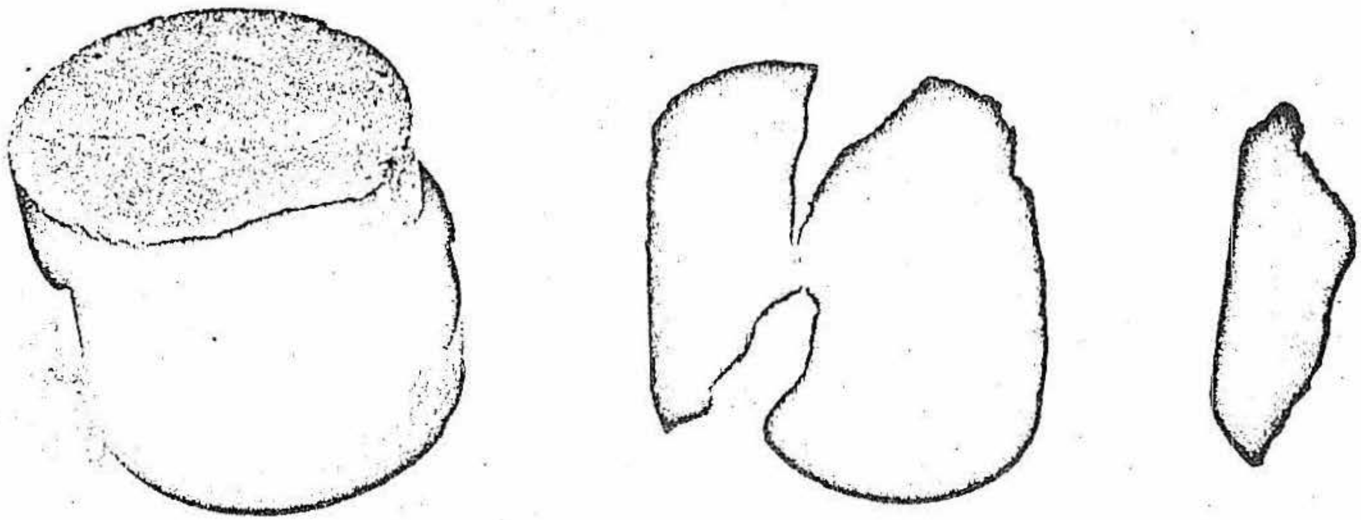
E. MATERIAL FIBER ORIENTATION STATIC TESTS

All test results reported thus far have been for compression loading in a plane normal to the surface of a production sheet, or the X axis. Tests were also conducted with loads parallel to the surface of the sheet, namely the Y and Z axes (see Fig. 1), to determine effects of fiber orientation on loading. Results of these tests were inconclusive. There was a wide scatter in the modulus of elasticity from low values of 3700 psi to high values of 7000 psi. Of greater interest, however, is the reduced level of ultimate strength, 135 psi in the Y axis and 185 psi in the Z axis.

Typical failures were in a plane nearly perpendicular to the faces of the cylindrically shaped specimens for both Y and Z axes, indicating definite fiber orientation characteristics. Figures 12b and 12c depict typical failure patterns.

F. LOAD RELAXATION TESTS

Load relaxation characteristics of one baked and one unbaked sample were determined with initial loadings of 170 and 130 psi, respectively. Deflection at these loadings was maintained constant and changes in load recorded as a function of time. These data are presented in Fig. 13. For example, extrapolation of these data indicates that after a period of one year the preload is only 75% of its original value under these particular conditions.



a. X Axis   b. Y Axis   c. Z Axis

Fig. 12. Typical Min-K 1301 Failures with Loads Applied in Different Axes

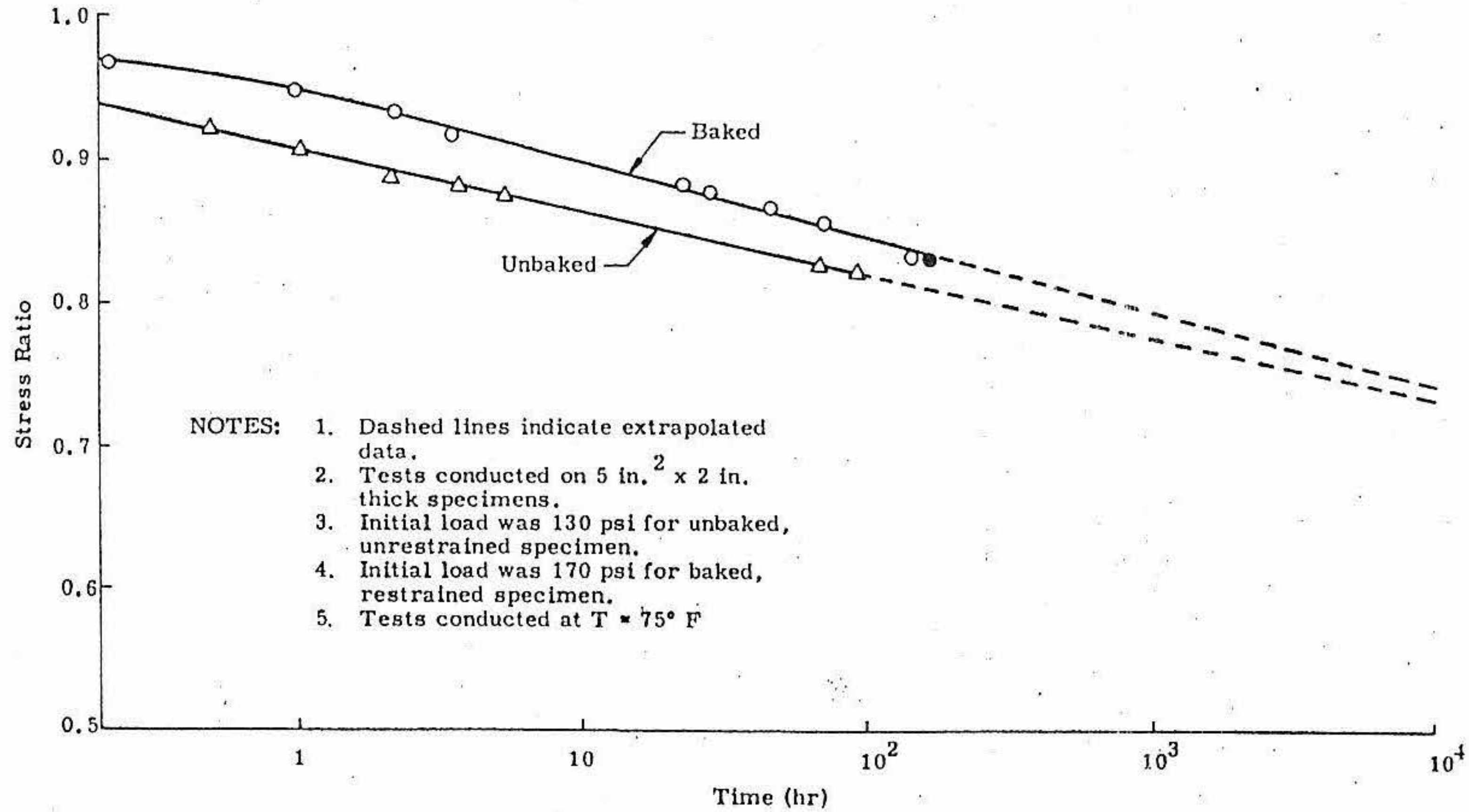


Fig. 13. Min-K 1301 Load Relaxation Characteristics

During the load weight compression tests, creep tests were conducted on one baked specimen at 67-psi constant load. After 64 hours, there was only a 0.04% change in specimen length. This indicates that the creep, or load relaxation, characteristic is definitely load-sensitive, based on these limited tests.

G. DYNAMIC TESTS

A summary of the dynamic test data is shown in Table 1. The average dynamic modulus is 5100 psi and the average damping is 1%. These averages were obtained from the same six specimens used for static tests. The average dynamic modulus is within 8% of that determined statically.

Dynamic tests were conducted on the same specimen to determine effects of restraint and temperature on the modulus and damping. These results are also reported in Table 1. As in the case of static testing, no significant changes in damping and modulus were detected due to either restraint or temperature.

Dynamic modulus was determined by measuring the free vibration frequency under various loads. (See Fig. 14 for typical vibration data.) From the frequency data, the material spring constant, $\overline{K}$, is determined from $f = \frac{1}{2\pi}\sqrt{\frac{\overline{K}}{M}}$, where M is the vibrating mass. Then the modulus $\overline{E}$ is determined from the geometry of the specimens and the spring constant as follows:

$$E = \frac{\overline{K}\,l}{A}$$

where l is the specimen length and A is the cross sectional area.

The damping is determined by measuring the rate of decay of vibration of the spring mass system from

$$G = \frac{1}{\pi N} \log_e \frac{A_0}{A_N}$$

where

G = structural damping

N = number of cycles

A_0 = initial amplitude of vibration

A_N = amplitude after N cycles of vibration

TABLE 1

Min-K 1301 Dynamic Properties

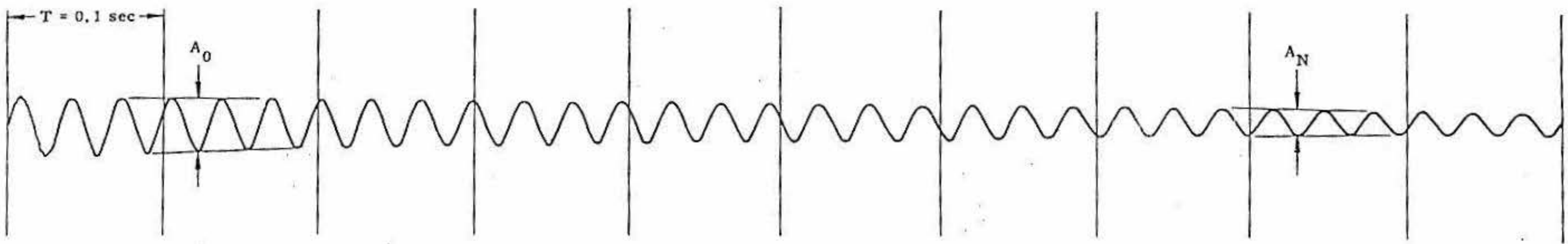
Specimen Number	Average Spring Constant, $\overline{K}$ (lb/in.)	Average Structural Damping, G (%)	Average Modulus, $\overline{E}$ (psi)
1	12,255	0.007	4992
2	12,148	0.011	4948
3	11,674	0.011	4755
4	14,641	0.011	5964
5	13,404	0.010	5460
6	10,928	0.007	4457

$\overline{E}$ average = 5096 psi = 5100 psi

$\overline{K}$ average = 12,510 lb/in. = 12,500 psi

G average = 0.0095 = 1%

Specimen No. 6	Average Spring Constant, $\overline{K}$ (lb/in.)	Average Structural Damping, G (%)	Average Modulus, $\overline{E}$ (psi)
Room temperature, unrestrained	10,928	0.007	4457
Room temperature, restrained	10,780	0.008	4390
T = 1000° F, restrained	11,963	0.011	4875



f = 31 cps

G = 1%

Stress level = 23.62 psi, W = 118.7 lb

Fig. 14. Min-K 1301 Dynamic Test Data--Typical Free Vibration Acceleration

V. CONCLUSIONS AND RECOMMENDATIONS

From the test conducted the following is concluded:

(1) Min-K 1301, 20 lb/ft^3 density, modulus of elasticity is 5400 psi for design purposes. This modulus applies over the linear range of the stress-strain curve from 30 to 200 psi, in the X direction.

(2) The apparent yield point is approximately 200 psi in the X direction.

(3) The average ultimate strength is 290 psi in compression in the X axis.

(4) Min-K 1301 should not be employed structurally in either a Y- or Z-axis application due to its inconsistent behavior and low ultimate strength.

(5) Temperature and restraint have no significant effects on the compression modulus within the range evaluated. Complete restraint does prevent material fracture but the material compacts (plastic range) and does not return to its original shape. Further, the modulus of elasticity decreases above 200 psi.

(6) The material creep and load relaxation properties are stress dependent. At low stress levels, 70 psi, the creep characteristic is almost insignificant (0.04% in 64 hr). At 130 to 170 psi, the load relaxation characteristics show a significant change with time.

(7) For design purposes, there is no significant difference between the static and dynamic modulus of elasticity. The material is lightly damped, 1% on the average.

It is recommended that Min-K 1301 be used as a structural material using the limits shown in this report as design guides.

ITEM NO. 10

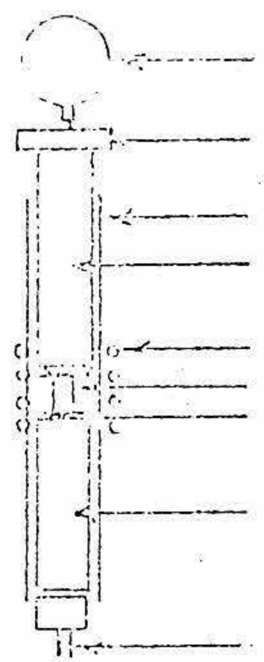
Kennametal Inc.
Latrobe, Pa.

CHEMICAL AND METALLURGICAL LABORATORY REPORT NO. A-401

By: M. Simon
Date: October 22, 1965

Object: To determine the deformation of W-10 versus temperature at a given load.

Test Apparatus



Test Procedure

A specimen, 0.4" diameter x 1" long, was loaded to 9 p.s.i. This load was calculated as maximum load at the base of the shield body, including the shield plug weight.

Specimen was directly heated by induction in an argon atmosphere and dial gauge readings taken at various temperatures. Temperature was read by optical means.

Test Results

To a temperature of 2350°F to 2385°F, only expansion was noted on dial gauge.

Temperature	Hold Time Minutes	Dial Gauge	Rate in./in./min.
2350 to 2385	8	0	-
2385 to 2395	16	.0082	5.1×10^{-4}
2425 to 2450	9	.023	25.5×10^{-4}
2960 to 3065	3.5	.030	86.0×10^{-4}

ITEM NO. 11

Calculation of Maximum Fuel Core Temperatures

LCG-25A

Under the worst conditions described in the safety report, it is remotely possible that the fuel capsule will come to within 25°F of the lower end of its melting range (2310°F to 2450°F). If it is assumed that the fuel capsule is indeed at this temperature, the maximum fuel centerline temperature and the tunsten shield temperature can be calculated as follows.

Fuel Capsule Temperature = T_C = 2310 - 25 = 2285°F

For the fuel centerline temperature, note that the capsule is filled primarily with helium and the liners fit close to the capsule wall. Thus the equation

$$\Delta T = \frac{sr^2}{4k}$$

will apply. This is the equation giving the temperature difference between the center and surface of an infinitely long cylinder producing heat uniformly throughout its volume. We may conservatively assume the following values

s = 1.0 watt/cc

r = 1.75 inches

k = 1.0 $\frac{BTU}{Hr\text{-}Ft\text{-}°F}$ for the fuel

then ΔT = 514°F

Max. Fuel Temperature = 2795°F

Even if we allow 100°F drop between the liner and fuel capsule, the fuel centerline temperature is still well below the fuel melting temperature of 3490°F.

For the tungsten shield temperature we can conservatively consider that the tungsten pieces are at the same temperature as the fuel capsule, 2285°F. From the Kenertium W-10 creep data, it can be seen this is 100°F below the softening point of the material so that the shield will not slump due to its own weight.

ITEM NO. 12

Carpenter A-286

	C	Mn	Si	Cr	Ni	Mo	Ti	V	Al	B	Fe
type analysis:	0.08% max.	1.00/ 2.00%	0.40/ 1.00%	13.50/ 16.00%	24.00/ 27.00%	1.00/ 1.75%	1.90/ 2.30%	0.10/ 0.50%	0.35 max.	.003/ .010%	Bal.

DESCRIPTION:

Carpenter A-286 is an alloy designed for service up to 1300°F on jobs requiring high strength and good corrosion resistance at the operating temperature. It offers high ductility in notched sections—in fact, the notched rupture strength of A-286 is superior to any other commercial alloy with comparable high temperature properties. A unique advantage of this alloy is that it can be precipitation hardened, and strengthened by heat treatment. This makes possible a high degree of uniformity in developing maximum strength, which can be duplicated on job after job.

No. A-286 is recommended for parts that must provide maximum strength and corrosion resistance at temperatures up to 1300°F. It is used in jet engines and superchargers for various high temperature applications such as turbine wheels and blades, frames, casings, afterburner parts and bolts.

PHYSICAL CONSTANTS:

Melting Range	2500/2600°F
Specific gravity	7.94
Density—lbs. per cu. in.	0.286
Magnetic Permeability	
Solution Treated	1.010
Solution Treated and Aged	1.007

Electrical Resistivity

Temperature °F	Microhm—cm.	Microhm—in.
87	91.0	35.8
1000	115.6	45.5
1200	118.8	46.8
1350	120.1	47.3
1500	122.4	48.2

Specific Heat, 104 to 1299°F, BTU/lb./°F 0.11

Thermal Conductivity

Temperature °F	BTU/sq ft/in/°F/hr.
302	104.2
1112	165.0

coefficient of thermal expansion

80°F to	Coefficient in/in/°F × 10^{-6}
200°F	9.17
400	9.35
600	9.47
800	9.64
1000	9.78
1200	9.88
1300	9.94
1400	10.32

Temperature °F	Modulus of Elasticity, p.s.i. × 10^6
70	28.8
1000	23.7
1100	22.8
1200	21.9
1300	21.1
1400	20.1
1500	18.7

HEAT TREATMENT:

solution treatment:

Two methods of heat treatment are recommended for this alloy:

1. Heat to 1800°F, hold 1 hour at heat and cool rapidly.
2. Heat to 1650°F, hold 2 hours at heat and cool rapidly.

The first (1) solution treatment results in higher hardness and increased rupture strength after aging, whereas the second (2) treatment results in better ductility.

precipitation hardening treatment:

Heat to 1300/1400°F, hold 12 to 16 hours at heat, and air cool. Hardness approximately 300 BHN.

Carpenter A-286, Continued

WORKABILITY:

hot working:

Carpenter A-286 is rolled or forged from temperatures of 1900-2050°F using a short soaking period. It is slightly more resistant to deformation than the austenitic stainless steels during hot working. Do not forge below 1700°F.

FORMABILITY:

In the solution treated condition, Carpenter A-286 can be satisfactorily cold drawn and formed. It is somewhat stiffer than stainless steels such as Types 316 and 310, and it work hardens rapidly.

WELDING:

Readily welded by the shielded-arc or inert-gas-arc methods. It is recommended that the alloy be in the solution treated condition for welding.

CORROSION RESISTANCE:

Corrosion resistance is excellent up to 1300°F against all atmospheres encountered in jet engine service. Oxidation resistance is equivalent to that of Type 310 Stainless Steel up to 1800°F.

FORMS AVAILABLE:

Billets
Hot rolled and cold finished bars
Wire
Cold rolled strip
Special shapes

MECHANICAL PROPERTIES:

Tensile Properties
Tests on ⅞" diameter bar stock
Solution treated 1800°F, 1 hour, oil quenched, aged 1325°F, 16 hours, air cooled

Test Temperature °F	0.02% Offset Yield Strength p.s.i.	0.2% Offset Yield Strength p.s.i.	Tensile Strength	% Elongation in 2"	Reduction of Area %
70	90,000	95,000	145,000	24.0	45.0
400	76,000	93,500	143,000	21.5	52.0
800	72,000	93,000	138,000	18.5	35.0
1000	62,000	87,500	131,000	18.5	31.0
1100	64,500	90,000	122,000	21.0	23.0
1200	62,500	88,000	103,500	13.0	14.5
1300	68,500	86,000	86,500	11.0	10.0
1400	44,500	62,000	64,000	18.5	23.0
1500	31,000	33,000	36,500	68.5	37.5

Stress Rupture Properties:
Solution Treated 1800°F, 1 hour, oil quenched,
aged 16 hours 1325°F, air cooled

Test Temp. °F	Stress (p.s.i.) for rupture		Stress (p.s.i.) for rupture	
	100 hours	% Elongation in 4D	1000 hours	% Elongation in 4D
1000°F	99,000	3.0	88,000	3.0
1100	81,500	3.0	71,500	3.0
1200	61,000	5.0	46,000	8.5
1300	44,500	12.0	29,000	30.0
1350	35,000	29.0	21,000	35.0
1500	13,000	55.0	7,700	...

V-Notch Charpy Impact Strength:

Test Temperature °F	Ft. lbs.
−310	57.0
−100	68.0
70	64.0
400	59.0
800	51.5
1000	45.5
1100	44.0
1200	35.0
1300	44.0

Creep Strength:

Test Temperature °F	Stress (p.s.i.) for creep of			
	0.5% in 100 hrs.	1.0% in 100 hrs.	0.5% in 1000 hrs.	1.0% in 1000 hrs.
1000	81,000	92,000	78,000	85,000
1100	76,000	80,000	68,000	70,000
1200	53,000	60,000	35,000	41,000
1300	30,000	35,500	......	......

TES-3206

ITEM NO. 13

April 1, 1966

Refer to: ACC-471
Internal Mail #845

U. S. Atomic Energy Commission
Division of Material Licensing
Washington, D. C. 20545

Attention: Mr. William H. Ray
Irradiated Fuel Branch

Reference: AEC Ltr. dated March 8, 1966 from W. H. Ray to C. W. Keller (DML:IFB:WHR)

Subject: Additional Information - Byproduct License 19-1398-34

Gentlemen:

We are happy to supply the additional information requested in the referenced letter.

1. During the design phase for the Martin LCG-25, the safety of the unit was defined by the containment of the fuel within the inner shield block and the outer generator housing and was not predicated on any contribution from the thermoelectric module or cooling fins. It is anticipated that the fins would be damaged and that the thermoelectric conversion package will become inoperative as a result of a four foot drop on the fins. However, this will cause no radiological hazard since we have shown in our previously submitted analysis that no hazards result from the increase in temperature following a fire which melts the fins and the thermoelectric couples. Even if the fins are sheared from the generator the heat rejection area would be larger than that resulting in our previously analyzed accident conditions and would not cause a dangerous heat rise in the system.

2. Depending on the severity of the reduction of air flow around the generator the thermoelectric conversion system associated with the Martin LCG may or may not become inoperative. Since an LCG without an operative thermoelectric system is useless and replacement of the system is costly, it is of prime concern to Martin that the entire LCG generator with all component parts be transported without damage. One of the authorized Martin representatives designated by this license will supervise the loading of the LCG on the transfer vehicle and indoctrinate the carrier personnel in the proper handling of the generator.

The Martin Company
Baltimore, Maryland

-2-

Refer to: ACC-471
April 1, 1965

2. (continued)

Maintaining spacing from other cargo to permit adequate air flow will be stressed. At destination an authorized Martin representative will personally receive the generator from the carrier and assure that proper air flow is maintained around the generator during display and interim storage of the LCG. The representative will also be responsible that proper action is taken in the return of the LCG to Martin facilities. In spite of these precautions if the generator should be inadvertently covered, we predict that no fire hazard would be created due to the low heat output of the generator.

3. One of the Martin representatives authorized by this license will be responsible for the custody and control of the LCG and its associated licensed material during display and demonstration at any location other than the Martin Quehanna Middle River facilities. We have supplied resumes for Messrs. Barker and Rexford in a previous application and have included resumes for Messrs. Morrison and Silvers with this submission. We consider these representatives well qualified to take whatever action may be required in case of an unforeseen malfunction of the LCG or handling accident. The Martin instruction to any carrier will specifically define action to be taken in case of an accident during transport of the LCG. Martin Health Physics personnel will also be on call to take whatever action may be deemed appropriate.

4. Martin management established the Radioisotope Safety Advisory Committee in 1963 to increase the assurance of safety in all operations involving the possession or use of radioactive material (excluding fissile materials) or radiation producing devices. Members of the committee who serve as advisors to operating groups and management regarding safety in such operations represent the best talent available at Martin. The Committee is responsible for reviewing the design, procedures, and operation of facilities, utilizing radioactive materials or radiation producing devices, both on and off the premises, and the safety criteria on which their design and operation are based. The Committee will fulfill this responsibility and make any appropriate recommendations with regard to the transport, display and demonstration of the Martin LCG-25.

Martin Company
Baltimore, Maryland -3- Refer to: ACC-471
April 1, 1966

Thank you for your usual prompt consideration of this additional information in granting an amendment to Byproduct Material License 19-1398-34 for the transport, display and demonstration of the Martin LCG-25.

Very truly yours,

MARTIN-MARIETTA CORPORATION
MARTIN COMPANY, Baltimore Div.

CWKeller

C. W. Keller, Nuclear
Accountability & Licensing Rep.

CWE/plm

ITEM NO. 14

Mail No. 84?
July 21, 1966

Refer to:
ACC-495

U. S. Atomic Energy Commission
Division of Material Licensing
Washington, D. C.

Attention: Mr. A. E. Aikens, Jr., Chief
Irradiated Fuels Branch

Subject: Additional Information - Transport, Display and Demonstration of Martin LCG-25 - Byproduct License 19-1398-34

Reference: (a) AEC Letter from A. E. Aikens, Jr. to C. V. Keller dated July 16, 1966 (DML:IFB:JCG)

Gentlemen:

This letter supplies the additional information requested in the referenced letter (parts a and b), as it applies to the Martin LCG-25 thermoelectric generator. In the very near future we will submit the required information with regard to the Martin MW-3000 as a separate application.

a. Since our July 8, 1966 meeting in Bethesda, we have designed and evaluated a shock absorbing structure for the LCG-25 which should absorb the energy involved in a four foot drop. We obtained your concurrence with this approach in our technical discussions on July 21, 1966. The detailed drawing and our stress analysis of the structure is included with this letter.

b. The maximum temperature which we have established for the wolfrom shield during normal operation is 1300°F. We do not anticipate that the temperature will ever reach this value without application of heat from an external source. We have previously proven the safety

of the device during the standard fire conditions. The satisfactory normal performance of the heat source and insulation system is established during initial generator checkout at our Middle River Facility prior to any shipment. Should any abnormal condition exist, it will become apparent during this test period and an analysis of the problem will be made under controlled conditions at that time. Since the fuel, insulation and module are subjected to extensive testing and inspection, we cannot envision any problem arising after our final check-out of all systems at our Martin facilities. Specific procedures to be followed in the very unlikely event of any malfunction of the LCG-25 will, in large measure, depend on the nature of the problem.

As you are aware, it is necessary that a shipment of the Martin LCG-25 be made to a customer during the week of July 25, 1966 and we request preliminary TWX or telecon verification of the granting of the amendment to Byproduct License 19-1398-34 authorizing the transport, display and demonstration of the Martin LCG-25 thermoelectric generator. Thank you for your usual fine cooperation in this matter.

Very truly yours,

MARTIN MARIETTA CORPORATION
MARTIN COMPANY, Baltimore Division

C W Keller

C. W. Keller
Nuclear Accountability &
Licensing Representative

CWK:mal

APPENDIX B

Supplemental Capsule Data - Sea Water Corrosion of Hastelloy C; Quality Control Procedures Used in Fabrication of Fuel Capsules; Hydrostatic Pressure Testing on a Sentinel 25 Capsule

(April 1985)

Isotopes, Inc. application dated September 15, 1969 (a reference to the current Certificate No. 4888, Rev. No. 5) was submitted in response to specific inquires from the Licensing Agency (then, U.S. Atomic Energy Commission: Irradiated Fuels Branch). Included with this submittal were the following.

a. Excerpts from report MND-SR-1676.

b. Sample quality control log with data pertaining to fuel capsule detail, assembly drawings, inspection sheets and fueling specification.

c. Report INSD-3015 on hydrostatic pressure testing of the Sentinel 25 capsule.

Item (a) was submitted in response to a request for additional data on sea-water corrosion of "as welded" Hastelloy C. The excerpts consist of the report cover page and pages 31, 42, 43, 44, 46, 48 and 56 from report MND-SR-1676, "Strontium 90 Power Project, Final Summary Report," March 1960, The Martin Co., Nuclear Division. These pages are included as part of this appendix.

Item (b) was also submitted in response to a request for information which would provide more insight into the quality control procedures used in the fabrication of the fuel capsules. The cover letter for the September 15, 1969 application included a summary description of the quality control procedure which is reproduced verbatim:

Fuel Capsule Quality Control
(15 September 1969)

"A sample quality control log is also enclosed. This log contains copies of the fuel capsule detail and assembly drawings, the inspection sheets that apply to each drawing, and the fueling specification. The finished components are inspected according to the requirements of the drawing plus any additional requirements noted on the log sheet. Note the specific items which must be checked. The log is prepared this way to avoid possible oversights. All components are checked by Isotopes Quality Control department regardless of whether the parts are made in-house or by an outside source. The finished components are forwarded to the approved fueling facility (Oak Ridge National Laboratories for all SENTINEL capsules produced so far). The fueling facility re-inspects the capsule components, and fuels the capsules in accordance with the fueling specification, NSD-10161. As the various steps are performed, they are initialed by the fueling facility to indicate compliance. This specification sheet is then returned to Isotopes along with a copy of the fueling facility quality control sheet which shows fuel form, fuel quantity, fuel analysis, decontamination, thermal inventory, and weld penetration. This data becomes part of the permanent documentation. When the fuel capsule is installed in a generator, the fuel capsule log will become part of the generator log."

Item (c) was submitted as being information of general interest. The report, "Hydrostatic Pressure Test, SENTINEL 25 Fuel Capsule," INSD-3015, December 24, 1968, Isotopes, Nuclear Systems Division described external hydrostatic pressure tests performed on a SENTINEL 25 fuel capsule. The fuel capsule was like that shown on Figure 2 of this report and was constructed of Hastelloy C. A lava plug was inserted

into the test capsule to simulate fuel pellets. The capsule was then seal welded according to procedures for fueled units. Testing consisted of a series of pressure cycles to 12,500, 15,000 and 17,500 psi respectively. After each pressure excursion, physical measurements and a dye penetrant check were performed. Dye penetrant checks showed no evidence of cracks in the capsule. Dimensional checks showed little or no evidence of permanent material deformation. A conclusion drawn from the results of the testing was that the unit would not rupture when exposed to pressures in excess of 15,000 psi (the design pressure). This report also presented a very conservative plastic stress analysis which predicts a failure pressure of 16,900 psi.

The information presented in this appendix is considered applicable to all SENTINEL (LGC) units.

END APPENDIX B

STRONTIUM 90 POWER PROJECT

FINAL SUMMARY REPORT

MND-SR-1676

MARCH 1960

James J. Keenan

Assistant Project Engineer

III. SUBTASK 1.3--CLADDING OF THE HEAT ELEMENTS*

This subtask included the investigation and determination of the cladding requirements for the Strontium-90 heat elements. The requirements are:

(1) Chemical compatibility with strontium titanate.

(2) Resistance to fresh or sea water corrosion.

(3) Suitably high melting point.

(4) Thermal shock resistance.

(5) Reliable fabricability.

Selection of a suitable cladding material was governed by the same requirements that hold true for the other metal parts of a Strontium-90-fueled generator for land or sea use. Tungsten, molybdenum, tantalum, nickel and other metals were investigated with respect to the above itemized qualities. All exhibited suitably high melting points and all have good thermal shock resistance. However, tungsten, molybdenum and tantalum presented a problem in sealing, since none can be welded with a rod of the parent material. Each oxidizes in the presence of air or in liquids containing oxygen. Nickel, though it is readily fabricated and welded, showed pitting tendencies in sea water. The same held true for Inconel. Hastelloy C, on the other hand, can be welded with Hastelloy C welding rods, has a suitable melting point and does not pit in sea water. In this medium it corrodes less than 0.0001 in./year. A cladding made from Hastelloy C can be expected to contain helium at the required helium pressure throughout the useful life of the generator. Therefore, this alloy was chosen as the cladding material for the strontium titanate heat elements. The corrosion resistance of Hastelloy C is itemized under Subtask 1.4.

When ceramic or cermet material is encased in a metal block, there is a possibility of reaction, so tests have been run in a constant argon atmosphere at 800°C for 120 hours. Cobalt cermets and chromium cermets of strontium titanate were placed on pieces of titanium, Hastelloy C, nickel, Inconel and KT silicon carbide. There was no reaction with any of the materials except the silicon carbide. Therefore, during the active life of a Strontium-90 generator at operating temperatures or less, there will be no side reaction that might accelerate, through compound transformation, the known properties of either the strontium titanate heat elements or its cladding material.

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*J. McGrew

2. Containment Material Investigation

A number of metals and alloys were studied for application to the principal components of the generator. Some of these metals were Inconel, nickel, titanium, Illium G and Hastelloy C. Inconel and nickel were eliminated because of their known susceptibility to pitting in quiescent sea water, which is one of the two more probable environments. Titanium was eliminated because of the poor quality of the weld metal. Illium G was eliminated because of its poor fabricability.

Hastelloy C was chosen for the outer corrosion resistance wall, the fuel cladding and the heat accumulator for many reasons. The most important reason is the excellent resistance of Hastelloy C to sea water corrosion. Also, Hastelloy C exhibits all of the other desired properties such as fabricability, weldability, and high density (good shielding characteristics), and it is a standard item of commerce. It does not suffer pitting or general corrosion in sea water, stagnant or moving, and it retains a high luster even after prolonged exposure to a marine atmosphere.

Hastelloy C was exposed in sea water for 10 years at Kure Beach, North Carolina. Actually, two specimens were exposed; one had a rolled and sandblasted surface and the other had a cast and ground surface. The following data is reported in the "Catalogue of Specimens, Kure Beach--Harbor Island Museum, Harbor Island, North Carolina":

			Corrosion Rate		
Surface Condition	Weight Loss (gm)	Test Period (days)	(mdd)*	(ipy)	Pitting
Rolled and sand-blasted	2	3646	0.1	0.0001	None
Cast and ground	8	3618	0.23	0.0001	None

*Milligrams/sq decimeter/day

A general summation of the resistance of Hastelloy C to sea water is contained in the Catalogue which says:

> "The superiority of the Hastelloy C composition is clearly demonstrated. The apparent pits in the cast Hastelloy C are actually casting defects originally

present. The rolled Hastelloy C is absolutely free from pitting or crevice corrosion and its weight loss during the exposure was no more than the experimental error of cleaning and weighing. This alloy is highly resistant to erosion by sea water at high velocity and for critical services in sea water under any conditions that may be encountered is probably the most reliable of all commercially available compositions."

Another exposure test to a marine atmosphere at a location 800 feet from the ocean at Kure Beach, North Carolina demonstrated its ability to withstand the severely corrosive atmospheric environment. Polished Hastelloy C, along with other materials commonly used for searchlight mirrors, was exposed for 18 months. Reflectivity measurements were made upon removal from exposure. The data are as follows:

	Reflectivities (%)	
Material	Before Cleaning	After Cleaning
Hastelloy C	38.9	53.6

Thus, the specimen retained about 73% of its original reflectivity. A duplicate specimen remains on test today and after 17 years still retains a luster equivalent to that of the specimen removed after 18 months.

Based primarily on this data, Hastelloy C was selected as the alloy to be used throughout the Strontium-90 generator design. On the basis of the reported 10-year studies, the life of a Hastelloy C corrosion resist on a submerged generator can be calculated from the thickness of the resist itself providing there is no substantial increase in the corrosion rate due to surface heating from within in an operating generator. Simulated tests with electrically heated Hastelloy C models in sea water were begun at Harbor Island, North Carolina, to learn whether the elevated skin temperature increases the corrosion rate. Figure 10 shows the design of the test unit. Figure 11 shows the unit before making the final weld. The exposed surface finishes are as indicated in Fig. 10. Two units were fabricated; one was exposed between the maximum low tide and the bottom of the inlet, the other was buried in the silt on the bottom. The surface temperature of the suspended unit will be maintained at about 20°F higher than the surrounding water temperature. Twenty degrees Fahrenheit is the calculated temperature differential on the outer surface of an operating

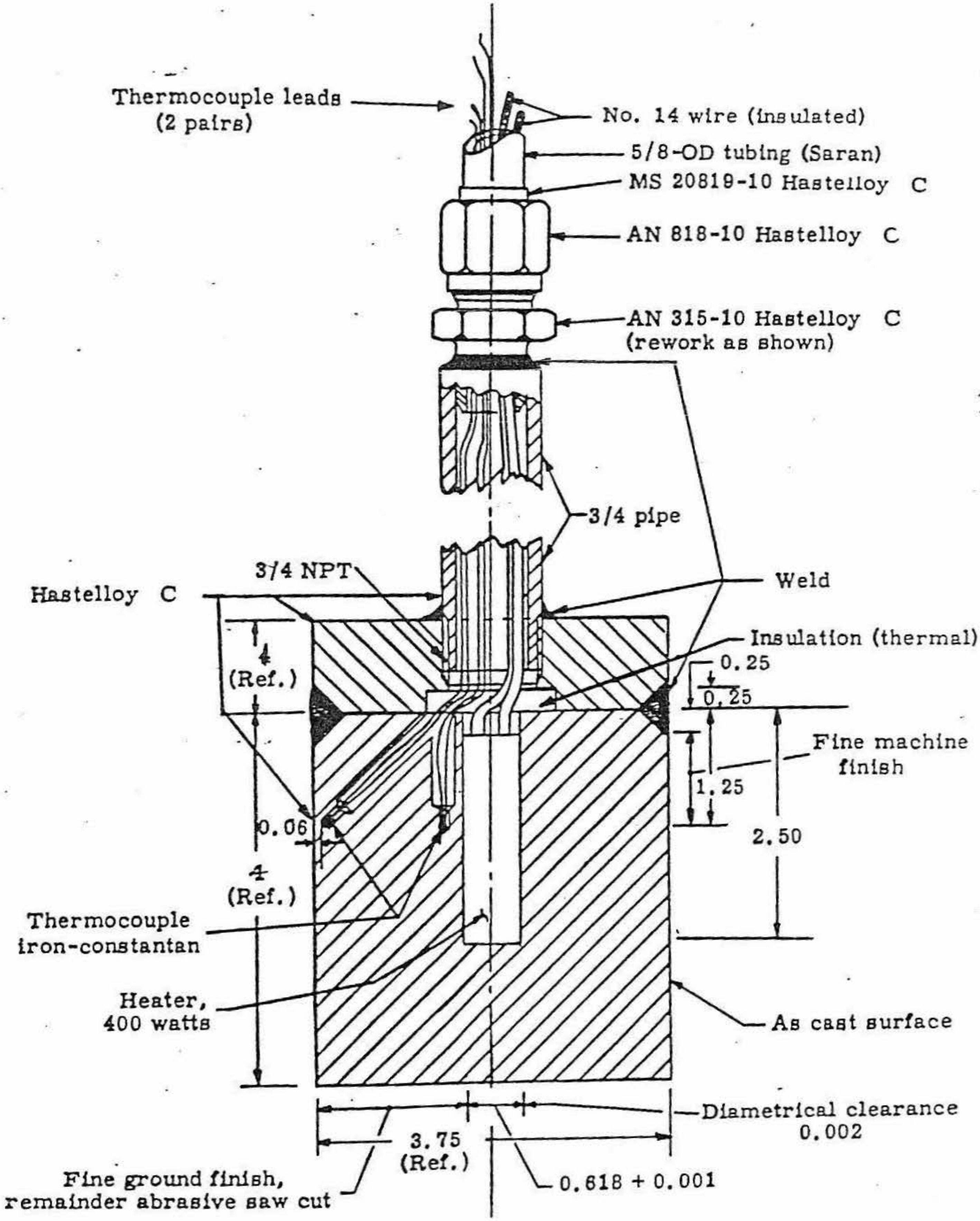

Fig. 10. Underwater Corrosion Test Generator Housing

generator in sea water. The units were calibrated and a Variac was used to control the heat input. The units will be inspected at the end of one year. At this time, the silt-test may be discontinued, depending upon the results, but the suspended unit will continue test for an additional four years or to heater element failure.

With the decision to fabricate the corrosion resist of Hastelloy C, it appeared advantageous to use Hastelloy C for the electrical leads also, provided the anode is not of the sacrificial type. If it should happen that the power connector were damaged in any way, which would permit sea water to contact the anode, an electrolytic cell would result. An experiment was conducted to determine what, if any, corrosion would result. An electrolytic cell with Hastelloy C anode and cathode in sea water was assembled as shown in Fig. 12. An attempt was made to duplicate the power conditions of the 100-watt generator, i.e., 12 volts and 8 amperes. At 12 volts, the initial current flow was only 1 ampere; this increased to 3 amperes after 2 hours when the test was concluded. In this short time, the anode suffered considerable damage, quite obvious with visual inspection. The anode corrosion rate at 12 volts and an average 2 amperes was 1 gm/sq in./hr. The cathode was unaffected.

Platinum anode and cathode were inserted into the cell and, after 2 hours at 12 volts and a steady 2.4 amperes, neither electrode suffered any detectable weight change or visually apparent damage. Continuing the investigation, a platinum anode and Hastelloy C cathode were inserted into the cell and, after 2 hours at 12 volts and a steady 3.2 amperes, neither electrode suffered any detectable weight change or visually apparent damage.

Hastelloy C has a very low electrical conductivity, making it undesirable for the cathode material. Platinum for both the anode and cathode is preferred.

Several tests were run to evaluate the susceptibility of Hastelloy C to crevice corrosion and air-to-water interface corrosion on welded and unwelded specimens. Information from the Harbor Island Test Station of the International Nickel Company showed that Hastelloy C does not suffer general corrosion or crevice corrosion in quiescent sea water at ambient temperature. However, no information on the corrosion resistance of Hastelloy C at somewhat elevated temperatures was available. Likewise, no information on the corrosion resistance of Hastelloy C weldments to sea water at any temperature was available. These tests were run to provide some insight into what might occur in the areas where data were unavailable. However, they do not simulate the internal heat effect of an operating generator.

A crevice corrosion specimen (two washers clamped together) with no weldment, a fully submerged specimen with weldment, and a half submerged specimen with vertically oriented weldment were exposed to sea water in individual containers at room temperature and at 180° F. The test time was 1872 hours. Table 18 lists the pertinent results.

TABLE 18

Hastelloy C Specimens in Sea Water at 180° F

Specimen	Location	Temperature	Weight Change (mg)	Appearance
Crevice corrosion	Submerged	Ambient	-1.4 -1.0	Unchanged Unchanged
Crevice corrosion	Submerged	180° F	+2.4 +2.3	Iridescent film Iridescent film
Weldment	Interface	Ambient	-0.7	Unchanged
Weldment	Interface	180° F	+6.6	Iridescent film
Weldment	Submerged	Ambient	-0.8	Unchanged
Weldment	Submerged	180° F	+8.9	Iridescent film

No attempt was made to clean the specimens after exposure because the weight change due to the test is so slight that cleaning would cause a greater weight change than was incurred by the test. This refers to those specimens which gained weight. None of the specimens which lost weight needed any cleaning treatment other than rinsing and drying. To illustrate the very low rate of attack, one of the pair of washers from the ambient crevice corrosion specimen which lost 1.4 mg corroded at the rate of 6×10^{-6} ipy. In some cases, the reported weight change is close to the accuracy of the balance, so it is judged that no significant corrosion occurred even at 180° F.

B. RADIOACTIVE TRACER CORROSION STUDIES

For the tracer corrosion studies, a box was built to contain six 4-liter battery jars. Several turns of heating tape were made around each jar to heat the water in the jars. The current through the tape

E. CORROSION OF IRRADIATED HASTELLOY C

Three samples of Hastelloy C measuring 1.3 x 4.5 cm were irradiated in the Brookhaven National Laboratory reactor. The samples were washed thoroughly to remove any radioactive particles that may have been picked up during the handling and irradiation. The samples were then suspended, on glass rods, in four liters of natural sea water at a temperature of 65° C. The water was continuously stirred with electrically driven stirrers. Samples were removed weekly, evaporated to dryness and counted to determine if any correlation as to time versus corrosion could be made. The amount of activity found in each sample was negligibly small. At the end of the study, three samples were taken from each vessel. The samples were counted and the average of the three counts was used for the calculation.

A monitor of each Hastelloy sample was weighed and dissolved. The resulting solution was properly diluted and an aliquot of each counted in duplicate. This activity was equivalent to a specific weight of Hastelloy. Knowing this, the activity obtained from the water samples could then be translated to micrograms of Hastelloy. By using a standard formula, the weight was converted to inches per year.

The final corrosion data showed that two of the three samples had the same amount of corrosion while the third showed approximately 12% less. However, the highest data was used in the calculation.

It was found that Hastelloy C in sea water at 65°C corroded 5.4×10^{-7} inches per year.

APPENDIX C

Modification of Shipping Package for SENTINEL (LCG) Generators to Eliminate the Protective Cage

(April 1985)

Isotopes, Inc. application dated September 16, 1969 (Isotopes Letter SEN-CNY-323) requested deletion of the protective cage portion from the transportation package. This letter, along with attached report and drawing, presented evidence that, with respect to safety criteria, the protective cage portion of the transport package was not required. The single exception to this statement is the use of the protective cage with a specific unit, the SENTINEL 25C3, to limit radiation dose rates to meet the then applicable DOT regulations for shipment of the generator as general cargo.

Prior to the September 16, 1969 request, the transportation package for all SENTINEL (LCG) generators consisted of the generator mounted to a pallet assembly (Dwg. No. 001-90039)* enclosed by the protective cage (Dwg. No. 001-90040) which was attached to the pallet assembly. The combination of the protective cage and the pallet assembly was as shown on Dwg. No. 001-90041 entitled "Shipping Pallet Assembly." Subsequent approval of this request, then, redefined the transporation package as a SENTINEL (LCG) generator (any model) attached to the pallet assembly - Dwg. No. 001-90039. Mounting instructions, peculiar to specific models, are stated on the 001-90039 drawing. The user has the option of including the protective cage when necessary or desirable to limit external radiation dose rates.

Originally, at the time of design of the shipping pallet assembly, 00-190041, it was thought that cooling fins used in the generator must be protected to satisfy

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* This drawing included in Appendix D.

safety criteria. Consequently, the rather elaborate protective cage was built to fit over the generator which would absorb the total energy during normal handling incidents such as the four foot drop. Subsequent thermal analysis demonstrated that an over heat situation does not exist even if the fins were to be totally lost.

The remainder of this appendix provides a summary of the thermal analyses and supporting information referenced in or submitted with the September 16, 1969 application, and two subsequent applications dated March 30, 1970 and April 20, 1970 which were actually supplements to the Setptember 16, 1969 submittal.

Two possibly detrimental effects may result from mishaps such as the four foot drop. The first, cited above, is the possible damage to the generator external cooling fins. Additionally, the shock may act to produce an electrical open circuit. The normal mode of transportation for the generator is for the series connected electric circuit to be placed on short circuit. This is the condition for which, given a fixed set of external ambient conditions, temperatures within the generator unit are the lowest. On the other hand, an open circuit with the same fixed external conditions is the configuration for which the internal temperatures are the highest.

Two generators were selected for detailed thermal analysis. One, the SENTINEL 25D, was selected as representive of those members of the family constructed with cast iron steel housings (SENTINEL, LGC-25A, SENTINEL, LCG-25B, SENTINEL-25D, SENTINEL 25E). The second, the SENTINEL-25C3 was selected as representive of the units with aluminum housings (SENTINEL, LGC-25C, SENTINEL -25C3, SENTINEL-25F).

Thermal analysis for the 25D unit is described in report, "SENTINEL 25D Transportation Fire Analysis," INSD-3035, 25 July 1969, Isotopes, Nuclear Systems Division. One of the analyses reported therein was for the 25D unit, on open circuit

with cooling fins removed, 130°F ambient air and solar heating. The results of this analysis became the initial condition for a transportation fire analysis. The transportation fire environment specification for this analysis was similar to the current specification (10 CFR Part 71.73 (3)). The thermal environment specification at the time of the analysis, however, allowed for artificial cooling for times greater than three hours after the cessation of the one-half hour thermal environment. The prior environments in the accident sequence (30 foot drop, puncture) were postulated to leave the steel housing and lid intact: the thermal configuration during the fire and post fire period was an intact generator on open circuit minus cooling fins.

A survey of the initial (steady state) temperatures and temperature histories produced during the fire and for the three hour period following the five revealed that there was no melting of any component of the generator over this period. Hence, the main heat transfer path from the strontium titanate fuel through the capsule, tungsten shield, thermoelectric module, module heat sink and (unfinned) steel lid remains intact. During the thermal environment (first half-hour), temperatures in the steel body and lid rise rapidly. Internal temperatures, however, rise slowly indicating relatively little heat transfer to interior components. After the thermal environment, the housing cools rapidly but interior temperatures continue to rise. At the end of the three hour cooling period most of the interior temperatures have begun to decrease. Those components which continue to rise in temperature at this time appear to be quite near their peak value and their rise rate in less than 5°F per hour.

Maximum temperatures for components of primary concern are presented in Table C-1 along with time of occurrence and critical (melt) temperatures for the component.

TABLE C-1

SENTINEL 25D Peak Temperatures Due to a Transportation Fire

Component	Time After Start of Fire (minutes)	Temperature Peak(°F)	Temperature Critical(°F)
Fuel Capsule	240.	1494.	2318.
Biological Shield	240.	1395.	6170.
Module Heat Sink	34.6	751.	1220.
Lid	30.0	777.	2750.
Housing	30.0	711.	2790.

Detailed thermal analysis for the SENTINEL 25C3 was performed and reported in "Sentinel 25C-3 Transportation Fire Analysis in Support of AEC License Amendment Application," INSD-3037, 8 September 1969, Isotopes, Nuclear Systems Division. This unit has an aluminum housing and is very similar in construction to the 25F. A comparison of the thermal analysis for the 25D (from INSD-3035) and for the 25C3 (INSD-3037) for a common condition - that of normal generator operation with cooling fins in an ambient air of 70°F - shows that the 25C3 unit runs somewhat cooler. From this comparison, it is inferred that, if the fins were removed from the 25C3 unit, the temperatures would not be higher than the 25D unit under the same conditions. Hence, given a four foot drop of the 25C3 unit which may result in cooling fin damage and electrical open circuit, it is inferred from the 25D analysis that internal temperatures would be well below any temperature which could result in either loss of fuel containment capability or loss of integrity of the radiation shielding.

Transportation fire analysis for the 25C3 unit assumed unit temperatures consistent with an 130°F ambient air temperature and solar heating but assumed an intact finned lid. Obviously, the prior environments (30 foot drop, puncture) in the accident sequence could have resulted in damage to the cooling fins. A review of the analysis, however, indicates that the somewhat higher initial temperatures resulting from fin damage is probably inconsequential to the major findings of the fire analysis. For the 25C3 unit it was found that the entire aluminum housing (assumed finless during the fire period) had attained the aluminum melt temperature and the aluminum lid and module heat sink were within 100°F of the melt temperature, after the first 17 minutes of the 30 minute radiator period. At this point the thermal model was revised to a configuration which assumed that the aluminum component and the thermoelectric materials had been removed by melting. Insulation was left in place. The analysis continued with this configuration through the remainder of the "fire" period and through the three hour post fire period. The post fire period assumed 130°F ambient air and solar input. Additionally, a steady state analysis was conducted to determine the surface temperature of the tungsten shield for rejecting the 2500 Btu/hr fuel inventory to the fire (assumption that all the insulation was removed at 17 minutes into the fire). Following the fire, the tungsten would then be exposed to 130°F and and sun.

Principal results from the computer thermal model are given in Table C-2.

TABLE C-2

SENTINEL 25C-3 PEAK TEMPERATURES DUE TO A TRANSPORTATION FIRE

Component	Time After Start of Fire: Max. Temp. (min)	Time After Start of Fire: Initiation of Melt (min)	Temperature: Peak (°F)	Temperature: Melt (°F)
Fuel	210	--	1565	3470*
Fuel Capsule	210	--	1255	2318**
Biological Shield	210	--	1125	6170**

* Rimshaw, S. J. and Ketchen, E. E., "Strontium-90 Sheets, "ORNL-4043, Oak Ridge National Laboratory, Oak Ridge, Tennessee, Nov. 1966 (Confidential).

** Materials Engineering, Materials Selector Issue, Oct. 1968.

The more conservative "steady state" fire analysis yielded a maximum fuel capsule temperature of 1640°F. From this result it may be inferred that maximum fuel and biological shunt temperatures may be on the order of 400°F higher than the values of Table C-2. However, maximum temperatures for critical components are still well below the melt temperatures for the components. Hence, the transportation fire has compromised neither fuel containment system nor the radiator shield integrity.

During normal conditions of transport, including a four foot drop of a package without the protective cage, the above analysis supports the conclusion that the housing would not be damaged to the extent of compromise of the package function. Damage to the cooling fins of any SENTINEL (LCG) design to the extent of complete loss is not

critical. Furthermore, fin damage is not critical for consideration of the hypothetical transportation fire.

For the case of the 30 foot drop, structural analyses for the various member of the SENTINEL generator family conservatively assumed no benefit from the shipping pallet assembly or protective cage.

This completes the evidence presented in the September 16, 1969 application to delete the protective cage portion of the shipping pallet assembly from the transportation package (but retaining the right to use the cage to limit personnel access and hence, external radiation dose rates, if desirable).

Subsequent to the September 16, 1969 application, questions were raised by the reviewing agency (U.S. AEC: Irradiated Fuels Branch) as to whether or not the thermal analysis (summarized above) did represent the worst case. It was postulated that damaged fins may pose a more severe environment than the "fins removed" case. TES response to this inquiry was additional thermal analysis which was the subject of the Isotopes, Inc. application dated March 30, 1970. The bulk of this submittal is reproduced (almost) verbatum below:

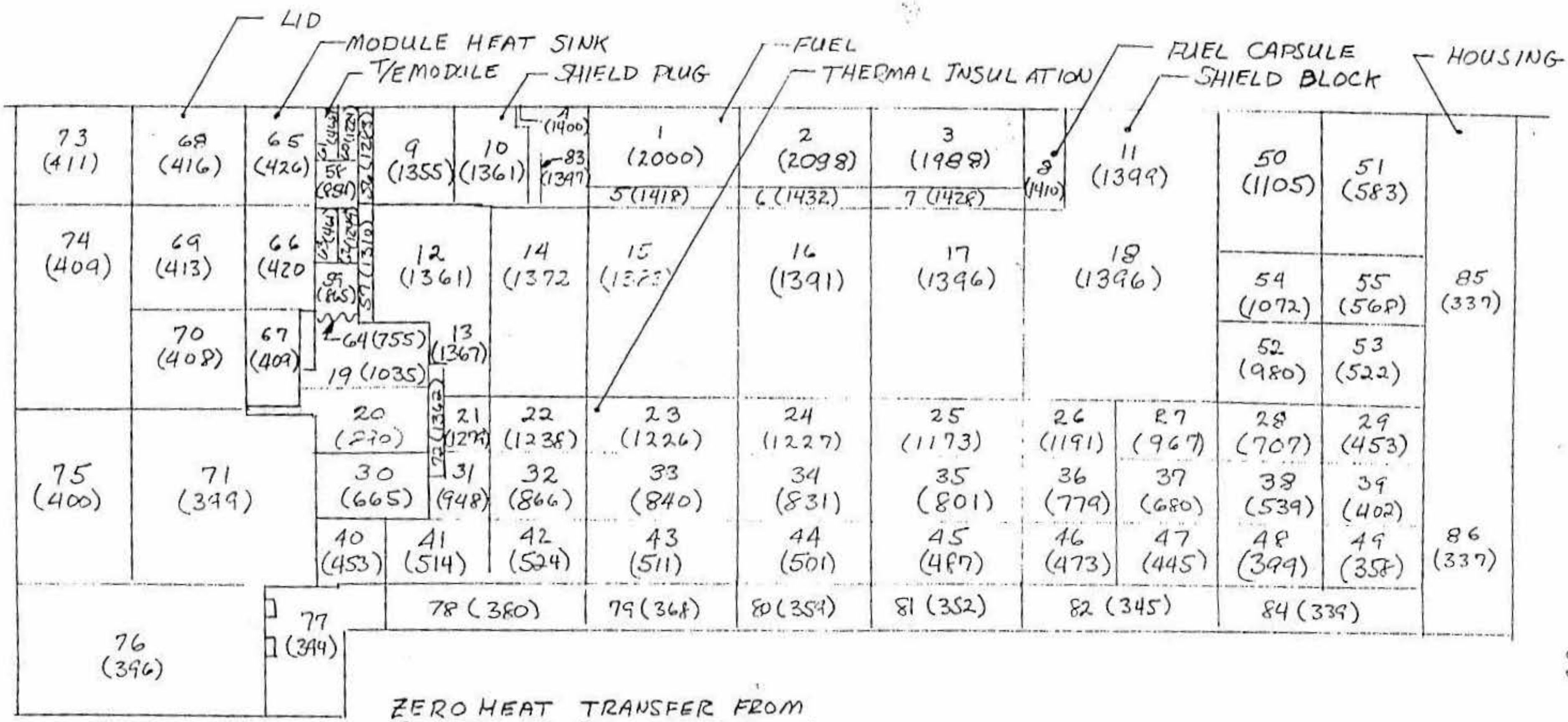
Subsequent Thermal Analysis
(From Letter SEN-CNY-429)
(March 30, 1970)

A question was subsequently raised as to whether or not having the fins completely removed would be the worst case. There is a possibility that having the fins bent over might present a greater thermal impedance. Since the bent fin case cannot be readily defined, it was decided to look at a limiting case where no heat was transferred from the top surface of the generator. A computer run was made on this limiting

case using the SENTINEL 25F, and the results are shown in Figure C-1. The data shows that the generator has no critical temperatures. These temperatures reflect the short circuit conditions for the generator which is the normal shipping configuration. If the generator should go open circuit during the accident, no node would experience a temperature rise of more than 120-140°F. These would still be well within safe limits. This analysis is considered very conservative for the following reasons:

1. The thermal inventory used for the SENTINEL 25F represents an upper fuel inventory limit (850 watts) which is larger than the actual inventory on any existing SENTINEL 25 generator. Thus, because of fuel inventories and geometries, we would expect any other SENTINEL 25 to have correspondingly lower temperatures.
2. Even if the generator should fall inverted into mud or loose sand, some heat transfer from the fins would exist.
3. A conservative heat transfer coefficient was used. The coefficient was based on a surface temperature of 150°F. Since the temperature of the surface is much higher, the heat transfer capability is much higher, and the actual internal temperatures would be lower than those indicated.

Isotopes, Inc. application dated April 20, 1970 (apparently) was in response to additional inquires from USAEC-IFB. This application consisted of Isotopes letter SEN-CNY-443 dated April 20, 1970, which identified the computer program used for the March 30, 1970 thermal analysis (above) and prior (INSD-3051) analysis and provided information on thermal properties used for the analysis. The body of this letter is reproduced below:



ZERO HEAT TRANSFER FROM GENERATOR HEAD ~ STEADY STATE TEMPERATURES IN °F. 130 °F AMBIENT AIR, NATURAL CONVECTION TO HOUSING. SHORT CIRCUITED MODULE.

FIGURE C-1
SENTINEL 25F THERMAL NODE MAP

Computer Program Identification, Thermal Properties
for the Thermal Analysis Report in the March 30, 1970 Submittal
(April 20, 1970)

This letter is to supply supplemental data to our letter SEN-CNY-429 dated 30 March 1970. The steady-state analysis presented in the above reference used the Linearized Matrix Program (LIMP) which is an Isotopes proprietary program. The problem was run on a CDC 6600 computer. This is the same program used to obtain the steady-state analysis presented in INSD-3051.

The convective heat transfer coefficients used varied according to position on the generator surface and ranged from 0.65 to 0.68 BTU/hr ft^2 °F. (Eq. 7.46, McAdams, W.H., Heat Transmission, McGraw Hill, New York 1954). A solar load of 340 BTU/hr ft^2 °F was applied to the exterior top (actually bottom of the inverted generator) and side surfaces. The surface solar absorptivity was assumed to be 0.4.

Table C-3 is a listing of the thermal conductivities used. Two values are listed for Min-K 1301. These values are based on experimental data from several generators. The thermoelectric modules use an argon gas fill. Sometimes krypton may be used in the housings to reduce the parasitic heat losses. The use of the lower thermal conductivity gas results in higher temperatures for the generator internals. Hence, the values shown in SEN-CNY-429 are even more conservative by this factor since it is planned to use argon as the fill gas on the SENTINEL 25F.

TABLE C-3

MATERIAL THERMAL PROPERTIES

Item	Thermal Conductivity (BTU/HR-FT-^{o}F
Fuel	0.95
Capsule	10.50
Biological Shield	75.00
Insulation (Housing Min-K 1301 with Krypton)	.017
Insulation (Module Min-K 1301 with Argon)	.019
Insulation (Glassrock)	0.08208
Module Hot Plate	13.20
Module T/E Elements	1.13870
Bellows	9.30
Module Heat Sink, Lid and Housing	99.0
Insulation Holddown Ring	13.7

END APPENDIX C

RESUBMITTAL OF PRIOR APPLICATIONS
AND SUPPLEMENTS FOR APPROVAL TO
TRANSPORT THE SENTINEL-25F
RADIOISOTOPE THERMOELECTRIC GENERATOR
AND NEW INFORMATION TO SUPPORT THE
TYPE B ( ) DESIGNATION

TES-3202

APRIL 19, 1985

REVISION 1

OCTOBER 1986

REVISION 2

DECEMBER 1991

TELEDYNE ENERGY SYSTEMS
110 W. TIMONIUM ROAD
TIMONIUM, MARYLAND 21093

PREFACE

(April 1985)

By this submission, Teledyne Energy Systems (TES) hereby requests approval for transport of its Sentinel 25F Radioisotope Thermoelectric Generator (RTG) under the classification Type B(U) (as defined in 10 CFR Part 71, January 1, 1985).

This report consists of the information previously submitted for the 25F RTG and additional information specific to the new designation Type B (U). The 25F unit is currently licensed for transport as a Type B package under Certificate of Compliance, Certificate No. 4888, Revision 5 issued by the U. S. Nuclear Regulatory Commission (NRC) dated September 6, 1983.

Certificate No. 4888 is license for transport of the several TES RTGs generally designated Sentinel 25 or the former designation LCG-25 with suffixes for the various models (A, B, C, C3, D, E, F for Sentinel and A, B, C for LCG). The certificate cites an original application dated August 13, 1965 and several amendments with supplements. This report contains the information originally provided in the amendments which applies specifically to the Sentinel 25F unit or is generally applicable to all Sentinel units (and, hence, applies to the 25F). Specifically, the information contained in the following amendments and supplements cited on the certificate is provided:

1. Isotopes, Inc. application dated March 27, 1970; with supplement TES-MIH-1403 dated: January 25, 1978.
2. Isotopes, Inc. applications dated: September 15 and 16, 1969; and March 30* and April 20, 1970.

Item 1 pertains specifically to the 25F. Item 2 provides general information and addresses a revised shipping configuration for all Sentinel 25 models.

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* The date on the certificate is wrong: reads March 3, should read March 30.

The format of this report is such that all relevant information is contained within the body of the report. Furthermore, future submittals (if required) will be such that they are in the form of replacement pages for the report and will be identifiable as new information by inclusion of the date (month and year of the submittal). This report has been prepared in this manner. Unless specifically identified by a date and vertical bar in the right hand margin by the title of the section (as above for this preface), the information is from the original submittal for the 25F unit: "Sentinel 25F, Structural and Thermal Evaluation," INSD-3051, March 26, 1970, Teledyne Isotopes,* Nuclear Systems Division, 110 West Timonium Road, Timonium, Maryland 21093. The chapter titles of INSD-3051 have been retained. Subsequent submittal information has been inserted into the appropriate chapter or included as a new appendix.

To facilitate future updates, the page numbering system has been modified to reflect the individual chapters. For example, Chapter II, Generator Description is numbered II-1, II-3, etc. The last page of each chapter, section or appendix is identified by the mark "END ...." following the last portion of text.

Information specific to the peculiar requirements for the new designation Type B (U) is included in the text.

END PREFACE

* Now TES, same address.

I. INTRODUCTION

The SENTINEL 25F is basically the same generator as the SENTINEL 25C3. Certain minor modifications have been made which reduce the radiation levels and improve the generator mounting brackets. The reduction in radiation has been accomplished by small increases in the tungsten shield thicknesses. The mounting brackets have been simplified so that shims are no longer required when attaching the generator to the pallet. The housing is constructed from a forged aluminum tube rather than two welded half-sections as before. The wall thickness has been increased from 0.75 to 0.88 inch. The weight of the complete generator, including the finned shipping header, is 1397 pounds. The SENTINEL 25F assembly is shown on drawing 001F10000 (Appendix D).

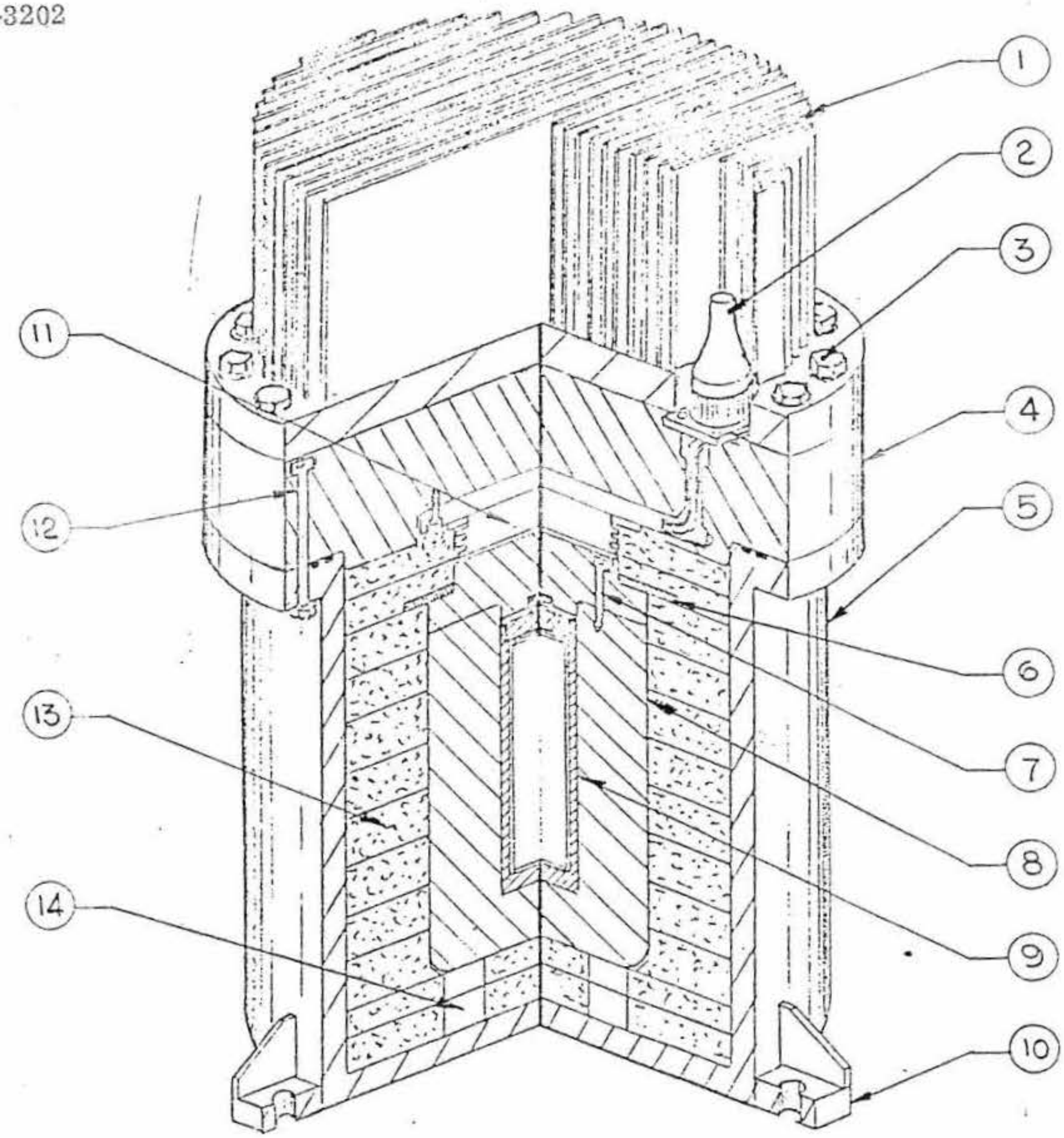
A complete evaluation of the SENTINEL 25F follows.

END CHAPTER I

II. GENERATOR DESCRIPTION

Figure 1 is a cutaway sketch of the SENTINEL 25F showing the generator configuration and the materials of the structural components. The thermoelectric module is not shown in detail since it does not substantially effect either the mechanical or thermal analysis. Mechanically, the generator is designed to carry the loads resulting from the tungsten shield through the thermal insulation with the help of the retaining ring. Thermally, the effects of the module are considered in the post accident fire analysis, but the module has little effect on the critical temperature.

The fuel is strontium 90 in the titanate composition. The fuel pellets are loaded in a stainless steel liner to facilitate contamination control. The liner cap is pressed in place. The liner is then loaded into a Hastelloy C-276 (or Uniloy HC) capsule. The capsule lid is threaded for strength and welded to provide a positive seal. The fuel capsule is inserted into the tungsten shield, and the shield plug is bolted in place. The shield is so designed that the bolts are actually required only in case of a static inversion. The space between the housing and the shield is filled with Johns Manville Min-K 1301 except for the space occupied by the thermoelectric module. A glass rock insulation is added under the shield to increase the compression allowable on the insulation. On the upper end of the shield a retainer ring has been added to give additional



1. Auxilliary Radiator-6061-T6 Aluminum
2. Electrical Power Outlet (Shorting Plug)
3. Radiator Attach. Hrdw. (2024-T4 Bolts, Nuts)
4. Lid Assembly-6061 T6 Aluminum
5. Housing Assembly-6061 T6 Aluminum
6. Retaining Ring - CRES-A-286
7. Shield Bolt-CRES-A-286 (Plated)
8. Biological Shield-Tungsten Alloy
9. Fuel Capsule Assembly
10. Mounting Pad-6061 T6 Aluminum
11. Thermoelectric Module Assy
12. Lid Attach. Hrdw (2024-T4 Bolts, Nuts)
13. Thermal Insulation (Min-K 1301)
14. Load Bearing Insulation (Glass Rock)

FIGURE 1
SENTINEL 25F GENERATOR

bearing area. The insulation directs the heat upwards through the thermoelectric module where a portion is converted directly to electrical energy. The aluminum lid forms a heat sink for the module. The aluminum housing completes the generator. A finned header is used to reduce the temperature of the module heat sink during shipping and storage, and also for certain installations. The finned header is required for proper thermoelectric performance, but it is not required for safety.

The generator is bolted to a pallet for transportation using four 3/4-inch bolts.

A. CHANGE OF FUEL FORM TO STRONTIUM FLUORIDE
(January 25, 1978)

The unavailability of the strontium titanate fuel form has made it mandatory to use the strontium fluoride ($^{90}SrF_2$) fuel form for future production of the Sentinel 25F generator. Substitution of a Hastelloy C-276 liner for the previous stainless steel liner in the fuel capsule is shown to satisfy the requirements for a Certificate of Compliance to transport the $^{90}SrF_2$ Sentinel 25F.

B. UNIT MAXIMUM INTERNAL PRESSURE
(April 1985)

The new designation Type B(U) (10 CFR 71.4, Package (2)) restricts maximum normal operating pressure of the package to less than 100 psi and prohibits the use of a pressure relief device which would allow the release of radioactive material under the tests specified in paragraph 71.73 (hypothetical accident conditions). The Sentinel 25F has no pressure relief devices and, as evidenced by the discussion below, exhibits internal pressure well below the 100 psi limit under environments associated with normal conditions of transport. With respect to internal pressure and pressure relief devices, the unit qualifies for the B (U) designator.

During the generator assembly process, all spaces internal to the generator housing (including fuel capsule, module assembly within the bellows seal, and insulation void within the housing) are charged with a mixture of inert gases. The nominal pressure at the time the seal is effected is about one atmosphere (absolute). Even under adverse conditions of high ambient air temperature and insolation, the pressure within any of the internal regions cited above will be no more than a few psi above atmospheric.

C. SECURITY SEAL REQUIREMENT
(April 1985)

This section addresses the requirement of 10 CFR Part 71 (January 1, 1985), paragraph 71.43 (b).

The joint between the RTG lid and RTG housing is sealed with a "bead" of Weatherban-101 sealant. The sealant is a 3M Company product that chemically cures when exposed to moisture to form a firm, rubbery waterproof seal. Removal of the RTG lid would effect complete (360°) rupture of this sealing compound and present positive evidence of RTG opening. An essentially intact seal, then, would be evidence that the package has not been opened by unauthorized persons.

D. UNINTENTIONAL OPENING
(April 1985)

This section addresses the requirement of 10 CFR Part 71 (January 1, 1985) paragraph 71.43 (c).

The RTG lid to housing attachment bolts are concealed in countersunk holes beneath the finned radiator assembly (see Figure 1). Access to these bolts can only be obtained by completely removing the finned radiator assembly. In view of the relative difficulty, any attempt at opening the unit must be regarded as a deliberate act (as opposed to an unintentional opening).

END CHAPTER II

III. FUEL CAPSULE

The fuel capsule assembly (see Figure 2) consists of the fuel, a liner, and the capsule. The liner is used only to facilitate contamination control, and no credit is taken for either strength or corrosion considerations. The fuel capsule consists of a body machined out of bar stock and a cap. The cap threads into the body and the threads are capable of carrying the design loads. The weld is required to furnish a seal and also is the limiting corrosion barrier. The fuel capsule and cap are made from Hastelloy C-276 (or Uniloy HC). If a highly conservative seawater corrosion rate of 0.0001 inch per year[1] is used, the 0.055 minimum weld thickness will provide a capsule seal for 550 years. At that time, the remaining activity of the strontium titanate fuel will be well below one curie. This is based on a license restriction of 125,000 curies initial inventory. Actually, the initial loading will be approximately 111,000 curies.

The capsule is designed for 10,000 psi external hydrostatic pressure. It has been pressure-tested to 11,000 psi[2] without evidence of yielding, and then tested to a final pressure of 17,500 psi without compromise of the containment and only minor deformation. The analysis which follows is based completely on "worst case" conditions. Capsule material is accepted based on individual material certification.

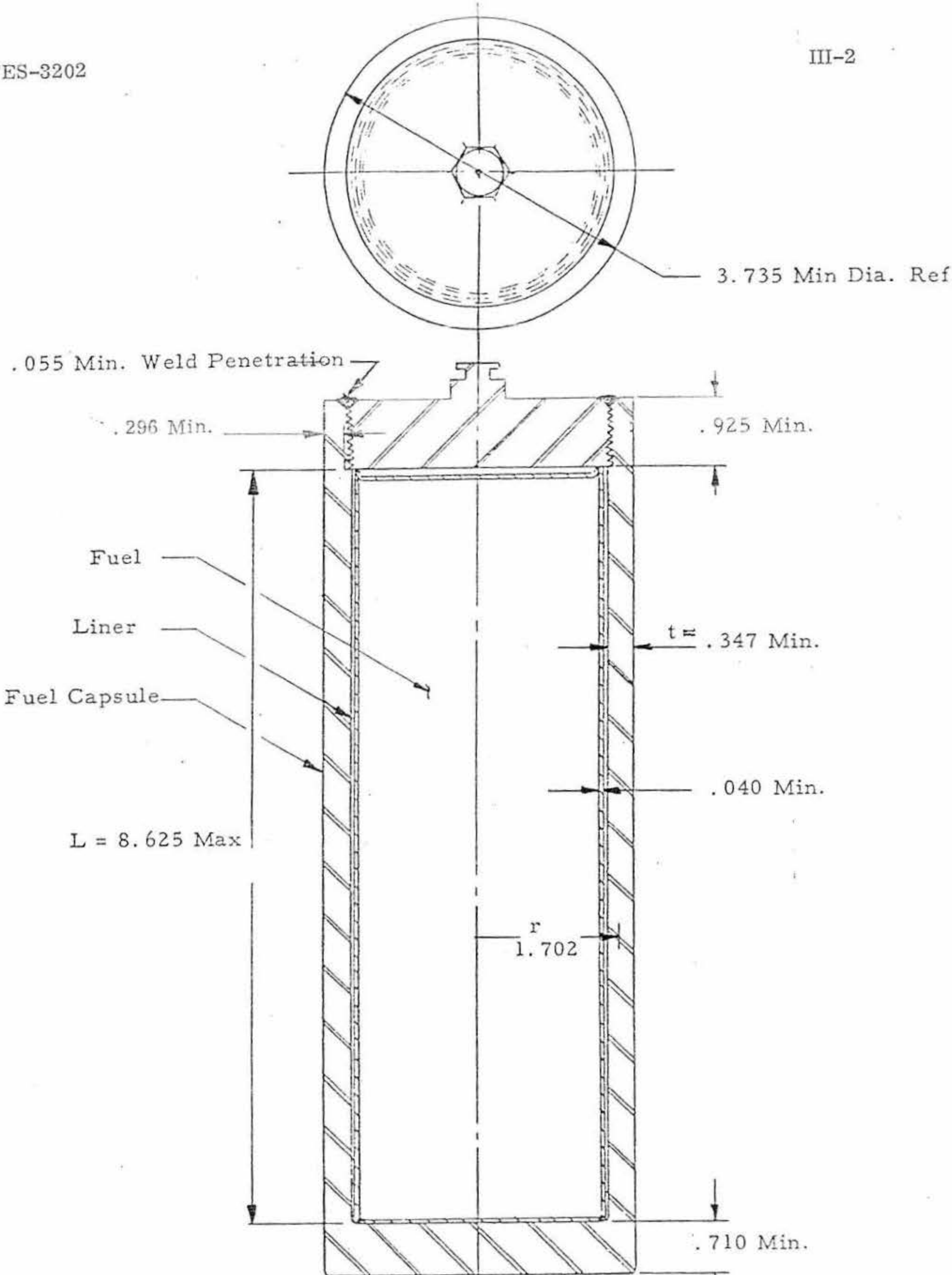


FIGURE 2
FUEL CAPSULE ASSEMBLY

A. DESIGN CRITERIA

Pressure:	10,000 psi (external) at 100°F
Allowable Primary Membrane Stress:	$Sm = 0.9\ F_{ty}$
Local Primary Membrane Stress:	$1.35\ F_{ty}$
Secondary Membrane Stress:	$2.7\ F_{ty}$
Buckling Instability:	$P < 0.5\ Pcr$

B. MATERIAL PROPERTIES

$\sigma_{ty} = 51,500$ psi (minimum acceptable - room temperature)

$E = 28.5 \times 10^6$ psi

$\nu = 0.3$

C. STRESS CALCULATIONS

1. Buckling [9]

Very long cylinder: $\left(\frac{L}{r}\right)^2 > \frac{5r}{t}$

$\left(\frac{L}{r}\right)^2 = 25.7 \qquad \frac{5r}{t} = 24.5$

$\eta \approx 0.3$

$$\sigma_{cr} = \eta \cdot \frac{0.25E}{(1 - \nu_c^2)} \left(\frac{t}{r}\right)^2 = 98,200$$

$$P_{cr} = \frac{\sigma_{cr}\ t}{r} = 20,000$$

$$P = 0.5\ P_{cr} = \underline{10,000}$$

2. Primary Membrane Stress

(Equivalent stress at center of wall)

$$\sigma_{eq} = \frac{1.732\, r_o^2\, r_i^2\, P}{r^2\,(r_o^2 - r_i^2)} = \underline{41,000}$$

0.9 (51,500) = 45,900 > 41,000

3. Discontinuity Stresses at Bottom Head (10)

a. In cylinder

$$\sigma_z = \pm 6\,\frac{Mo}{t_c^2} - \frac{Pr}{2\,t_c}$$

$$\sigma_h = \left(\frac{-2\beta^2 r}{t_c} \pm \frac{6\,\nu}{t_c^2}\right) Mo + \frac{2\beta\, r\, V_o}{t_c} - \frac{Pr}{t_c}$$

$$M_o = \frac{Pr^2}{8\lambda}\left[\frac{2c^3\lambda^3 + c^4\lambda^2(1-\nu) + 2(2-\nu)(1+\nu)}{2c^3\lambda^2 + \lambda[c^4(1-\nu) + (1+\nu)] + c(1-\nu^2)}\right]$$

$$V_o = \frac{Pr}{4}\left[\frac{c^3\lambda^3 + 2c^3\lambda(2-\nu) + 2(2-\nu)(1+\nu)}{2c^3\lambda^2 + \lambda[c^4(1-\nu) + (1+\nu)] + c(1-\nu^2)}\right]$$

$$c = \frac{t_c}{t_h} = .489 \qquad \lambda = \sqrt[4]{\frac{3r^2(1-\nu^2)}{t_c^2}} = 2.85$$

$$\beta = \sqrt[4]{\frac{3(1-\nu^2)}{r^2\, t_c^2}} = \frac{\lambda}{r} = 1.675$$

M_o = 2,090 in lb/in $\qquad$ V_o = 5,680 lb/in

σ_z (outside) = +79,500

σ_z (inside) = $\underline{-128,500}$

σ_h (outside) = +17,100

σ_h (inside) = $\underline{-45,500}$

2.7 (51,500) = 139,000 > 128,500

1.35 (51,500) = 69,500 > 45,500

b. Bottom

$$\sigma = \pm \frac{6M_o}{t_h^2} \pm \frac{3\,Pr^2(3\,m + 1)}{8\,m\,t_h^2} - \frac{V_o}{t_h}$$

$$m = \frac{1}{\nu}$$

σ (outside) = -40,000

σ (inside) = +24,000

1.35 (51,500) = 69,500 > 40,000

4. Discontinuity Stresses at Top Head

a. Cylinder

Analysis same as in (3) above except:

$c = 0.320$ $\lambda = 3.08$ $\beta = 1.81$

$M_o = 1,520$ $V_o = 4,920$

σ_z (outside) = +75,300

σ_z (inside) = -132,700

σ_h (outside) = +18,800

σ_h (inside) = -43,700

2.7 (51,500) = 139,000 > 132,700

1.35 (51,500) = 69,500 > 43,700

b. Cap

σ (outside) = -57,900

σ (inside) = +47,300

1.35 (51,500) = 69,500 > 57,900

c. Seal Weld

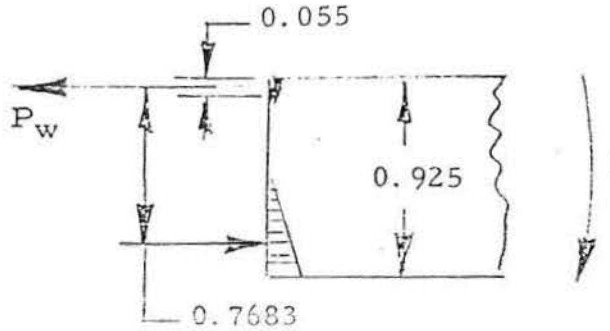


FIGURE 3
Capsule Seal Weld

Weld penetration 0.055 in(min)

$$P_w = \frac{M_o}{0.7683} = 1,980 \text{ lb/in.}$$

$$\sigma_w = \frac{P_w}{t_w} = \underline{35,800} \text{ psi}$$

$$0.9\,(51,500) = 45,900 > 35,800$$

5. Primary Membrane Stress at Inside Wall

(based on Von Mises criteria)

$$\sigma_{eq} = \frac{1.732\, P r_o^2}{r_o^2 - r_i^2} = 51,400$$

$$F_{ty} = 51,500 > 51,400$$

D. QUALITY ASSURANCE

All fuel capsule material is purchased with a certification requirement. The actual properties are examined against structural requirements. The individual components are inspected to quality control log sheets[3] which are maintained for a permanent record. These sheets are prepared from engineering drawings, specifications, and procedures. The fuel loading and final seal weld are in accordance with a written fueling procedure [4]. Included in this specification are the requirements for loading, welding, inspection, and shipment of radioisotope heat sources. Weld quality is assured by the use of weld test specimens before, during,

and following the welding of the fuel capsules. In addition to the weld samples, leak tests are performed on the finished fuel capsule.

E. INFORMATION IN SUPPORT OF THE CHANGE TO THE STRONTIUM FLUORIDE FUEL FORM

(January 25, 1978, Sections E.1 through E.4 below)

E.1 INTRODUCTION

The Teledyne Energy Systems Thermoelectric Generator Model Number Sentinel 25F has used strontium titanate ($SrO \cdot TiO_2$) as the fuel form. The ^{90}Sr was recovered at the Hanford facility in Washington from wastes generated by reprocessing reactor fuels. Because of waste management considerations, the wastes are now being converted to strontium fluoride ($^{90}SrF_2$). The availability of the titanate has been reduced to negligible levels, and the equipment used for its preparation has been largely dismantled. Therefore, the encapsulated $^{90}SrF_2$ stored at the Waste Encapsulation and Storage Facilities (WESF) is the only major source of ^{90}Sr available for use in heat source applications.

The purpose of this section is to evaluate the feasibility of using strontium fluoride instead of strontium titanate as the fuel form in the Sentinel 25F heat source, and to provide the technical analyses to support the request for a revision to the current Certificate of Compliance to ship the Sentinel 25F.

E.2 MODIFIED LINER DESIGN DESCRIPTION

The fuel capsule assembly (Figure 2) consists of the fuel, a fuel liner, and the capsule. The strontium titanate fuel capsule, fabricated from Hastelloy C-276, and having a minimum thickness of .347 inch, was shown (above) to satisfy the provisions

of 10 CFR 71 for the packaging of radioactive materials for transport. A nominal .055 inch liner of stainless steel AISI 304L was used to facilitate contamination control during fueling. No credit was taken for either strength or corrosion considerations of the liner after the fueling operations.

In order to accommodate the strontium fluoride fuel form, the .055 inch fuel liner will be fabricated from Hastelloy C-276 instead of stainless steel. To take advantage of the additional fuel containment capability afforded by the C-276 material, the fueling procedure has been modified to include TIG welding of the liner lid to the liner. No other changes in the Sentinel 25F generator or the previous fuel capsule design are contemplated. A more detailed discussion of fuel compatibility with containment materials is presented in the next section of this report.

E.3 MATERIAL COMPATIBILITY

The Battelle Pacific Northwest Laboratories initiated a program under ERDA sponsorship in 1973 to develop the technology needed to support approval of $^{90}SrF_2$ fuel heat sources. The Teledyne analysis of the latest PNL data is contained in Ref. 13. It is concluded therein that Hastelloy C-276 is a satisfactory substitute for the stainless steel liner used previously because of its superior compatibility with stronium fluoride.

The stainless steel liner was incorporated in the original Sentinel design to facilitate decontamination operations so that the strength member could be assembled and welded in a "clean" hot cell. The presence of the liner was not considered in safety tests or analyses of the heat source. The liner was considered to be sacrificial and long-term compatibility with strontium titanate was not required. The purpose of the Hastelloy C-276 liner with the strontium fluoride fuel form is similar, but, in addition, the test data show a significant containment ability. For a nominal

thickness of .055 inch (the same as for the stainless steel liner) the $^{90}SrF_2$ will be contained within the liner for many years. This prediction is based on the long-term tests with nonradioactive strontium fluoride which show that penetration is constant after about 6000 hours and the long-term tests with radioactive strontium fluoride which show that the penetrations at 6000 hours are essentially the same as at 1000 hours. Accordingly, PNL has recommended the use of Hastelloy C-276 as the fuel clad (linder) in their heat source program (Ref. 14).

E.4 FUELING AND QUALITY CONTROL

The requirements for the radioisotope fuel, fuel form, fuel encapsulation, quality assurance provisions, and preparation for shipment of strontium 90 radioisotope heat sources for application in the Teledyne Energy Systems 25 Watt(e) Sentinel series thermoelectric generators are presented in the Heat Source Specification, Ref. 15. The Quality Plan, Ref. 16, describes the quality assurance activities at Teledyne Energy Systems in support of the $^{90}SrF_2$ fueled Sentinel RTG program. The plan meets the intent of MIL-Q-9858A, entitled" Quality Program Requirements" and applicable Military Specifications and Standards.

END CHAPTER III

IV. HEAT SOURCE

The biological shield forms the primary structure to protect the fuel capsule from damage during hypothetical accident conditions, as well as performing the basic function of providing radiation shielding during both normal and accident conditions.

The maximum radiation levels have been calculated to be:

On surface of generator	148 mr/hr
3 feet from surface of generator	8.3 mr/hr
3 feet from surface of exposed shield	183 mr/hr

These calculations have been compared with the calculated and actual radiation levels on the similar SENTINEL 25C3 generator. Nominal design dose rates have been chosen to insure that the actual measurements will not exceed 10 mr/hr at 3 feet from the generator and 200 mr/hr at the surface of the generator.

RADIATION LEVELS FOR UNITS FUELED WITH STRONTIUM FLUORIDE (January 25, 1978)

The Sentinel 25F with the strontium fluoride fuel form will comply with the external dose rate regulations of 49 CFR Part 173, as does the present Sentinel 25F with the strontium titanate fuel form.

While some uncertainty exists regarding the exact external dose rates of the Sentinel 25F with the strontium fluoride fuel form, substantial changes are not anticipated.

Relatively small dose rate variations may be introduced because of (a) increased Bremsstrahlung production in the fluoride fuel form as compared with the titanate, (b) variations in bulk fuel density and fuel power density, and (c) possible effects of hard gamma emitting fission product impurities in the fuel. Also, the fuel loading procedure (placement of filler material within the capsule) can cause additional variations in actual dose rates.

If testing of Sentinel 25F strontium fluoride fueled units indicate a requirement to reduce external dose rates for compliance with 49 CFR 173, this can be accomplished by limiting access (shipping cage) and/or additional shielding. Integral unit shielding can also be increased to provide operational dose rates consistent with the actual intended application of the unit.

Structural Analysis

The most severe structural case for the generator is the 30 foot free drop as specified in 10 CFR, Part 71, Appendix B. It is conservatively assumed for the purposes of this analysis that the shipping container is not present. It is further assumed that no structural benefit is gained from the housing of the generator other than to hold the thermal insulation in place around the shield up to the time of impact. The following analysis shows that the tungsten shield will remain intact, and thus the integrity of the fuel capsule is assured as well as the radiation limitations of Part 71.36(a)(1).

A. IMPACT ON SHIELD BODY

In order to evaluate the impact or shock resistance of the shield, the critical impact velocity resulting from stress wave propagation is determined. This value is then compared to the shield velocity as it meets a non-yielding surface. The geometry is shown in Figure 6.

The shield is made of tungsten (Kennertium Grade W-10, or equivalent) having the following strength properties at the anticipated shield soak temperature of 1300°F.

Ultimate strength	31,000 psi
Yield strength	25,500 psi
Elastic modulus	38×10^6 psi
% Elongation	4%
Density	0.61 lb/in^3

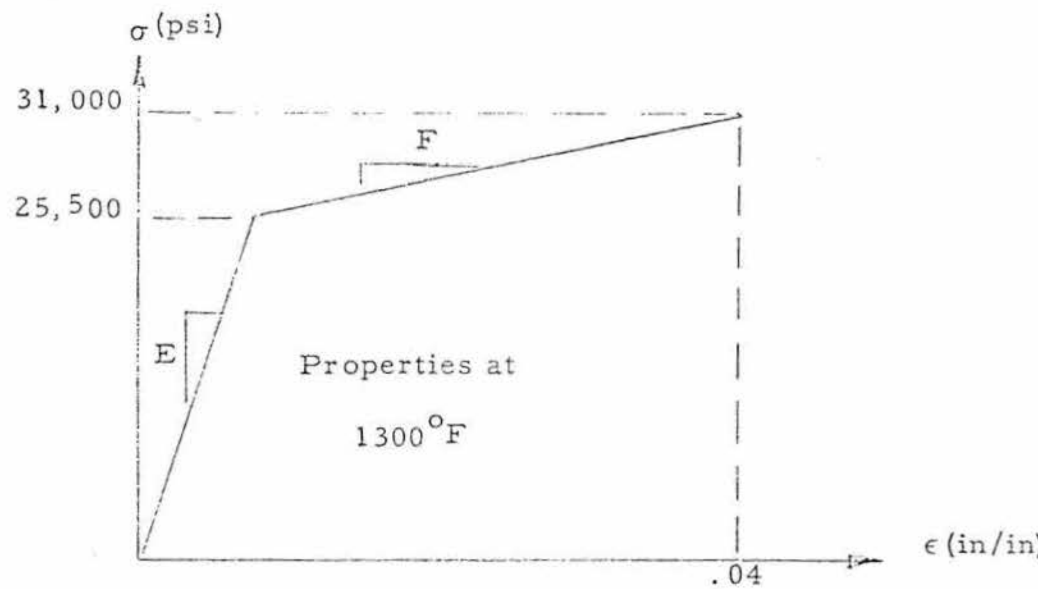


FIGURE 4
IDEALIZED KENNERTIUM W-10 STRESS-STRAIN CURVE

To examine the stress wave resulting from impact, the general differential equation is:

$$\rho \frac{\partial^2 u}{\partial t^2} = \frac{\partial \sigma}{\partial x} \qquad \text{(Eq. 1)}$$

where u is the particle displacement and σ is the stress magnitude. For an idealized stress-strain curve, figure 4, where elastic-linear strain hardening is assumed, the solution is:

$$V_{cr} = \frac{\sigma_y}{\sqrt{\rho E}} + \frac{\sigma_u - \sigma_y}{\sqrt{\rho F}} \qquad \text{(Eq. 2)}$$

where:

V_{cr} = Impact velocity associated with ultimate failure

E = elastic modulus

F = plastic modulus

σ_u = ultimate strength

σ_y = yield strength

ρ = mass density

From figure 4:

$$F = \frac{31,000 - 25,500}{.04 - \frac{25,500}{38 \times 10^6}} = 1.40 \times 10^5$$

the mass density of the tungsten W-10 is

$$\rho = (.61 \text{ lb/in}^3) \left(\frac{1}{(12)(32)} \frac{\text{Sec}^2}{\text{in}} \right) = 1.59 \times 10^{-3} \frac{\text{lb sec}^2}{\text{in}^4}$$

Substituting into equation (2)

$$V_{cr} = \frac{25,500}{\sqrt{(1.59 \times 10^{-3})(38 \times 10^6)}} + \frac{5500}{\sqrt{(1.59 \times 10^{-3})(1.40 \times 10^5)}}$$

$$V_{cr} = \underline{472 \text{ in/sec } (39.3 \text{ ft/sec})}$$

The weight of the fuel capsule and shield is 919 lbs. The energy available from a 30 foot drop in 919(30) = 27,570 foot-lbs. A portion of this energy is absorbed by the Min-K 1301 insulation. The minimum energy absorption will occur when the minimum amount of insulation is crushed, which will be the end-on case for this configuration. The crushed area is 95 sq. in. and the depth of the insulation is 4 inches.

The crushed height of the insulation is taken as 1.45 inches, which is twice the solid height associated with the basic fiber density.

$$\frac{4.00 - 1.45}{4.00} = .63 \text{ in/in strain}$$

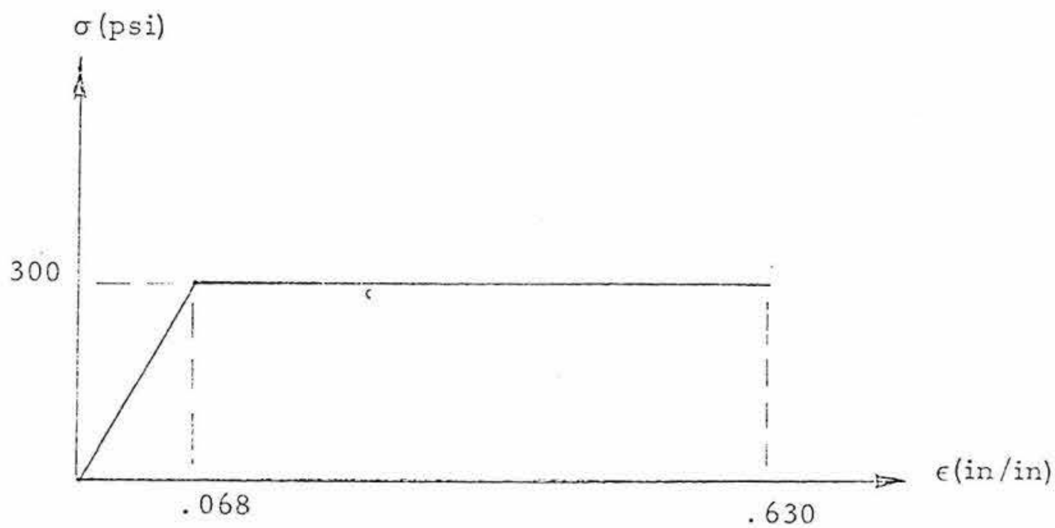


FIGURE 5
Min-K 1301 STRESS-STRAIN CURVE

Neglecting all of the energy absorption capability of generator housing, pallet, supporting framework, etc. and using a shock rise time of one millisecond (rigid steel against concrete per reference (5) -- actual shock rise time would probably be at least one magnitude higher).

$$G = \frac{72}{1} \sqrt{(30)(12)} = \underline{1367 \text{ g's}} < 1380 \text{ g's}$$

C. LID ATTACHING BOLTS

The shield geometry is such that the lid attaching bolts are only required for handling of the shield in a tilted or inverted position such as might occur in case of an accident. The following analysis shows that no dynamic loads are imposed on the bolts, and this has been further substantiated by a scale model.

It is assumed that the shield assembly impacts on the edge of the lid (Point 0) with the center of gravity of the shield body in line with the path of motion as shown in Figure 6. Although the edge of the shield plug has been cut back as shown, the point of impact may be considered to lie on the line A0. This is because the shield plug is immediately against the Min-K insulation which will allow the sharp edges to sink in making the effective point of impact on the line of action.

In the following analysis the shield plug is treated as a free body as shown in Figure 6. The analysis is based on static equilibrium, since the

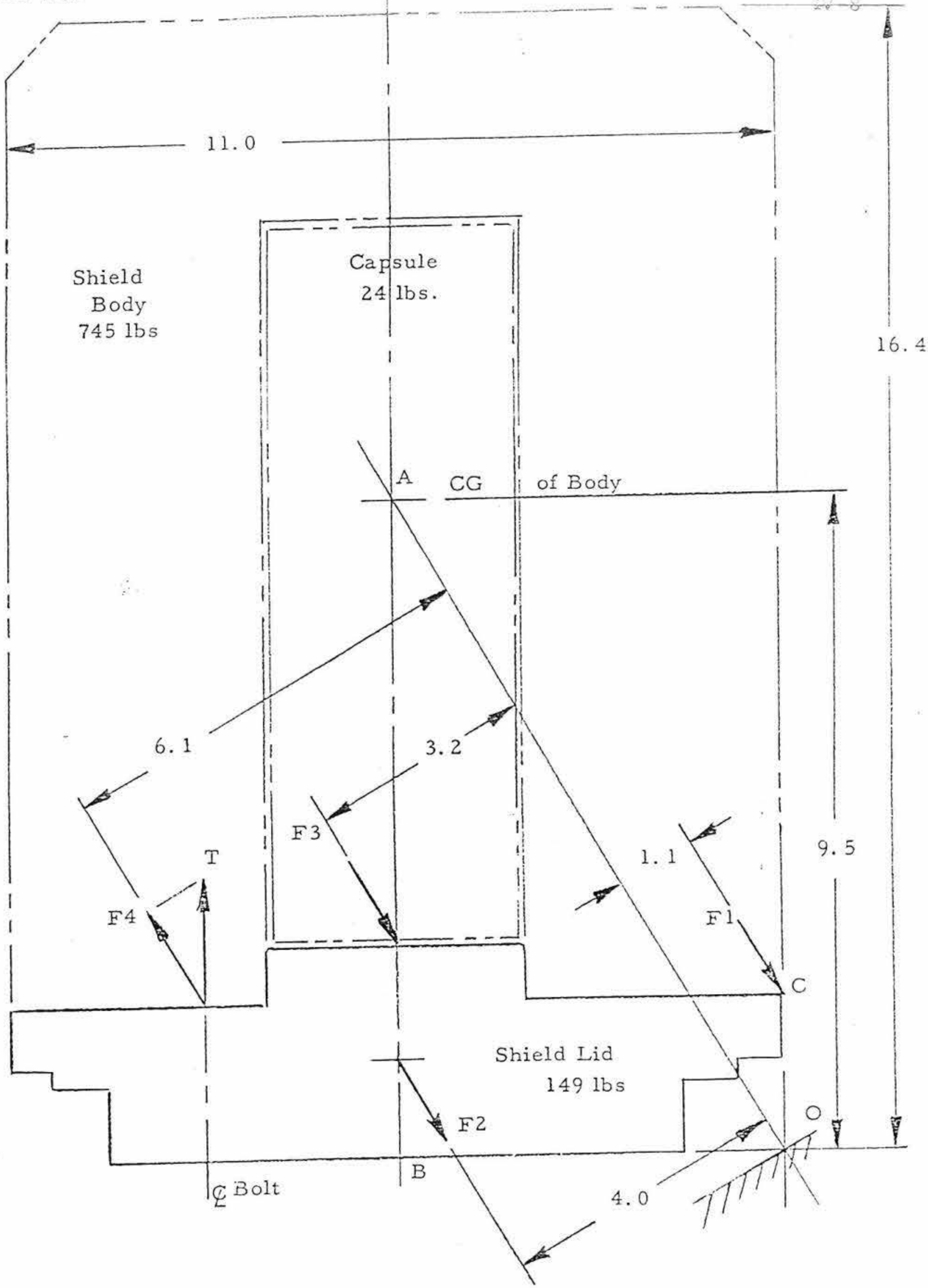


FIGURE 6
SHIELD GEOMETRY

distribution would be linear proportional for higher G loadings. In order for tension, T, to exist in the bolt there must be a separation between the body and the lid such that contact exists only at poing C.

$$OA = 10.1 \text{ inches}$$

$$F_1 = 745 \text{ lbs}$$

$$F_2 = 149 \text{ lbs}$$

$$F_3 = 24\left(\frac{9.5}{10.1}\right)^2 = 21.2 \text{ lbs}$$

Taking moments about point "0".

$$\Sigma M = (745)(1.1) - (149)(4.0) - (21.2)(3.2) + F \quad (6.1) = 0$$

$$F_4 = -25.4 \text{ lbs.}$$

The negative sign indicates that the face is in compression, and therefore there is no load in the bolt at impact.

D. IMPACT OF SHIELD ON RIGID CYLINDER

For the hypothetical case where the generator falls through 40 inches onto a 6 inch diameter rigid cylinder, the velocity at the instant of impact is:

$$V = \sqrt{\frac{(2)(32)(40)}{12}} = 14.6 \text{ ft/sec}$$

Penetration equations will not apply with a shielding material of rather brittle nature and a very low impact velocity. The stresses induced will be in the same mode as for the previous impact evaluation, that of stress

wave propagation. It is obvious that a velocity of 14.6 ft/sec is far below a critical velocity. These assumptions are extremely conservative since it is doubtful that any appreciable damage would occur to the aluminum housing and thus the shield and capsule would receive a negligible perturbation.

END CHAPTER IV

V. GENERATOR HOUSING

The generator housing and lid are made from 6061-T6 aluminum. The structural properties (6) at ambient temperature are:

$\tau_{su} = 27,000$ psi

$F_{tu} = 42,000$ psi

$F_{ty} \approx F_{cy} = 35,000$ psi

$E = 9.9 \times 10^6$ psi

$\nu = 0.3$

In addition, the housing will be subjected to sea water corrosion and hydrostatic pressure and the following allowances (7) are made:

Corrosion rate: 1.48 MPY

Yield strength: -1.0%

These reductions are applicable to the housing hydrostatic analysis only.

A. GENERATOR MOUNTING

The generator housing is provided with four fittings at 90° intervals. These fittings are bolted directly to the pallet with four 3/4 inch diameter bolts.

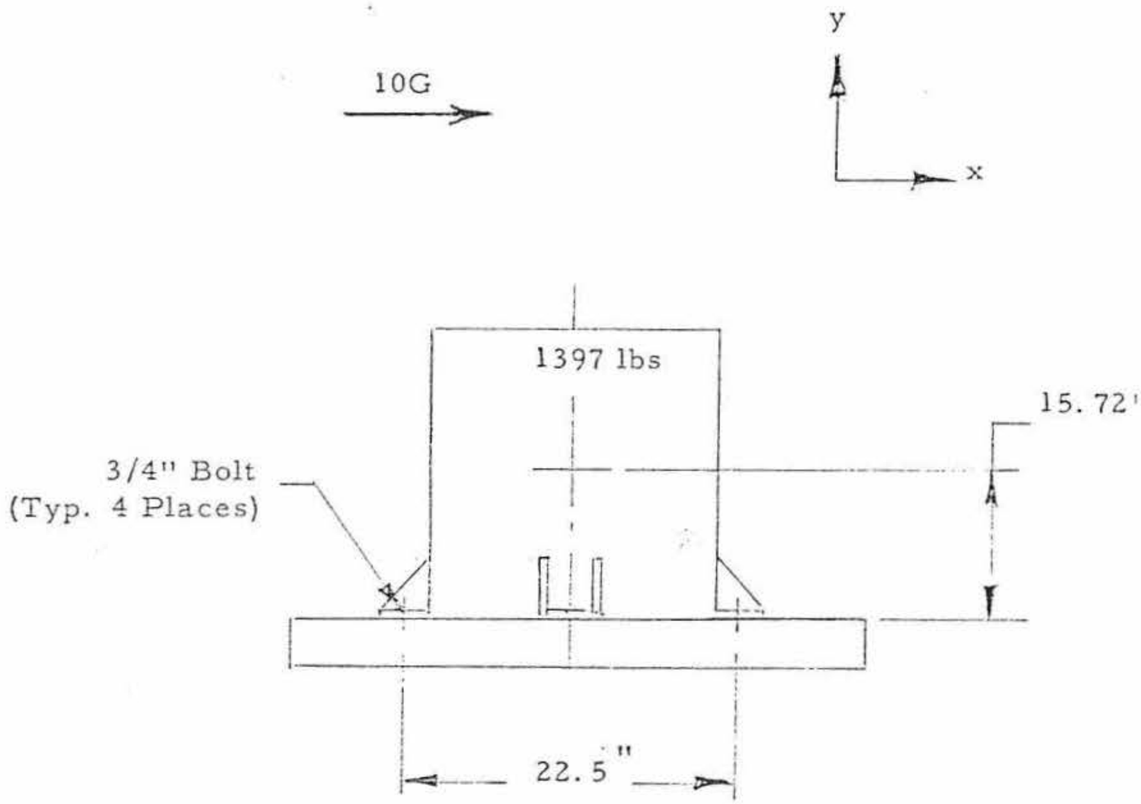


FIGURE 7

GENERATOR MOUNTING

From Figure 7, the maximum load on a single fitting for a 10G horizontal load is:

$$F_y = \frac{(1397)\ (10)\ (15.72)}{22.5} = 9,800 \text{ lbs}$$

$$F_x = \frac{(1397)\ (10)}{4} = 3,500 \text{ lbs}$$

Since all fitting welds are full penetration, the minimum area will be in the parent material. The shear stress where the fitting joins the housing is:

$$\tau = \frac{9800}{(2)\ (.50)\ (3.25) + (.72)\ (4.50)} = \underline{1510 \text{ psi}}$$

The bending moment at the housing interface is:

$$M = (9,800)\ (1.37) = 13,400 \text{ in lb.}$$

Referring to Figure 8:

	A	y	Ay	Ay^2	I_o
1.	3.25	2.34	7.60	17.80	2.86
2.	3.24	.36	1.17	.42	0.14
	6.49		8.77	18.22	3.00

$$\bar{y} = \frac{8.77}{6.49} = 1.35$$

$$c = 3.97 - 1.35 = 2.62$$

$$I = 18.22 + 3.00 - (6.49)\ (1.35)^2 = 9.39$$

$$\sigma = \frac{Mc}{I} = \frac{(13,400)\ (2.62)}{9.39} = \underline{3,740} \text{ psi}$$

The bending in the fitting end pad is determined in the following manner[8] (refer to Figure 8):

$$\frac{r_i}{a} = 0.265 \quad \frac{b}{a} = 1.47 \quad K_3 = 0.550 \quad \text{(Fig. 8, Ref. 8)}$$

$$f_b = \frac{p\ (2d - t_b)}{t_e^2\ a} K_3 = \frac{9800\ (5.00 - 1.13)}{(0.72)^2\ (3.06)}\ (.550) = \underline{13,200} \text{ psi}$$

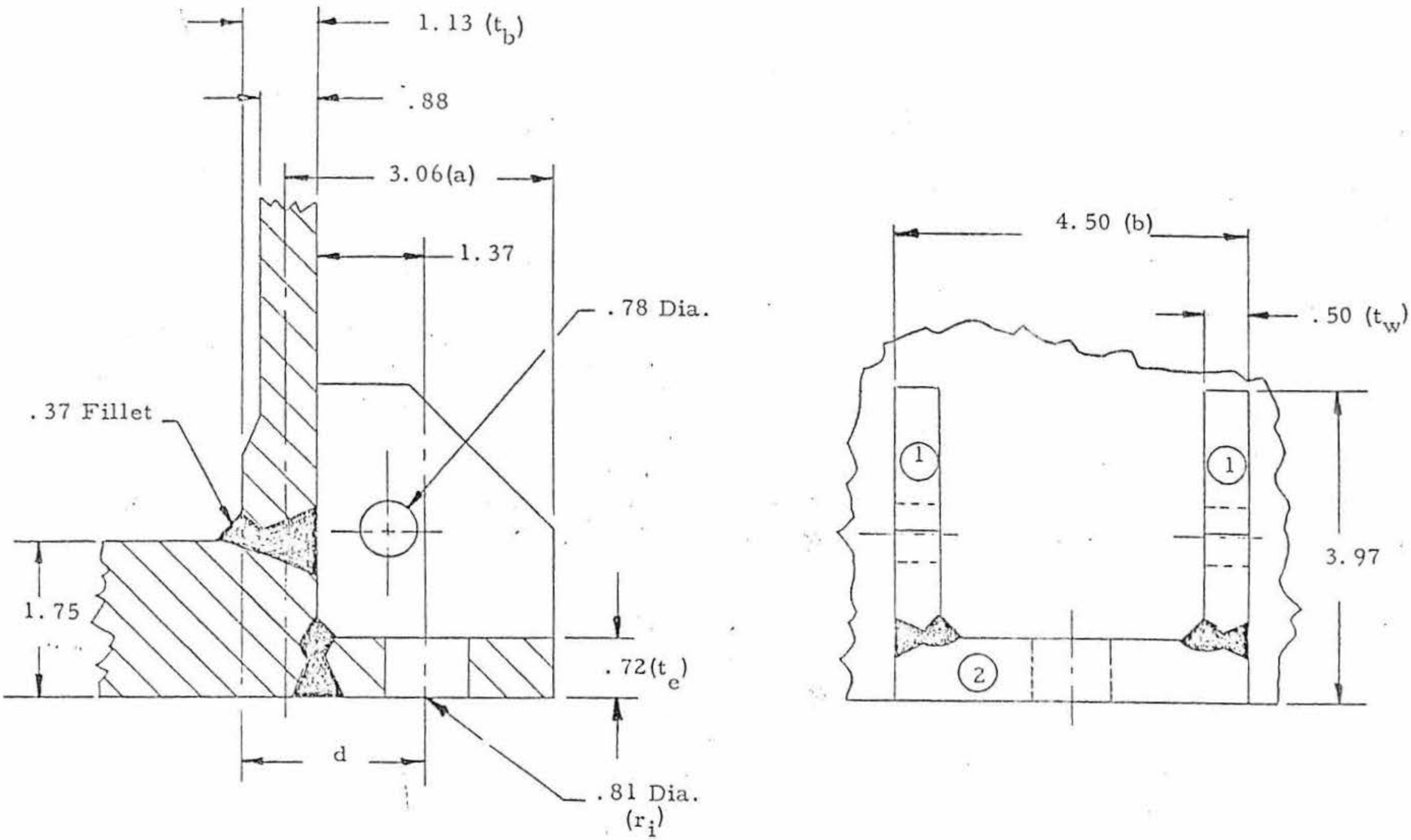


FIGURE 8
ATTACHMENT FITTING

Shear of the end pad is:

$$f_s = \frac{9800}{(9.50)\,)0.72)} = \underline{1,430}\text{ psi}$$

Plug type tear out of the bolt is:

$$\tau = \frac{9,800}{\pi\,(1.23)\,(.720)} = \underline{3,530}\text{ psi}$$

B. HYDROSTATIC PRESSURE

The generator is designed for normal operation in sea water with external pressures up to 500 psi. The housing is designed for a proof pressure of 750 psi without benefit of internal support.

The housing has an outside diameter of 19.750 inches and a 0.875 inch minimum wall thickness. The wall thickness is increased locally at the bottom (see Figure 9) to 1.135 inches. This increased thickness compensates for the stress induced by the lower closure head.

1. Circumferential Stress

The ratio of the housing diameter to the wall thickness is of sufficient magnitude to warrant thin wall shell equations.

$$\sigma_{\theta_m} = \frac{pR}{t}$$

where: $p = 750 \pm 25$ psi (proof pressure)

$R = \frac{19.375}{2} = 9.688$ in (mean radius)

$t = 0.875 - (5)\,(.00148) = 0.868$ (wall thickness)

$$\sigma_{\theta_m} = \frac{(775)\,(9.688)}{.868} = \underline{8650}\text{ psi}$$

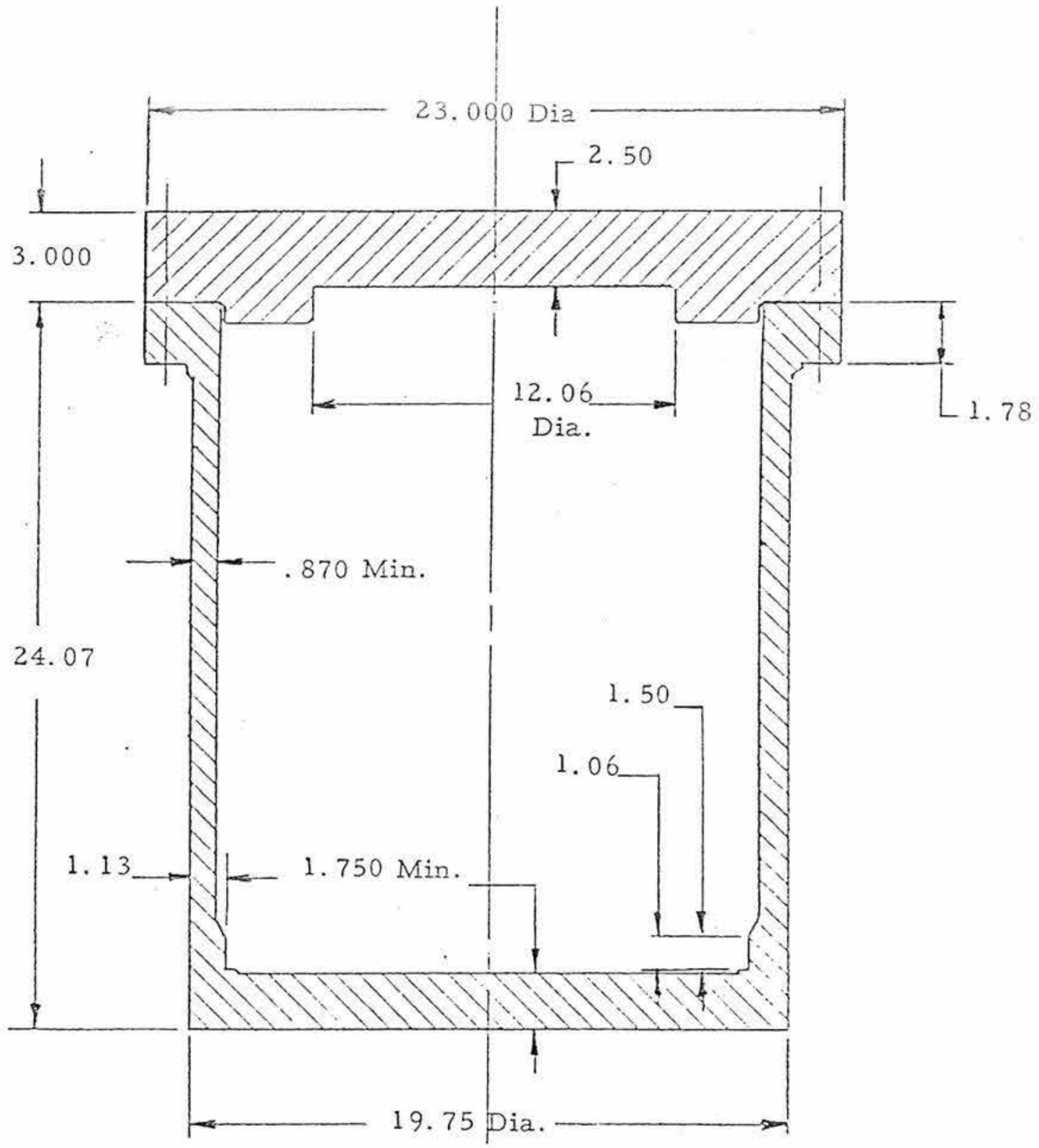


FIGURE 9
HOUSING CONFIGURATION

2. Buckling stability

$$\frac{L^2}{Rt} = \frac{(20.6)^2}{(9.688)(.868)} = 51 < 100 \quad \text{Use short equations}^{(9)}$$

$$\sigma_{cr} = \frac{K \pi^2 E_t}{12(1 - \nu^2)} \left(\frac{t}{L}\right)^2$$

where: $E_t = E = 9.9 \times 10^6$ (tangent modulus)

$L = 20.6$ (cylinder length)

$K = f(Z_L)$ (buckling coefficient)

$\nu = 0.3$ (Poisson's ratio)

$$Z_L = L^2 (1 - \nu^2)^{1/2} / Rt = 48.2$$

from Figure 35b, Ref. 9

$K \approx 9$

$$\sigma_{cr} = \frac{9(\pi)^2 (9.9 \times 10^6)(.868)^2}{12(.91)(20.6)^2} = 142,000 \text{ psi}$$

Since this value is considerably higher than the yield stress limit (35,000 psi), the implication is that the housing would yield before it would buckle.

3. Discontinuity Stresses at Lower Closure Head-Cylinder Interface. [10]

$$V_o = \frac{-pR}{4}\left[\frac{c^3\lambda^3 + 3.4\,c^3\lambda + 4.42}{2\,c^3\lambda^2 + \lambda(.7c^4 + 1.3) + .91c}\right]$$

$$M_o = \frac{pR^2}{8\lambda}\left[\frac{2c^3\lambda^3 + .7c^4\lambda^2 + 4.42}{2c^3\lambda^2 + \lambda(.7c^4 + 1.3) + .91c}\right]$$

where: $c = \frac{t_c}{t_h}$

$$\lambda = \sqrt[4]{\frac{2.73\,R^2}{t^2}}$$

The discontinuity plus membrane stress in the longitudinal direction is,

$$\sigma_Z = \frac{6\ Mo}{t_c^{\ 2}} + \frac{\sigma_{\theta m}}{2}$$

The discontinuity plus membrane stress in the circumferential direction is,

$$\sigma_\theta = \left(2\beta^2\frac{R}{t_c} + \frac{6\nu}{t_c^{\ 2}}\right) Mo + 2\beta\left(\frac{R}{t_c}\right) V_o + \frac{\sigma_{\theta m}}{t_c}$$

where:

$$\beta = \sqrt[4]{\frac{3\,(1-\nu^2)}{R^2\,t_c^{\ 2}}}$$

Examining the stresses at the interface between the side wall and the lower closure wall:

$R = 9.31$, $t_c = 1.13$, $t_h = 1.75$, $c = 0.645$, $\lambda = 3.69$

$V_o = -\ 2910$ lbs/in, $M_o = 5690$ in-lbs/in.

$\sigma_z = \underline{31,125}$ psi

The allowable bending stress is (35,000) (1.25) = 43,750 psi.

$$\beta = 0.396$$

$$\sigma_\theta = \underline{12,350} \text{ psi}$$

The preceding analysis has neglected the weld fillet which would further reduce the stress values computed. The attenuation length is $1/\beta$, approximately 2.5 inches, so at the point where the wall is decreased the stress is greatly reduced.[11] In fact, if the thinner wall were carried all the way to the base, the stress would just equal the maximum allowable stress.

4. Stress in Lower Closure Head

The lower closure head may be considered as a clamped circular plate with a 9 inch radius. The maximum stress occurs at the edge of the plate and is ,[12]

$$\sigma_r = \frac{3pa^2}{4t^2}$$

$$\sigma_r = \frac{(3)\ (775)\ (9)^2}{(4)\ (1.75)^2} = \underline{15,400} \text{ psi}$$

5. Stress in Lid

The lid boundary condition is between the limits of a simply supported edge and a clamped edge. A conservative approach is to assume a uniform circular plate 2.5 inches thick. The maximum moment occurs at the center where the radial and tangential moments are equal.

$$M_r = M_t = \left(\frac{3 + \nu}{16} \right) pa^2$$

The corresponding maximum stress is,

$$\sigma = \frac{3\,(3+\nu)\ p\,a^2}{8t^2}$$

$$= \frac{(3)\,(3.3)\,(775)\,(9)^2}{(8)\,(2.5)^2} = \underline{12,400}\ \text{psi}$$

END CHAPTER V

VI. SHIPPING PALLET

The shipping pallet used for the Sentinel 25F is the same as used with all other Sentinel 25 generators. This pallet is in accordance with Drawing No. 001-90039, (Appendix D). Since this assembly has been used with generators weighing three times as much as the generator under consideration, only the special mounting provisions are discussed here.

The generator is attached to the pallet with four AN12 bolts as shown in Figure 10. Each bolt is rated for 33,730 lbs tensile yield and 33,150 lbs single shear. In Chapter V it was determined that the maximum tensile load would be 9,800 lbs and the shear would be 3,500 lbs. Therefore, the attaching bolts have a large margin of safety.

The detail of the generator attachment is shown in Figure 11. It is obvious from the geometry and materials that the pallet is stronger than the previously analyzed generator fitting.

NOTE: (April 1985)

The protective cage, shown in Figure 10, is no longer used for shipment of the Sentinel 25F generator. The package for shipment consists of the generator mounted to the shipping pallet. Justification for deletion of the protective cage from the package is provided in Appendix C of this report.

END CHAPTER VI

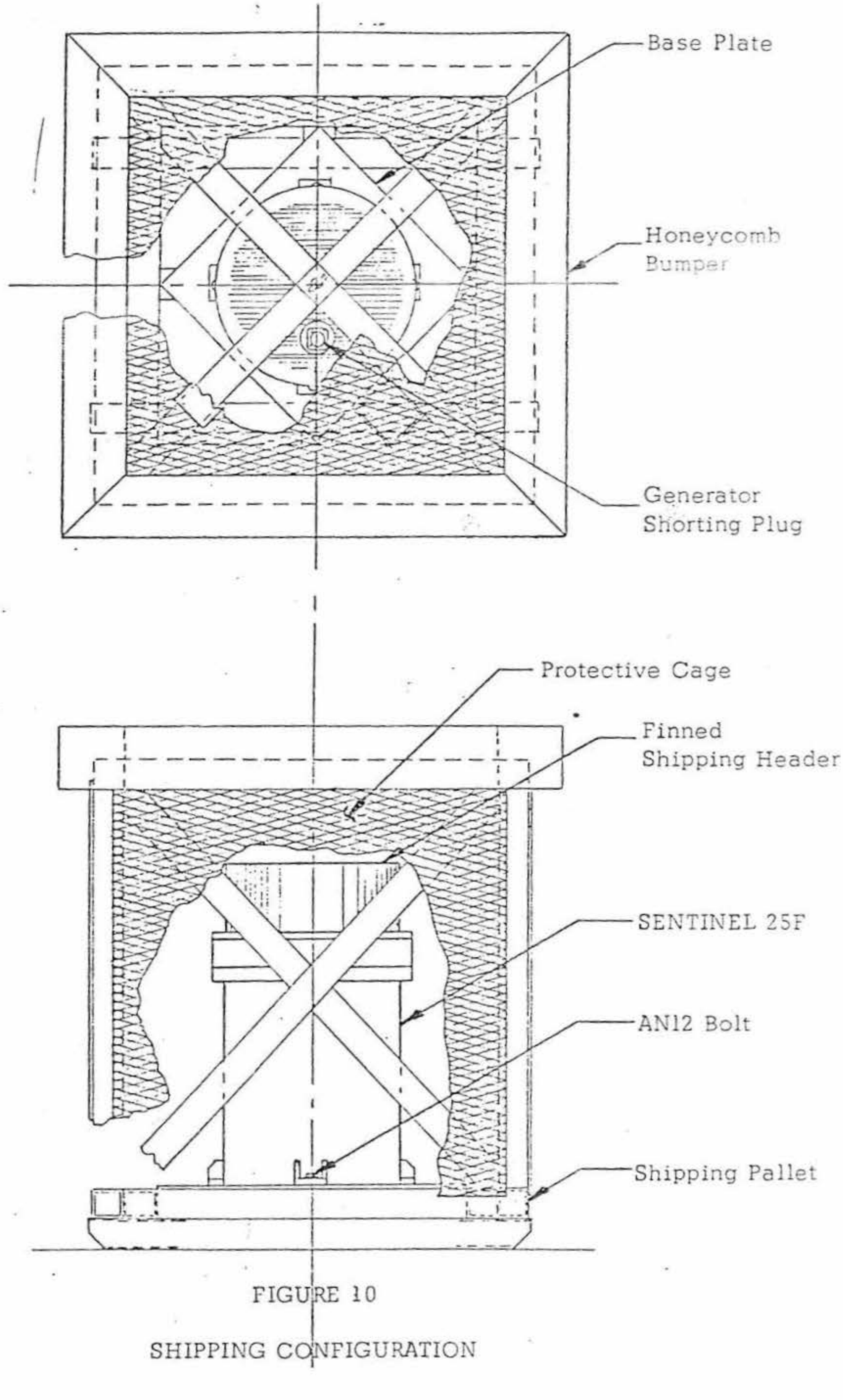


FIGURE 10

SHIPPING CONFIGURATION

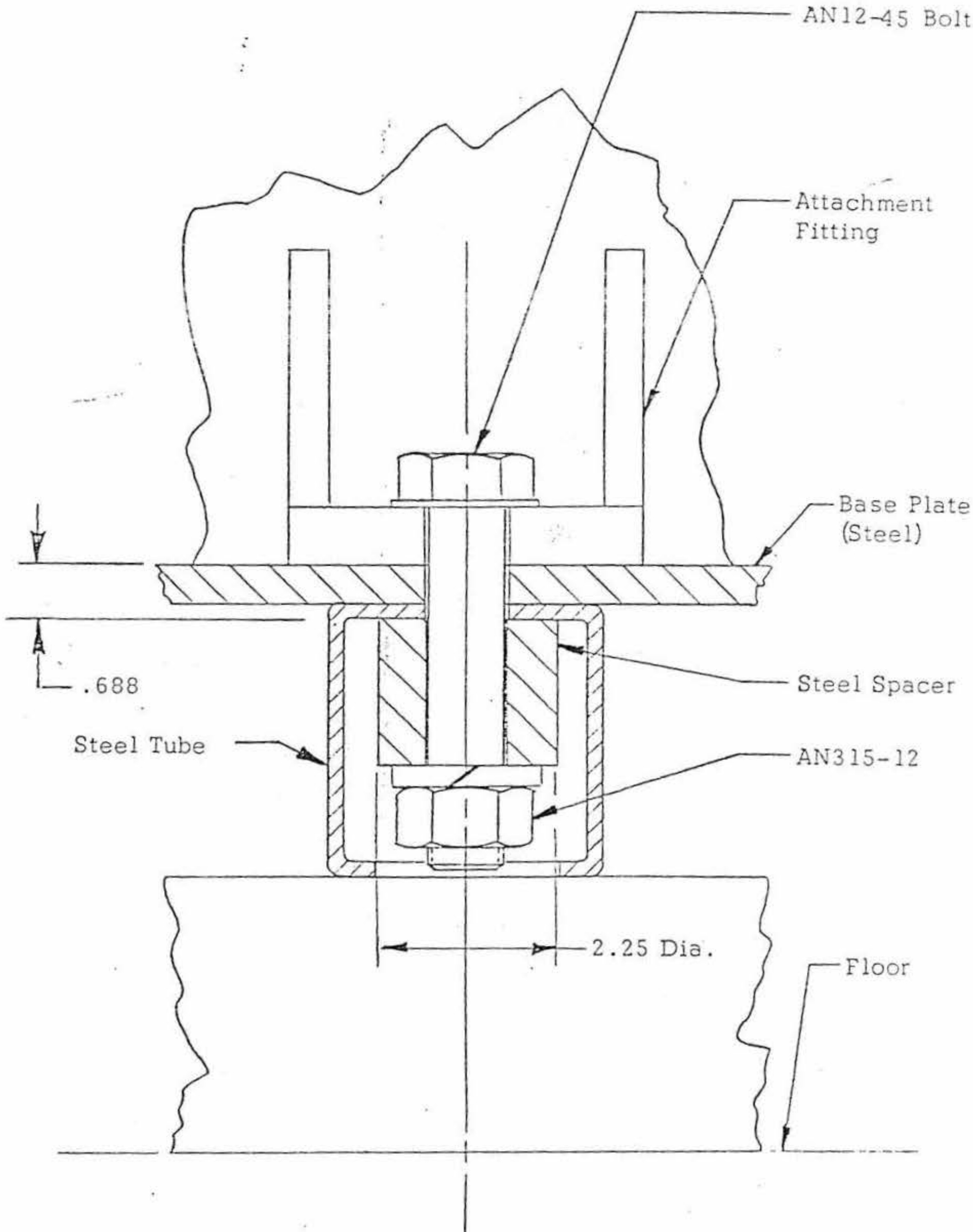


FIGURE 11

GENERATOR ATTACHMENT

VII. HYPOTHETICAL ACCIDENT FIRE ANALYSIS

A. SUMMARY OF FIRE ANALYSIS*

The SENTINEL 25F Generator is shown to be capable of experiencing a standard transportation fire without disruption of its structural integrity. Temperatures reached by the biological shield and fuel capsule are well below their respective softening points thereby assuring fuel containment. However, the aluminum housing, lid, and module heat sink melt after about 18 minutes of fire exposure.

For this analysis, digital computer codes were used to predict the SENTINEL generator thermal response to steady state and transient environmental conditions. Code runs were made to determine short-circuit steady state (equilibrium) temperatures in 130°F ambient air with solar heating, and then to find the temperatures during and up to 3 hours after a standard transportation fire (radiation from a 1475°F source for 30 minutes). Thermal inertia effects and internally generated heat cause generator internal temperatures to continue rising after the end of the fire. Considerable conservatism has been introduced by assuming the maximum possible fuel inventory (850 watts thermal) and fire impingement over the total generator surface. An additional highly conservative hand calculation was performed to determine the highest possible temperature should the fire last indefinitely.

---

* Fire analysis prepared by R. Hanna and V. Lougheed

Significant component temperatures are presented in Table 1:

TABLE 1

SENTINEL 25F TEMPERATURES
3 HOURS AFTER A TRANSPORTATION FIRE

Component	Temperature (°F)		
	Predicted		Critical
Fuel Capsule	1396*	1639**	2318
Biological Shield	1359*	1489**	6170

* Computer code predictions for housing, lid and module heat sink meltdown.

** Supplementary hand calculations assuming everything but biological shield, fuel capsule and fuel are destroyed.

Substantial margin is indicated in Table 1, thus assuring satisfactory containment.

B. DESCRIPTION OF ANALYSIS

1. Thermal Model

A projection of the half-plane containing the central axis of the cylindrical generator divided into 86 nodes is shown in Figure 12. Nodal volumes are obtained by calculating the volume occupied by a 360° ring whose cross-section equals the nodal area in Figure 12. The components of the generator are constructed of homogenous isotropic materials. In order to limit the nodes required to a reasonable number, the module is approximated by lumping the elements into two groups:

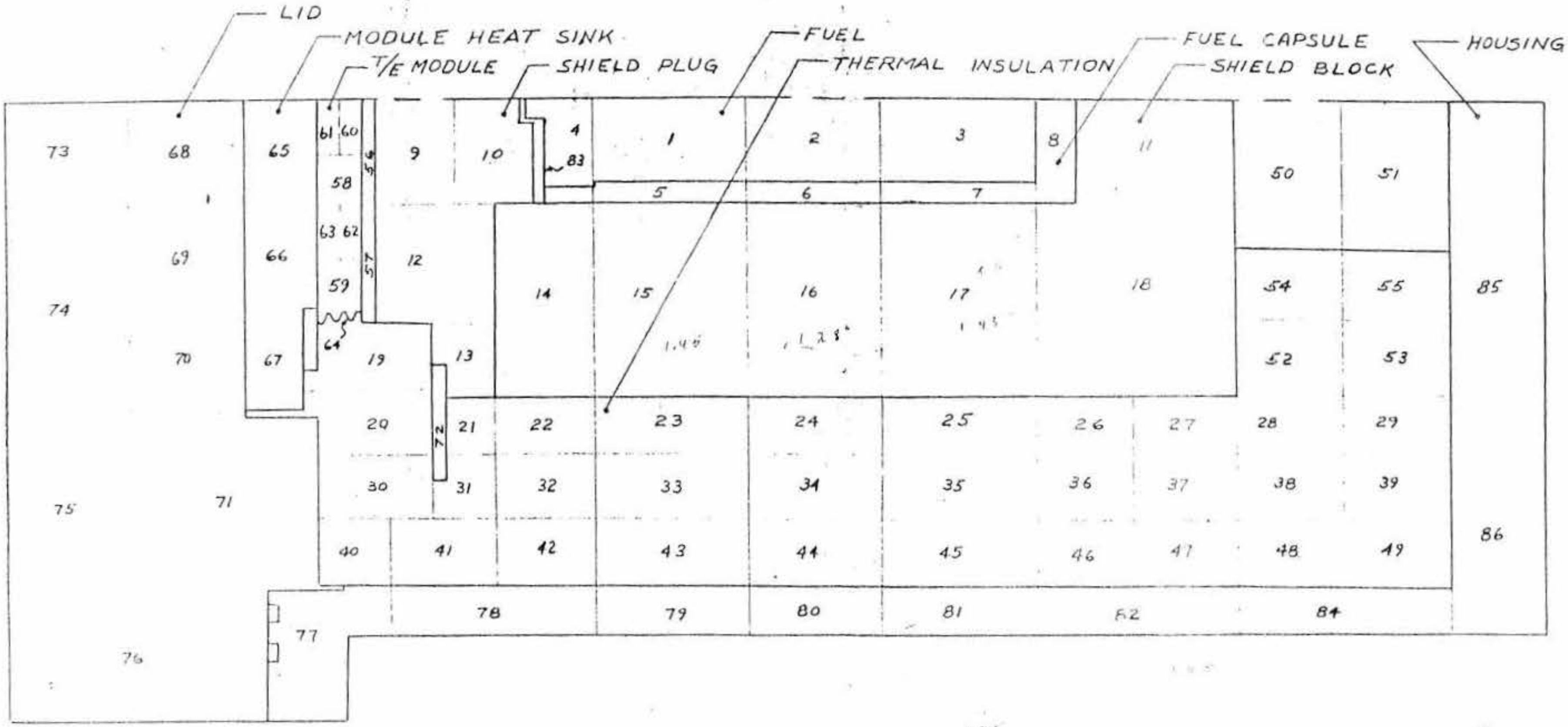


FIGURE 12
Sentinel 25F Thermal Node Map

INSD-3051

an inner ring and an outer ring of elements. Three nodes were provided for each group; one node of each group represents the inter-element Min-K insulation, while the other two represent the hot and cold element junctions, respectively.

Heat transfer from the fuel to the biological shield and from the lower lip of the lid to the housing is assumed to be by radiation and conduction through argon gas. Other surfaces of the lid touching the housing, the lid and module hold-down, together with the biological shield top plug and body, are assumed to exchange heat across a thermal interface resistance. The resistance is represented by additional thickness of material, and is predicted from either thermal joint resistance test data or SENTINEL generator operating experience. No thermal resistance is assumed for the interfaces between the insulation and housing or biological shield.

The analysis model enables representation of fins attached to the head as in the normal configuration, and also enables removal of the fins for studying accident configurations. The finned head was assumed removed immediately prior to the fire.

The generator thermal inventory used herein was 850 watts for additional conservatism, and the thermoelectric module was considered to have additional element area so as to maintain tolerable hot junction operating temperatures.

2. Computer Codes

The computer code used for transient response analysis was a central finite difference heat transfer program from the Isotopes Computer Library. Written in Fortran IV, it accounts for heat transfer by conduction, convection, and radiation. Both positive and negative internal heat generation are possible. Material properties can be put in as variables with respect to temperature. Anisotropic thermal conductivity can be accepted for a limited number of materials.

Nodal properties, such as volume, density, conductive distances, areas, etc., are required inputs. Thermal properties, such as conductivity, specific heat, emissivity, etc., must also be put in. Boundary conditions, such as a constant convective heat transfer coefficient, external air temperature, external radiative heat source temperature, etc., can be loaded into the code, as required.

A steady state heat transfer code was used to predict the pre-fire generator equilibrium temperatures. This code establishes independent linear equations thermally describing the system and solves them by matrix inversion. Heat conduction, convection, and radiation are considered by the code, as well as internal heat generation. Material properties must be input as constants. Nodal property and boundary condition inputs are similar to those in the transient code except that boundary conditions are constant.

3. Supplementary Analysis

In addition to the computer code analysis, a hand calculation was performed to conservatively estimate the maximum capsule and biological shield temperatures in the event that the Min-K housing insulation and the complete module assembly disintegrated upon housing meltdown, or that the fire should last indefinitely. The surface temperature of the biological shield was found assuming the total fuel inventory dissipated by radiation to the 1475 $^{\circ}$F fire environment. The corresponding temperature was determined for the fuel capsule. This extremely conservative approach further demonstrates that containment is not violated by a transportation fire. The calculations are presented in the Appendix.

4. Boundary Conditions

The steady state code was used initially to obtain equilibrium temperatures of the generator with fins in 130 $^{\circ}$F ambient air with solar heating. For this case, a constant convective heat transfer coefficient was applied to the heat rejection surfaces. The heat flux equivalent to solar heating was added to external surface nodes.

For the transient code run simulating the fire, the convective heat transfer coefficient was assumed zero. Radiation to all surfaces of the generator was assumed from a source at 1475 $^{\circ}$F. No convective cooling was allowed, and no energy was dissipated from the module in order to simulate an open circuit condition. When the first aluminum node melted

(housing side at 18.55 minutes after fire start), the code model was modified by removing the housing, lid and module heat sink nodes. The outside of the module and insulation now directly faced the radiative heat input. At the end of thirty (30) minutes total fire exposure the radiative heat input was decreased to zero and natural convection restored. The ambient air was again assumed to be 130 $^{\circ}$F, and solar heating was applied. Open circuit module characteristics were used.

C. RESULTS AND CONCLUSIONS

The temperature histories at important locations within the SENTINEL 25F generator are shown in Figure 13. These nodes do not necessarily reach the highest temperatures, but were chosen as typical of each component. The initial points of the curves (temperatures at time zero) in Figure 13 represent the equilibrium temperatures with the generator short circuited (normal shipping practice) in a 130 $^{\circ}$F ambient air environment with solar heating. The first half hour of time shows the effect of exposure to the standard transportation fire. During this time, all temperatures rise because of the exterior radiation heat input and the internal isotope decay heat. About halfway through the fire, the aluminum housing, lid, and module heat sink melt away. At the end of the first half hour, the fire ceases but the generator internal temperatures continue to rise at a decreasing rate.

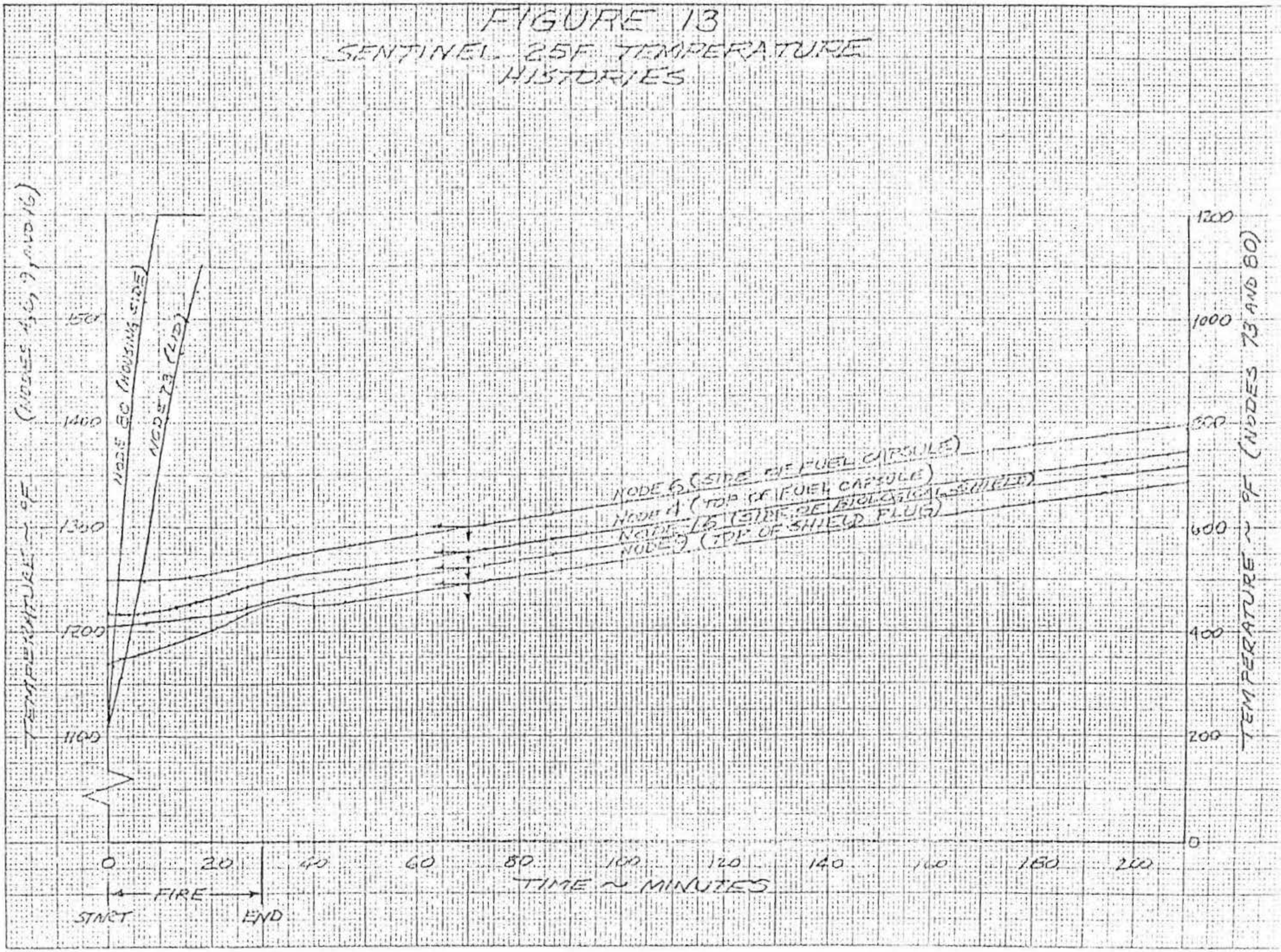


FIGURE 13
SENTINEL 25F TEMPERATURE HISTORIES

The thermoelectric element temperatures, as calculated from the predicted module temperatures, will not completely melt out. Consequently, the conductive heat path from the biological shield to the outside ambient air remains intact. Temperatures predicted for three hours after the end of the fire are compared to critical temperatures in Table 1. In every case, a substantial margin exists between the predicted value and the critical temperature, thus assuring fuel containment.

Additional data are presented in Appendix A for comparison to these results. The temperature of each of the 86 nodes is given for:

1. Normal full load operation at thermal equilibrium with finned head in 70°F ambient air.
2. Short circuit operation at thermal equilibrium (with finned head) in 130°F ambient air, with solar heating.
3. Same as Case 2 above (except without finned head) immediately after a standard transportation fire.
4. Same as Case 2 above (except three hours after the end of a standard transportation fire and without finned head).

It is apparent that the initial point assumed for the fire accident, Case 2, exhibits higher temperatures than the normal shipping condition or the normal operating condition.

The supplementary analyses presented in Appendix A show that loss of both the module and the Min-K coincident with the melting of the aluminum housing does not compromise containment integrity.

D. THERMAL ANALYSIS FOR UNITS FUELED WITH STRONTIUM FLUORIDE (January 25, 1978)

The highest temperatures within a Sentinel 25F heat source containing the strontium fluoride fuel form were determined for both normal and hypothetical fire transportation accident conditions.

For a given design and thermal inventory of fuel, the substitution of the strontium fluoride for the strontium titanate fuel form, and the substitution of a Hastelloy C-276 liner for a stainless steel liner do not affect temperatures of the capsule surface or any components external to the capsule. For the Sentinel 25F design, the liner/fuel interface and the fuel certerline temperatures are given in Table 2.

TABLE 2

SENTINEL 25F FUEL TEMPERATURES

Location	Temperature, °C Strontium Titanate	Strontium Fluoride
	Steady State Operation	
Liner/Fuel Interface	756	756
Fuel Centerline	949	1024
	End of Transportation Fire	
Liner/Fuel Interface	849	849
Fuel Centerline	1067	1150

The highest temperature for the strontium fluoride is 1150°C at the fuel centerline after the transportation fire accident. This is well below the fuel melt temperature of 1450°C. In steady state operation, the strontium fluoride temperatures are 1024°C at the centerline and 756°C at the liner/fuel interface.

The preceding results show that the Sentinel 25F will employ the fluoride fuel form at acceptable temperatures. Specifically, the fuel will be kept below its melting point even for accidental conditions and the fuel-liner interface temperature is near or below the conditions of the compatibility tests (800 to 1000°C).

END CHAPTER VII

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END REFERENCES

APPENDIX A

Tabulation of nodal temperatures for specific generator conditions:

Case 1: Normal generator operation (with finned head) in 70°F ambient air.

Case 2: Short circuit generator operation (with finned head) in 130°F ambient air and with solar heating.

Case 3: Open circuit generator operation (without finned head) after a one-half hour transportation fire.

Case 4: Three hours after the end of the fire in 130°F ambient air and with solar heating (open circuit).

	Temperatures (°F)			
Node	Case 1	Case 2	Case 3	Case 4
1	1812	1817	1866	2031
2	1910	1916	1975	2155
3	1793	1799	1848	2016
4	1213	1218	1247	1370
5	1229	1235	1260	1387
6	1243	1249	1266	1396
7	1239	1245	1259	1392
8	1220	1226	1237	1371
9	1164	1169	1224	1340
10	1170	1176	1224	1343

Node	Temperatures (°F) Case 1	Case 2	Case 3	Case 4
11	1208	1214	1225	1359
12	1170	1175	1224	1342
13	1176	1182	1223	1344
14	1181	1187	1223	1347
15	1192	1197	1225	1353
16	1200	1206	1226	1358
17	1205	1211	1225	1359
18	1205	1211	1223	1357
19	816	849	1270	483
20	660	705	1330	333
21	1081	1095	1126	1241
22	1031	1049	1066	1177
23	1026	1045	1060	1168
24	1029	1049	1062	1170
25	973	998	1040	1167
26	993	1017	1029	1138
27	763	806	814	909
28	497	563	607	632
29	236	326	1386	304
30	418	482	2099	453

Node	Temperatures (°F) Case 1	Case 2	Case 3	Case 4
31	727	768	937	848
32	641	690	800	755
33	619	670	780	730
34	614	668	777	728
35	586	643	754	722
36	567	627	734	700
37	466	535	690	598
38	323	405	651	472
39	184	278	1289	300
40	188	269	1015	229
41	262	340	1306	302
42	276	354	1303	306
43	272	351	1303	305
44	269	351	1303	305
45	260	344	1303	304
46	250	337	1300	300
47	223	311	1300	296
48	180	273	1250	292
49	138	236	959	205
50	906	938	958	917

Node	Temperatures (^oF) Case 1	Case 2	Case 3	Case 4
51	370	449	1523	350
52	716	764	810	822
53	307	391	1540	351
54	872	907	1067	970
55	355	435	1512	418
56	1092	1097	1233	1318
57	1119	1124	1229	1326
58	620	666	1122	470
59	631	676	1064	472
60	1029	1038	1240	1297
61	187	274	1273	970
62	1054	1063	1233	1307
63	183	269	1241	938
64	511	566	1185	1321
65	148	235		
66	142	228		
67	132	217		
68	139	226		
69	136	221		
70	131	217		

	Temperatures (°F)			
Node	Case 1	Case 2	Case 3	Case 4
71	125	211		
72	1171	1177	1216	1325
73	135	211		
74	131	216		
75	124	210		
76	124	210		
77	124	210		
78	123	212		
79	122	213		
80	121	215		
81	120	215		
82	119	216		
83	1210	1216	1245	1368
84	118	217		
85	118	218		
86	118	218		

Calculation of biological shield equilibrium surface temperature in a standard transportation fire:

$$q = \sigma A \epsilon \quad (T_2^{\,4} - T_1^{\,4})$$

where: q = Heat dissipated, $\frac{BTU}{HR}$

σ = Boltzmann's constant, $0.174 \times 10^{-8} \ \frac{BTU}{HrFt^2 \ {}^{o}R^4}$

A = Net surface area, Ft^2

ϵ = Effective emissivity, dimensionless

T_1 = Fire temperature, ^{o}R

T_2 = Biological shield surface temperature, ^{o}R

$$2898.5 = (0.174 \times 10^{-8})(5.25)(0.734)(T_2^{\,4} - 14.02 \times 10^{12})$$

$$T_2^{\,4} = 14.45 \times 10^{12}$$

$$T_2 = 1949^{o}R$$

$$= 1489^{o}F$$

The computer runs indicate that the temperature difference in equilibrium between the biological shield and the fuel capsule is less than 150^{o}F. Therefore, the peak capsule temperature is less than 1639^{o}F, and containment integrity is assured.

END APPENDIX A

APPENDIX B

Supplemental Capsule Data - Sea Water Corrosion of Hastelloy C; Quality Control Procedures Used in Fabrication of Fuel Capsules; Hydrostatic Pressure Testing on a Sentinel 25 Capsule

(April 1985)

Isotopes, Inc. application dated September 15, 1969 (a reference to the current Certificate No. 4888, Rev. No. 5) was submitted in response to specific inquires from the Licensing Agency (then, U.S. Atomic Energy Commission: Irradiated Fuels Branch). Included with this submittal were the following.

a. Excerpts from report MND-SR-1676.

b. Sample quality control log with data pertaining to fuel capsule detail, assembly drawings, inspection sheets and fueling specification.

c. Report INSD-3015 on hydrostatic pressure testing of the Sentinel 25 capsule.

Item (a) was submitted in response to a request for additional data on sea-water corrosion of "as welded" Hastelloy C. The excerpts consist of the report cover page and pages 31, 42, 43, 44, 46, 48 and 56 from report MND-SR-1676, "Strontium 90 Power Project, Final Summary Report," March 1960, The Martin Co., Nuclear Division. These pages are included as part of this appendix.

Item (b) was also submitted in response to a request for information which would provide more insight into the quality control procedures used in the fabrication of the fuel capsules. The cover letter for the September 15, 1969 application included a summary description of the quality control procedure which is reproduced verbatim:

Fuel Capsule Quality Control
(15 September 1969)

"A sample quality control log is also enclosed. This log contains copies of the fuel capsule detail and assembly drawings, the inspection sheets that apply to each drawing, and the fueling specification. The finished components are inspected according to the requirements of the drawing plus any additional requirements noted on the log sheet. Note the specific items which must be checked. The log is prepared this way to avoid possible oversights. All components are checked by Isotopes Quality Control department regardless of whether the parts are made in-house or by an outside source. The finished components are forwarded to the approved fueling facility (Oak Ridge National Laboratories for all SENTINEL capsules produced so far). The fueling facility re-inspects the capsule components, and fuels the capsules in accordance with the fueling specification, NSD-10161. As the various steps are performed, they are initialed by the fueling facility to indicate compliance. This specification sheet is then returned to Isotopes along with a copy of the fueling facility quality control sheet which shows fuel form, fuel quantity, fuel analysis, decontamination, thermal inventory, and weld penetration. This data becomes part of the permanent documentation. When the fuel capsule is installed in a generator, the fuel capsule log will become part of the generator log."

Item (c) was submitted as being information of general interest. The report, "Hydrostatic Pressure Test, SENTINEL 25 Fuel Capsule," INSD-3015, December 24, 1968, Isotopes, Nuclear Systems Division described external hydrostatic pressure tests performed on a SENTINEL 25 fuel capsule. The fuel capsule was like that shown on Figure 2 of this report and was constructed of Hastelloy C. A lava plug was inserted

into the test capsule to simulate fuel pellets. The capsule was then seal welded according to procedures for fueled units. Testing consisted of a series of pressure cycles to 12,500, 15,000 and 17,500 psi respectively. After each pressure excursion, physical measurements and a dye penetrant check were performed. Dye penetrant checks showed no evidence of cracks in the capsule. Dimensional checks showed little or no evidence of permanent material deformation. A conclusion drawn from the results of the testing was that the unit would not rupture when exposed to pressures in excess of 15,000 psi (the design pressure). This report also presented a very conservative plastic stress analysis which predicts a failure pressure of 16,900 psi.

The information presented in this appendix is considered applicable to all SENTINEL (LGC) units.

END APPENDIX B

BURNT MOUNTIAN RTGs – AREA SURVEY Log

READING TAKEN AT: BM	Action Limit: (mR/hr)	Site: BM01 5 July 13		Site: BM02 8 July 13		Site: BM03 8 July 13		Site: BM04 8 July 13		Site: BM05 5 July 13	
RTG Serial Numbers:	-	017	008	020	009	001	014	010	018	019	004
30' from gate (BACKGROUND) (mR/hr)	0.05	.024		.027		.024		.018		.023	
Outside entrance gate (mR/hr)	0.5	.031		.016		.045		.045		.031	
Outside building door mR/hr)	1.0	.126		.119		.161		.137		.100	
Outside inner cage (work area) (mR/hr)	2.0	.373		.303		.700		.343		.437	
1 meter from generator end (mR/hr)	10	.704	1.1	.878	1.26	1.50	4.1	1.70	1.59	.779	1.97
1 meter from junction of generators (mR/hr)	20	2.36		3.34		5.54		3.33		2.81	
On contact with side (mR/hr)	50	20.6	19.9	17.3	18.7	39.5	24.5	17.1	17.0	18.3	19.3
Highest Unrestricted Area (mR/hr)	*1.0	.147		.147		.274		.153		.170	
Readings Corrected:	N or Y	N	N	N	N	N	N	N	N	N	N
RTG Surface Temp in degrees F		87.5	86.2	94.5	94.1	91.9	109.6	89.3	91.8	76.0	81.0
Ambient Air Temp in degrees F		65.5		74.1		66.0		71.2		56.1	

BKG has been subtracted

Meter type:	ADM 300
Meter serial number & cal due date:	S/N: 12072820 20140516
DATE:	5-8 July 2013
NAME:	SSgt Jonathan Bahr / SrA Paul Smith
REASON FOR VISIT:	Summer Mx and Leak Test

*Public will not be exposed to greater than 2 mrem in one hour. It's not anticipated someone would continuously occupy any area for more than 5 days (24 hours a day), therefore the public will not be exposed to greater than 100 mrem in a year.

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC

71-0587

18 April 2002

MEMORANDUM FOR HQ US NUCLEAR REGULATORY COMMISSION
ATTN: DIRECTOR

FROM: AFMOA/SGZR
110 Luke Avenue, Room 405
Bolling AFB, DC 20332-7050

SUBJECT: Termination Request for Transportation Quality Assurance Program for Radioactive Packages No. 0587

On behalf of the Air Force Radioisotope Committee, I respectfully request the termination of the Transportation Quality Assurance Program (QAP) for Radioactive Packages No 0587 maintained under the USAF Master Radioactive Material License (MML).

We have determined that a Transportation QAP under the USAF MML is not needed. Generally, the only movement of Type B quantities are end-of-useful-life-type movements and the materials are *transferred* on-site to a contractor who has an NRC-approved QAP before any transportation actions are taken.

As stated in Air Force Instruction 40-201, "", individual USAF MML permittees may apply for a Transportation QAP if a need is identified. The Air Force Technical Application Center (AFTAC), for example, maintains a broadscope Transportation QAP (No. 0772) primarily for the transportation of Radioisotopic Thermoelectric Generators (RTG's).

If you have any questions, please contact me at (202) 767-4308, telefax (202) 404-8089, or E-mail: kali.mather@pentagon.af.mil.

Kali K Mather
KALI K. MATHER, Lt Col, USAF, BSC
Chief, Radiation Protection Division and
USAF Radioisotope Committee Secretariat
Air Force Medical Operations Agency
Office of the Surgeon General

cc:
USNRC, Region IV, Mr. Tony Gaines

NMSS01
Public

71-0587

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC

19 February 2002

MEMORANDUM FOR HQ US NUCLEAR REGULATORY COMMISSION
ATTN: DIRECTOR

FROM: AFMOA/SGZR
110 Luke Avenue, Room 405
Bolling AFB, DC 20332-7050

SUBJECT: Extension Request for Transportation Quality Assurance Program for Radioactive Packages No. 0587

Per my conversation with Thomas Matula today, I respectfully request an additional 30 day extension in order to clarify the Air Force's position on maintaining a Transportation Quality Assurance Program under the USAF Master Radioactive Material License (MML).

During my discussion with Mr Matula, it was determined that a Transportation QAP under the USAF MML is not needed if Type B quantities are always *transferred* on-site to a contractor who has an NRC-approved QAP before any transportation actions are taken. A QAP under the USAF MML will only need to be maintained if the Air Force determines the existence of or desires coverage for potential transportation activity requirements as defined by 10 CFR 71.

Individual USAF MML permittees may apply for a Transportation QAP if a need is identified. An example of this is the Air Force Technical Application Center (AFTAC) which maintains a broadscope Transportation QAP (No. 0772) primarily for the transportation of Radioisotopic Thermoelectric Generators (RTG's).

Thank you for your consideration. If you have any questions, please contact me at (202) 767-4308, telefax (202) 404-8089, or E-mail: kali.mather@pentagon.af.mil.

Kali K Mather
KALI K MATHER, Lt Col, USAF, BSC
Chief, Radiation Protection Division and
USAF Radioisotope Committee Secretariat
Air Force Medical Operations Agency
Office of the Surgeon General

cc:
USNRC, Region IV, Mr. Tony Gaines

NMSS01 Public

QUALITY ASSURANCE PROGRAM (QAP) FOR TRANSPORTATION OF RADIOISOTOPE THERMOELECTRIC GENERATORS (RTGs)

AIR FORCE TECHNICAL APPLICATIONS CENTER
PATRICK AFB, FLORIDA

1 April 1998

Atch 2

QAP FOR TRANSPORTATION
OF RTGs

1. Introduction

a. Under the provisions of United States Air Force Radioactive Material (USAF RAM) Permit No. 09-30272-lAFP issued pursuant to the Air Force's Nuclear Regulatory Commission (NRC) Master Materials License No. 42-23539-lAFP, the Air Force Technical Applications Center (AFTAC) is authorized to acquire, receive, store, use, or transfer Radioisotope Thermoelectric Generators (RTGs).

b. The purpose of this document is to outline the procedures which will be followed to comply with Subpart H of Title 10, Code of Federal Regulations, Part 71 (10 CFR 71) for transportation of type B quantities of radioactive material and to insure compliance with NRC General License requirements of 10 CFR 71.12 through 71.14.

c. NRC Regulatory Guide 7.10, Establishing QAPs for Packaging used in the Transport of Radioactive Material, Annex 2, was used as a guide in developing this plan.

d. Opening the RTGs to replace thermoelectric modules or perform other repairs is not covered under this program.

e. Packages currently used under NRC approved QAP are listed in Attachment 1. Sources are special form radioactive material.

f. Activities performed relative to transportation of RTGs include:

(1) Handling;

(2) Shipping;

(3) Storage.

2. Quality Assurance Organization. The final responsibility for the QAP rests with the AFTAC Radiation Safety Committee (RSC). The QAP is implemented using the organization outlined in Attachment 2.

3. Quality Assurance Program.

a. The RSC will implement the QAP through the organization described in paragraph 2. QAP revisions will not be made without committee approval. Implementation of the QAP will insure that all transportation activities involving the RTGs are performed in accordance with (IAW) applicable NRC, Department of Transportation (DOT), and Department of the Air Force

Regulations, USAF RAM Permit No. 09-30272-1AFP and the specific provisions of the appropriate Certificates or Compliance (COC) and USAF NRC Master Materials License. The QAP emphasizes control of the administrative and operational matters which are critical to safety. Controls have been established to insure that transportation activities involving the RTGs are conducted IAW the regulations, permits, licenses and approvals mentioned above.

b. Prior to engaging in any activity important to safety, all personnel will have had indoctrination or training in that activity.

4. <u>Design Control.</u> This organization is not involved in the manufacturing or fabrication of packages. RTGs are designed, and manufactured/fabricated by the manufacturer under an NRC approved QAP. RTGs shall be maintained in their original design configuration as specified in the manufacturer's drawings and documents. AFTAC shall hold the COCs and maintain all existing drawings, manufacturer documents, and procedures approved in the COC. AFTAC responsibilities are limited to responsibility for completeness, accuracy and maintenance of Safety Analysis Reports, drawings, design records, calculations and operating instructions for transportation packaging with Certificate of Compliance numbers 4888 and 5862.

5. <u>Procurement Document Control.</u> This organization is not involved in the manufacturing of packages or packaging. Procurement documents shall reflect that RTGs are authorized by a COC, USAF RAM Permit, and have been manufactured under an NRC approved QAP. This is limited to hardware items for package maintenance.

6. <u>Instructions, Procedures and Drawings.</u>

a. Preparation of package for use prior to and after shipment:

(1) Packages are visually inspected for damage;

(2) Required sealed source leak tests and radiation surveys are performed;

(3) Eye bolts are removed or inserted;

(4) Package security on pallet and pallet security on vehicle is verified.

b. Repairs, Rework and Maintenance. Packages are supplied by the manufacturer. Maintenance of the RTGs will be limited to hardware items (nuts, bolts, slings, eye bolts and pallets) and corrosion control measures to the exterior of the package only. Opening the RTGs is not authorized.

c. Loading and Unloading Contents. This organization does not load/unload radioactive material into or out of RTGs.

d. Transportation of Package. See paragraph 14.

7. **Document Control.** All documents related to the RTG package (e.g., COCs, Shipping and Receiving Procedures, etc.) will be controlled and maintained by the Radiation Safety Officer (RSO). All revisions and changes will be processed through the RSO. He/she will ensure that the latest versions of the documents are on file.

8. **Control of Purchased Material, Equipment and Services.** Design and fabrication of RTGs are not conducted under this QAP. Procurement of replacement parts important to safety will be reviewed to ensure appropriate technical and QA requirements are included in purchase orders. Replacement parts shall be purchased from the original vendor or an equivalent qualified supplier. Replacement parts from suppliers not previously identified as qualified sources will meet requirements equal to the original criteria.

9. **Identification and Control of Materials, Parts and Components.** Repairs or rework of RTGs will not be conducted under this QAP.

10. **Control of Special Processes.** RTGs should require no major repairs necessitating the use of special processes. USAF RAM permit No. 09-30272-lAFP does not authorize repair of RTGs.

11. **Inspection Control.** The RSO shall use a checklist to insure inspections are performed to verify that packages have been marked and labeled, and shipping papers are completed IAW the latest requirements.

12. **Test Control.**

a. RTGs are not fabricated under this QAP. Packages will be visually examined to insure that they conform to the COC package description and that they are in sound condition. Any other tests prescribed by the manufacturer's operation and maintenance manuals will be completed.

b. Following any maintenance to the package and prior to offering the RTG to a carrier for transport, radiation surveys will be completed to verify shielding integrity.

13. **Control of Measuring and Test Equipment.** USAF RAM Permit No. 09-30272-lAFP requires that all radiation survey equipment be in calibration during use.

a. Calibration of instruments is performed by either:

(1) An Air Force Precision Measurement Equipment Laboratory (PMEL) under NRC or agreement state license.

(2) Manufacturer according to procedures approved by the NRC.

b. All instruments are calibrated at intervals not exceeding twelve months. A calibration label is affixed to all instruments indicating the date calibrated, due date and calibrator's

certification stamp. Air Force reference standards are certified as traceable to the National Institute of Standards and Technology (NIST).

14. **Handling, Storage and Shipping Control.** Safety procedures concerning the handling, storage and shipping of RTGs will be followed. These procedures are performed IAW applicable NRC, DOT and US Air Force regulations, and the manufacturer's operation and maintenance manual. Work instructions will be provided for handling, storage and shipping operations. Shipments will not be made unless all tests, certifications, acceptances and final inspections have been completed. The manufacturer's operation and maintenance manual will be used as a guide to insure that the requirements of 10 CFR 71.85 and 71.87 are met and that packages are in good condition, adequately secured on the transport vehicle, marked and labeled IAW DOT regulations and identified by model and package identification numbers.

15. **Inspection, Test and Operating Status.** Inspection, test and operating status of the RTGs will be IAW manufacturer's recommendations and conditions specified in USAF RAM Permit No. 09-30272-1AFP.

16. **Non-Conforming Materials, Parts or Components.** RTGs are used as provided by the manufacturer. Any non-conforming materials, parts or components important to QA will be identified and returned to the vendor or set aside for discard.

17. **Corrective Action.** The RSO or his designated representative will conduct annual evaluation visits to RTG use or storage locations authorized IAW USAF RAM Permit No. 09-30272-1AFP. The written results of these visits will be provided to applicable headquarters, parent and subordinate units. The report will note any deviations or discrepancies, office of primary responsibility (OPR) for corrective action and abatement date, if applicable. Written response from the OPR is required to provide details of abatement. In addition, the RSO will report significant findings of staff visits to the AFTAC Radiation Safety Committee.

18. **Quality Assurance Records.** Records of package approvals (including references and drawings, relating to the use of the packaging) tests, audits, personnel training and qualifications, RTG shipments, and compliance inspections will be maintained by the RSO, or his alternate. Descriptions of RTGs, manufacturer's operation and maintenance manuals, and procedures pertinent to RTG activities will also be maintained. Records will be maintained and kept in such a manner as to be identifiable and readily retrievable. Record types and retention items will be kept IAW 10 CFR Part 71.91(a) and (c).

19. **Audits.** Individuals performing the audits will have no responsibility in the activity being conducted. Audits will be conducted using prepared checklists. Results of the audits will be maintained. Audit reports will be evaluated and deficient areas corrected.

MANUFACTURER MODEL NUMBERS
AND
CERTIFICATE OF COMPLIANCE

MANUFACTURER AND MODEL NO.	CERTIFICATE OF COMPLIANCE NO.
Teledyne Energy Systems Radioisotope Thermoelectric Generator Sentinel Model-25 Series	4888
Teledyne Energy Systems Radioisotope Thermoelectric Generator Sentinel Model-100 Series	5862

Attachment 1

Air Force Technical Applications Center (AFTAC)

Radiation Safety Committee

The Committee is convened quarterly by the Commander, Technical Operations Division (TOD), and reviews the Radiation Safety Program to include:

a. Adequacy of operation procedures, facilities and equipment.

b. Procedures for control and inventory of radioactive material.

c. Procedures for proper receipt and transfer of radioactive material.

d. Maintaining records of training of qualified users.

Records of significant actions of the committee are maintained and copies sent to the AF Radioisotope Committee (RIC).

At a minimum, the Radiation Safety Committee is comprised of the following members:

Commander, TOD (Chairperson)

Chairman, Environmental Protection Committee, TOD

Director, Occupational Safety and Health, AFTAC (Command RSO)

Chief, Radiation, Industrial and Environmental Safety, TOD (Alternate Command RSO)

McClellan AFB Radiation Safety Officer, 77 AMDS/SGPB

Director of Laboratories, TOD

Director of Laboratory Support, TOD

Director of Logistics and Engineering, TOD

Chiefs of Applied Chemistry, Gas, and Applied Physics Laboratories, TOD

Chief, Current Operations Division, AFTAC

Attachment 2

QUALITY ASSURANCE PROGRAM (QAP) FOR
TRANSPORTATION OF
RADIOISOTOPE THERMOELECTRIC GENERATORS
(RTGs)

AIR FORCE TECHNICAL APPLICATIONS CENTER
PATRICK AFB, FLORIDA

20 Oct 95

QAP FOR TRANSPORTATION
OF RTGs

1. Introduction

a. Under the provisions of United States Air Force Radioactive Material (USAF RAM) Permit No. 09-30272-0IAFP issued pursuant to the Air Force's Nuclear Regulatory Commission (NRC) Master Materials License No. 42-23539-0IAFP, the Air Force Technical Applications Center (AFTAC) is authorized to acquire, receive, store, use, or transfer Radioisotope Thermoelectric Generators (RTGs).

b. The purpose of this document is to outline the procedures which will be followed to comply with Subpart H of Title 10, Code of Federal Regulations, Part 71 (10 CFR 71) for transportation of type B quantities of radioactive material and to insure compliance with NRC General License requirements of 10 CFR 71.12 through 71.14.

c. NRC Regulatory Guide 7.10, Establishing QAPs for Packaging used in the Transport of Radioactive Material, Annex 2, was used as a guide in developing this plan.

d. Opening the RTGs to replace thermoelectric modules or perform other repairs is not covered under this program.

e. Packages currently used under NRC approved QAP are listed in Attachment 1. Sources are special form radioactive material.

f. Activities performed relative to transportation of RTGs include:

(1) Handling;

(2) Shipping;

(3) Storage.

2. Quality Assurance Organization. The final responsibility for the QAP rests with the AFTAC Radiation Safety Committee (RSC). The QAP is implemented using the organization outlined in Attachment 2.

3. Quality Assurance Program.

a. The RSC will implement the QAP through the organization described in paragraph 2. QAP revisions will not be made without committee approval. Implementation of the QAP will insure that all transportation activities involving the RTGs are performed in accordance with (IAW) applicable NRC, Department of Transportation (DOT), and Department of the Air Force Regulations, USAF RAM Permit No. 09-30272-0IAFP

and the specific provisions of the appropriate Certificates or Compliance (COC) and USAF NRC Master Materials License.

The QAP emphasizes control of the administrative and operational matters which are critical to safety. Controls have been established to insure that transportation activities involving the RTGs are conducted IAW the regulations, permits, licenses and approvals mentioned above.

b. Prior to engaging in any activity important to safety, all personnel will have had indoctrination or training in that activity.

4. Design Control. This organization is not involved in the manufacturing or fabrication of packages. RTGs are designed, and manufactured/fabricated by the manufacturer under an NRC approved QAP. RTGs shall be maintained in their original design configuration as specified in the manufacturer's drawings and documents. AFTAC shall hold the COCs and maintain all existing drawings, manufacturer documents, and procedures approved in the COC. AFTAC responsibilities are limited to responsibility for completeness, accuracy and maintenance of Safety Analysis Reports, drawings, design records, calculations and operating instructions for transportation packaging with Certificate of Compliance numbers 4888 and 5862.

5. Procurement Document Control. This organization is not involved in the manufacturing of packages or packaging. Procurement documents shall reflect that RTGs are authorized by a COC, USAF RAM Permit, and have been manufactured under an NRC approved QAP. This is limited to hardware items for package maintenance.

6. Instructions, Procedures and Drawings.

a. Preparation of package for use prior to and after shipment:

(1) Packages are visually inspected for damage;

(2) Required sealed source leak tests and radiation surveys are performed;

(3) Eye bolts are removed or inserted;

(4) Package security on pallet and pallet security on vehicle is verified.

b. Repairs, Rework and Maintenance. Packages are supplied by the manufacturer. Maintenance of the RTGs will be limited to hardware items (nuts, bolts, slings, eye bolts and pallets) and corrosion control measures to the exterior of the package only. Opening the RTGs is not authorized.

c. Loading and Unloading Contents. This organization does not load/unload radioactive material into or out of RTGs.

d. Transportation of Package. See paragraph 14.

7. Document Control. All documents related to the RTG package (e.g., COCs, Shipping and Receiving Procedures, etc.) will be controlled and maintained by the Radiation Safety Officer (RSO). All revisions and

changes will be processed through the RSO. He/she will insure that the latest versions of the documents are on file.

8. Control of Purchased Material, Equipment and Services. Design and fabrication of RTGs are not conducted under this QAP. Procurement of replacement parts important to safety will be reviewed to ensure appropriate technical and QA requirements are included in purchase orders. Replacement parts shall be purchased from the original vendor or an equivalent qualified supplier. Replacement parts from suppliers not previously identified as qualified sources will meet requirements equal to the original criteria.

9. Identification and Control of Materials, Parts and Components. Repairs or rework of RTGs will not be conducted under this QAP.

10. Control of Special Processes. RTGs should require no major repairs necessitating the use of special processes. USAF RAM permit No. 09-30272-0IAFP does not authorize repair of RTGs.

11. Inspection Control. The RSO shall use a checklist to insure inspections are performed to verify that packages have been marked and labeled, and shipping papers are completed IAW the latest requirements. See Attachment 3.

12. Test Control.

a. RTGs are not fabricated under this QAP. Packages will be visually examined to insure that they conform to the COC package description and that they are in sound condition. Any other tests prescribed by the manufacturer's operation and maintenance manuals will be completed.

b. Following any maintenance to the package and prior to offering the RTG to a carrier for transport, radiation surveys will be completed to verify shielding integrity.

13. Control of Measuring and Test Equipment. USAF RAM Permit No. 09-30272-0IAFP requires that all radiation survey equipment be in calibration during use.

a. Calibration of instruments is performed by either:

(1) An Air Force Precision Measurement Equipment Laboratory (PMEL) under NRC or agreement state license.

(2) Manufacturer according to procedures approved by the NRC.

b. All instruments are calibrated at intervals not exceeding twelve months. A calibration label is affixed to all instruments indicating the date calibrated, due date and calibrator's certification stamp. Air Force reference standards are certified as traceable to the National Institute of Standards and Technology (NIST).

14. Handling, Storage and Shipping Control. Safety procedures concerning the handling, storage and shipping of RTGs will be followed. These procedures are performed IAW applicable NRC, DOT and US Air Force

regulations, and the manufacturer's operation and maintenance manual. Work instructions will be provided for handling, storage and shipping operations. Shipments will not be made unless all tests, certifications, acceptances and final inspections have been completed. The manufacturer's operation and maintenance manual will be used as a guide to insure that the requirements of 10 CFR 71.85 and 71.87 are met and that packages are in good condition, adequately secured on the transport vehicle, marked and labeled IAW DOT regulations and identified by model and package identification numbers.

15. Inspection, Test and Operating Status. Inspection, test and operating status of the RTGs will be IAW manufacturer's recommendations and conditions specified in USAF RAM Permit No. 0930272-0IAFP.

16. Non-Conforming Materials, Parts or Components. RTGs are used as provided by the manufacturer. Any non-conforming materials, parts or components important to QA will be identified and returned to the vendor or set aside for discard.

17. Corrective Action. The RSO or his designated representative will conduct annual evaluation visits to RTG use or storage locations authorized IAW USAF RAM Permit No. 09-30272-0IAFP. The written results of these visits will be provided to applicable headquarters, parent and subordinate units. The report will note any deviations or discrepancies, office of primary responsibility (OPR) for corrective action and abatement date, if applicable. Written response from the OPR is required to provide details of abatement. In addition, the RSO will report significant findings of staff visits to the AFTAC Radiation Safety Committee.

18. Quality Assurance Records. Records of package approvals (including references and drawings, relating to the use of the packaging) tests, audits, personnel training and qualifications, RTG shipments, and compliance inspections will be maintained by the RSO, or his alternate. Descriptions of RTGs, manufacturer's operation and maintenance manuals, and procedures pertinent to RTG activities will also be maintained. Records will be maintained and kept in such a manner as to be identifiable and readily retrievable. Record types and retention items will be kept IAW 10 CFR Part 71.91(a) and (c).

19. Audits. Individuals performing the audits will have no responsibility in the activity being conducted. Audits will be conducted using prepared checklists. See Attachment 4. Results of the audits will be maintained. Audit reports will be evaluated and deficient areas corrected.

Attachment 1

MANUFACTURER MODEL NUMBERS
AND
CERTIFICATE OF COMPLIANCE

MANUFACTURER AND MODEL NO.	CERTIFICATE OF COMPLIANCE NUMBER
Teledyne Energy Systems Radioisotope Thermoelectric Generator Sentinel Model-25 Series	4888
Teledyne Energy Systems Radioisotope Thermoelectric Generator Sentinel Model-100 Series	5862

QUALITY ASSURANCE PROGRAM FOR TRANSPORTATION OF RADIOISOTOPE THERMOELECTRIC GENERATORS (RTGs)

AIR FORCE TECHNICAL APPLICATIONS CENTER
PATRICK AFB, FLORIDA

QUALITY ASSURANCE PROGRAM FOR TRANSPORTATION OF RTGs

1. **Introduction**

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c. NRC Regulatory Guide 7.10, Establishing Quality Assurance Programs (QAPs) for Packaging used in the Transport of Radioactive Material, Annex 2, was used as a guide in developing this plan.

d. Opening the RTGs to replace thermoelectric modules or perform other repairs is not covered under this program.

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(2) Shipping;

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a. The RSC will implement the QAP through the organization described in paragraph 2. QAP revisions will not be made without committee approval. Implementation of the QAP will insure that all transportation activities involving the RTGs are performed in accordance with (IAW) applicable NRC, Department of Transportation (DOT), and Department of the Air Force Regulations, USAF RAM Permit No. 09-30272-01AFP and the specific provisions of the appropriate Certificates or Compliance (COC) and USAF NRC Master Materials License.

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d. Transportation of Package. See paragraph 14.

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71.85 and 71.87 are met and that packages are in good condition, adequately secured on the transport vehicle, marked and labeled IAW DOT regulations and identified by model and package identification numbers.

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19. **Audits**. Individuals performing the audits will have no responsibility in the activity being conducted. Audits will be conducted using prepared checklists. See Attachment 4. Results of the audits will be maintained. Audit reports will be evaluated and deficient areas corrected.

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AFTAC Radiation Safety Committee

Membership

Chairman:
Commander, Technical Operations Division (TOD/CC)
Colonel Arthur T. Hopkins

Members:
Director, McClellan Central Laboratory (TOD/DL)
Mr. David W. Baker (GS-14)

Director, Logistics and Engineering (TOD/LE)
Lt Col Steve M. Maher

Chief, Current Operations Division (HQ AFTAC/DOO)
Lt Colonel Joseph P. Ward

Chief, Applied Chemistry Laboratory (TOD/DLC)
Lt Colonel Kenneth T. DenBleyker

Chief, Gas Analysis Laboratory (TOD/DLG)
Captain Michael Howard

Chief, Applied Physics Laboratory (TOD/DLP)
Lt Colonel James Dorman

Alternate AFTAC Radiation Safety Officer (TOD/SE)
Mr. George W. McAlister (GS-13)

Director, Laboratory Support (TOD/LS)
Lt Colonel Donald A. Huxtable

77 AMDS/SGPB (McClellan AFB Radiation Safety Officer)
Lt James Ross

AFTAC Radiation Safety Officer (HQ AFTAC/SE)
Major Mark Tiedemann

RADIOACTIVE MATERIAL SHIPMENT CHECKLIST

SHIPMENT SUMMARY

SHIPPED FROM:
- Name______
- Address______
- City______ State______ Zip______

SHIPMENT NO.______
DATE______
I.R. NO.______
LICENSE AUTHORIZATION:
Shipper's AFR Permit No.______

SHIPPED TO: TO ARRIVE NLT: ______
- Name______
- Address______
- City______ State______ Zip______

Recipient's License:
- ______ On File
- ______ Within Expiration Date
- ______ Authorizes R.A.M. Being Shipped

Shipping to License No.______

DESCRIPTION OF RADIOACTIVE MATERIAL: ______
(CHECK SOURCES, SPECIAL FORM, Etc.)

SHIPMENT TOTALS:
Total Number of Containers this Shipment______ LID #s this Shipment______

Radionuclides	Curies	Physical Form	Chemical Form	Normal Form A2 Limit	Special Form A1 Limit	Excepted Package Limits

Total ______

PROJECT OFFICER: ______ Date: ______ DIV CHIEF: ______
DIVISION/DIRECTORATE RPT ______ Date: ______ COORDINATION: DIRECTOR: ______

______NON-FISSILE MATERIAL
______FISSILE MATERIAL ______ FISSILE EXEMPT

___Class I Total Grams______ ____Special Form, A_1 Limit (Ci)______ Physical Form______
___Class II
___Class III Total Curies______ ____Normal Form, A_2 Limit (Ci)______ Chemical Form______

Sum of Fractions Rule Met ______Yes Hazard Class 7

PROPER SHIPPING NAME; UN NO.; & R.A.M. QUANTITY TYPE:
- ____Radioactive Material, Excepted Package-Articles, Manufactured from natural or depleted U or natural Th, UN 2910
- ____Radioactive Material, Excepted Package-Empty Packaging, UN 2910
- ____Radioactive Material, Excepted Package-Instruments or Articles, UN 2910
- ____Radioactive Material, Excepted Package-Limited Quantity of Material, UN 2910
- ____Radioactive Material, Fissile, n.o.s., UN 2918
- ____Radioactive Material, Low Specific Activity, LSA, n.o.s., UN 2912
- ____Radioactive Material, n.o.s., UN 2982
- ____Radioactive Material, Special Form, n.o.s., UN 2974.
- ____Other______

AM Quantity Type:
- ____Ltd Qty
- ____Type A
- ____Type B
- ____Other:

SHIPPING CONTAINER DATA: Container No.______ DOT Specification No.______; marked on outer container:______

R.A.M. LABEL APPLIED:
- ______Radioactive White I
- ______Radioactive Yellow II
- ______Radioactive Yellow III
- ______Empty
- ______No label required

OTHER MARKINGS APPLIED:
- ______Consignee's or consignor's name & address
- ______Proper shipping name/UN no. in block letters

OTHER LABELS APPLIED:
- ______Cargo Aircraft Only
- ______Package Orientation Marking

- ____Container Gross Weight______lbs.
- ____Other:______

INNER PACKAGE:
- ______Marked "Radioactive"

- ___Strong, tight package
- ___Package certification on file.
- ___Package meets standard package requirements of 49CFR173.24
- ___Package meets general package requirements of 49CFR173.411
- ___Each Type A package meets the design requirements of 49CFR173.412
- ___Tamper seal number(s) applied to container:______
- ___Transport index for this container:______

GENERAL CERTIFICATIONS & INFORMATION:
- ____Shipment meets quality control requirements 49CFR173.474 and 173.475.
- ____Shipment secured in order to prevent shifting during normal transportation requirements.
- ____Vehicle placarded ____No placarding required.
- ____Driver(s) briefed on nature of shipment, general route, emergency response procedure, shipping papers, shipping paper accessibility requirements (49CFR177.817(e)), maintenance on exclusive use on shipment, and placarding requirements (provide spares, if required).

Attachment 3

____Consignee notified of departure time and ETA.
____DD Form 1800 completed.
____Separation distance requirement of 49CFR177.842(b) met.
____D0 Form 836 completed and driver(s) briefed.
____Shipment within limits prescribed for ____passenger ____cargo-only aircraft.
____Shipment contains radioactive material intended for use in, or incident to, research, medical diagnosis or treatment.
____Shippers Declaration of Dangerous Goods completed
____Package containing RAM must be at least 3 feet from passengers.

SHIPPING PAPERS:
Shipping Papers Contain:

____Proper Shipping Name
____Hazard Class
____UN Number
____Total Quantity of Material
____Name of each Radionuclide
____Physical and chemical form
____Activity in each package
____Category of label applied
____Transport Index
____Fissile Exempt
____Exclusive use of vehicle
____24 hour emergency response number
____49CFR172.204 Shipper's Certification
____49CFR173.421-1 statement

Following provided with shipping papers:
______Instructions for maintaining exclusive use of vehicle.
______Emergency response plan.
______Receipt letter.

MODE OF SHIPMENT:

____Common carrier truck
____Passenger aircraft
____Federal vehicle
____U.S. Mail
____Contract carrier truck - Exclusive Use
____Cargo-only aircraft (attach special label)
____Private vehicle
____Other:____________________

DOCUMENT NUMBER:____________________ Shipment Date: ____________________
SHIPPING REPRESENTATIVE:____________________ Date: ____________________

RADIATION SURVEY DATA:
FOR RADIOACTIVE MATERIAL BEING SHIPPED (before being placed in the shipping container):
____Total millirem/hr @ contact ____________________
____Total millirem/hr @ 1 foot ____________________
____Total gamma millirem/hr @ 1 foot ____________________

____PRE-PACKAGING container contamination survey completed
... Alpha____________ dpm/100cm2 <220
... Beta/Gamma____________ dpm/100cm2 <2200

FOR FULLY LOADED AND CLOSED CONTAINER NO. ____________________:
____Maximum total millirem/hr @ external surface. . ____________________
____Maximum total millirem/hr @ 1 meter. . . . . . . ____________________
____Removable surface contamination: ... Alpha____________ dpm/100cm2 <220
... Beta/Gamma____________ dpm/100cm2 <2200

____PRE-LOADING transport vehicle contamination survey completed
... Alpha____________ dpm/100cm2 <220
... Beta/Gamma____________ dpm/100cm2 <2200

____POST-LOADING transport vehicle contamination survey completed
... Alpha____________ dpm/100cm2 <220
... Beta/Gamma____________ dpm/100cm2 <2200

POST-LOADING transport vehicle radiation survey:
___Maximum total millirem/hr @ any point on the vertical planes projected from the outer edges of the vehicle. . ________<200.
___Maximum total millirem/hr on the upper surface of the load. . . . . ____________<200.
___Maximum total millirem/hr on the lower external surface of the vehicle. ____________<200.
___Maximum total millirem/hr @ any point 2 meters from the vertical planes projected by the outer edges of the vehicle. . . . . ____________<10.
___Maximum total millirem/hr if any normally occupied space. . . . . ____________<2.

RSO/RPT/DRIVER:____________________ Date: ____________________

A' PURPOSE CHECKLIST

TITLE/SUBJECT/ACTIVITY/FUNCTIONAL AREA: RADIATION SAFETY PROGRAM

OPR: DOL

DATE: FEB 9?

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO
	All references are from CENR 161-1, dated Feb 89, unless otherwise specified.		
1.	Has the RPT completed a basic health physics technician course with certificate? (para 1-9a)		
2.	Are supervisors familiar with procedures to follow if one of their workers suspects that she may be pregnant? (para 1-11)		
3.	Are all female radiation workers familiar with procedures to follow when they suspect pregnancy? (1-12c)		
4.	Do all female radiation workers have a "Risk Acknowledgement" letter on file with the RSO? para 1-9i)		
5.	Are all radiation workers briefed annually on radiation exposure including topics in para 1-9h?		
6.	Are at least 2 of each type of calibrated radiation instrument available at any time? (para 5-1a and subjective)		
7.	Are all rooms where radioisotopes are used surveyed monthly? (para 5-2)		
8.	Is the disposal of all radioactive lab waste such as glassware, containers, etc. surveyed, documented, and disposed of properly? (Chapter 10)		
9.	Is an inventory of all radioactive sources performed each quarter? (para 7-2)		
10.	Are all radioactive sources properly identified and labeled? (para 7-2)		
11.	Are all radioactive sources controlled to prevent theft, loss, damage, or unnecessary human radiation exposure? (chapter 8)		
12.	Are all receipts of radioactive material documented on Can Form 83? (para 6-2)		
13.	Are all work areas properly posted for radiation hazards? (para 12-4)		
14.	Is the RSO immediately notified of losses or accidents involving radioisotopes? (para 11-6)		
15.	Is protective clothing (suits, gloves, booties, respirators, etc.) immediately available in case of contaminated work areas or accidents? (para 12-2j)		
16.	Are all sealed sources leak-tested as required? (para 5-3)		
17.	Do all purchase, disposal, and shipment actions of Radio Active Material receive prior approval of the RSO? (para 6-1a, 9-3, 10-2)		
18.	Does the RPT maintain procedures for each worst case accident situation? (para 11-1)		
19.	Does the RPT maintain a series 161 OI pertaining to his/her organization? (para 1-9c)		
20.	Does the RPT maintain current copies of applicable permit documents? (para 1-9f)		

AF FORM 2519, NOV 91 *(EF)* PREVIOUS EDITION WILL BE USED.

Attachment 4

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N
	21. Are NRC-3 forms posted for radiation workers to review? (para 1-9g)			
	22. Is the required notation attached to the NRC-3 forms? (para 1-9g)			
	23. Does the RPT provide initial orientation and annual recertification to all radiation workers? (para 1-9h)			
	24. Is radiation worker training documented on AF Form 55? (para 1-9h)			
	25. Is there an active dosimetry program? (para 4-1)			
	26. Are the dosimetry results reviewed by the RPT? (para 4-5)			
	27. Does the dosimetry program contain provisions for briefing and monitoring visitors? (para 4-1)			
	28. Are NRC-4 forms (or equivalent) on file for all assigned radiation workers? (para4-3)			
	29. Does the RPT have procedures to investigate radiation doses above the preset "investigation level"? (para 4-5)			

71-0772

DEPARTMENT OF THE AIR FORCE
Air Force Medical Operations Agency
Radiation Protection Division
Radioisotope Committee Secretariat

FACSIMILE TRANSMITTAL

TO: Robert J. Lewis
Transportation and Storage Safety and Inspection Section
Spent Fuel Project Office

SUBJ: QAP Approval

PHONE NO:

FAX NO: 301-415-8555

NUMBER OF PAGES (including cover sheet): 10

COMMENTS: Original Copy to follow in the mail.

DAVID L. PUGH, Capt, USAF, BSC
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110 Luke Avenue, Suite 405
Bolling AFB, DC 20332-7050

VOICE (202) 767-4307
FAX (202) 404-8089

"Do not transmit classified information over unsecured telecommunications systems. Official DoD telecommunications systems are subject to monitoring. Using DoD telecommunications systems constitutes consent to monitoring."

NMSS01

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC

29 September 2003

MEMORANDUM FOR ROBERT J. LEWIS, CHIEF
TRANSPORTATION AND STORAGE SAFETY
AND INSPECTION SECTION
SPENT FUEL PROJECT OFFICE
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
UNITED STATES NUCLEAR REGULATORY COMMISSION

FROM: AFMOA/SGZR
110 Luke Ave Room 405
Bolling AFB DC 20032-7050

SUBJECT: RENEWAL REQUEST FOR QUALITY ASSURANCE PROGRAM APPROVAL, NO. 0772.

Attached, you will find a Quality Assurance Program for radioactive material packages for your review and approval. The current QAP Approval for docket number 71-0772 expires on 31 October 2003. If you have any questions regarding this QAP, you may reach me at 202-767-4307 or email, david.pugh@pentagon.af.mil.

DAVID L. PUGH, Capt, USAF, BSC
Health Physicist
Radiation Protection Division and
USAF Radioisotope Committee Secretariat
Air Force Medical Operations Agency
Office of the Surgeon General

Atch:
Quality Assurance Program For Transportation of Radioisotope Thermoelectric Generators (RTGs), 18 Sep 03

cc:
HQ AFTAC/SE w/o atch

DEPARTMENT OF THE AIR FORCE
AIR FORCE TECHNICAL APPLICATIONS CENTER (AFTAC)

18 September 2003

MEMORANDUM FOR AFMOA/SGZR

FROM: HQ AFTAC/SE
1030 South Highway A1A
Patrick AFB FL 32925-3002

SUBJECT: Request Submission of Radioisotope Thermoelectric Generator (RTG) Quality Assuance Program (QAP) to the Nuclear Regulatory Commission (NRC), Permit No. 09-30272-1AFP, Docket No. 030-90188

1. The subject program is due to expire on 31 October 2003. Please submit the program to the NRC on our behalf (Attachment 1).

2. Please contact me at DSN 854-3870 if you have any questions in this regard. Thanks for your assistance.

// SIGNED //

JOY M. POWELL
Chief, Occupational Safety and Health
Permit Radiation Safety Officer

Attachment
1. AFTAC QAP, 18 September 2003 (7 pages)

QUALITY ASSURANCE PROGRAM (QAP) FOR TRANSPORTATION OF RADIOISOTOPE THERMOELECTRIC GENERATORS (RTGs)

AIR FORCE TECHNICAL APPLICATIONS CENTER
PATRICK AFB, FLORIDA

18 September 2003

QUALITY ASSURANCE PLAN
OF
RADIO THERMOELECTRIC GENERATORS

1. INTRODUCTION

a. Under the provisions of the United States Air Force Radioactive Material (USAF RAM) Permits No. 030-00409, issued pursuant to the Air Force's Nuclear Regulatory Commission (NRC) Master Materials License No. 42-23539-1AFP, the Air Force Technical Applications Center (AFTAC) is authorized to acquire, receive, store, use, or transfer Radioisotope Thermoelectric Generators (RTGs).

b. The purpose of this document is to outline the procedures which will be followed to comply with Subpart H of Title 10, Code of Federal Regulations, Part 71 (10 CFR 71) for transportation of type B quantities of radioactive material and to insure compliance with NRC General License requirements of 10 CFR 71.12 through 71.14.

c. NRC Regulatory Guide 7.10, Establishing QAPs for Packaging used in the Transport of Radioactive Material, Annex 2, was used as a guide in developing this plan.

d. Opening the RTGs to replace thermoelectric modules or perform other repairs in not covered under this program.

e. Packages currently used under NRC approved QAP are listed in Attachment 1. Sources are special form radioactive material.

f. Activities performed relative to transportation of RTGs include:
(1) Handling;
(2) Shipping;
(3) Storage.

2. Quality Assurance Organization. The final responsibility for the QAP rests with the AFTAC Safety Office (SE). The QAP is implemented using the organization outlined in Attachment 2.

3. Quality Assurance Program.

a. The SE will implement the QAP through the organization described in paragraph 2. QAP revisions will not be made without the Safety Office approval. Implementation of the QAP will insure that all transportation activities involving the RTGs are performed in accordance with (IAW) applicable NRC, Department of Transportation (DOT), and Department of the Air Force Regulations, USAF RAM Permit No. FL-00409-00/00AFP, Docket No. 030-00409, and the specific provisions of the appropriate Certificates or Compliance (COC) and USAF NRC Master materials License. The QAP emphasizes control of the administrative and operational matters which are critical to safety. Controls have been established to insure that transportation activities involving the RTGs are conducted IAW the regulations, permits, licenses and approvals mentioned above.

b. Prior to engaging in any activity important to safety, all personnel will have had indoctrination or training in that activity.

4. Design Control. This organization is not involved in the manufacturing or fabrication of packages. The RTGs are designed, and manufactured/fabricated by the manufacturer under an NRC approved QAP. RTGs shall be maintained in their original design configuration as specified in the manufacturer's drawings and documents. AFTAC shall hold the COCs and maintain all existing drawings, manufacturer documents, and procedures approved in the COC. AFTAC responsibilities are limited to responsibility form completeness, accuracy and maintenance of Safety Analysis Reports, drawings, design records, calculations and operating instructions for transportation packaging with Certificate of Compliance numbers 4888 and 5862.

5. Procurement Document Control. This organization is not involved in the manufacturing of packages or packaging. Procurement documents shall reflect that RTGs are authorized by a COC, USAF RAM Permit, and have been manufactured under an NRC approved QAP. This is limited to hardware items for package maintenance.

6. Instructions, Procedures, and Drawings.

a. Preparation of package for use prior to and after shipment;
   (1) Packages are visually inspected for damage;
   (2) Required sealed source leak tests and radiation surveys are performed;
   (3) Eye bolts are removed or inserted;
   (4) Package security on pallet and pallet security on vehicle is verified.

b. Repairs, Rework and Maintenance. Packages are supplied by the manufacturer. Maintenance of the RTGs will be limited to hardware items (nuts, bolts, slings, eye bolts and pallets) and corrosion control measures to the exterior of the package only. Opening the RTGs is not authorized.

c. Loading and Unloading Contents. This organization does not load/unload radioactive material into or out of RTGs.

d. Transportation of Package. See paragraph 14.

7. Document Control. All documents related to the RTG package (e.g., COCs, Shipping and Receiving Procedures, etc.) will be controlled and maintained by the Radiation Safety Officer (RSO). All revisions and changes will be processed through the RSO. He/she will ensure that the latest versions of the documents are on file.

8. Control of Purchased Material, Equipment and Services. Design and fabrication of RTGs are not conducted under this QAP. Procurement of replacement parts important to saety will be reviewed to ensure appropriate technical and QA requirements are included in purchase orders. Replacement parts shall be purchased from the original vendor or an equivalent qualified supplier. Replacement parts from suppliers not previously identified, as qualified sources will meet requirements equal to the original criteria.

9. Identification and Control of Materials, Parts and Components. Repairs or rework of RTGs will not be conducted under this QAP.

10. Control of Special Processes. RTGs should require no major repairs necessitating the use of special processes. USAF RAM permit No. FL-00409-00/00AFP, Docket No. 030-00409, does not authorize repair of RTGs.

11. Inspection Control. The RSO shall use a checklist to insure inspections are performed to verify that packages have been marked and labeled, and shipping papers are completed IAW the latest requirements.

12. Test Control.

a. RTGs are not fabricated under this QAP. Packages will be visually examined to insure that they conform to the COC package description and that they are in sound condition. Any other tests prescribed by the manufacturer's operation and maintenance manuals will be completed.

b. Following any maintenance to the package and prior to offering the RTG to a carrier for transport, radiation surveys will be completed to verify shielding integrity.

13. Control of Measuring and Test Equipment. USAF RAM Permit No. FL-00409-00/00AFP, Docket No. 030-00409, requires that all radiation survey equipment be in calibration during use.

a. Calibration of instruments is performed by either:

(1) An Air Force Precision Measurement Equipment Laboratory (PMEL) under NRC or agreement state license.

(2) Manufacturer according to procedures approved by the NRC.

b. All instruments are calibrated at intervals not exceeding twelve months. A calibration label is affixed to all instruments indicating the date calibrated, due date and calibrator's certification stamp. Air Force reference standards are certified as traceable to the National Institute of Standards and Technology (NIST).

14. Handling, Storage and Shipping Control. Safety procedures concerning the handling, storage, and shipping of RTGs will be followed. These procedures are performed IAW applicable NRC, DOT and US Air Force regulations, and the manufacturer's operation and maintenance manual. Work instructions will be provided for handling, storage and shipping operations. Shipments will not be made unless all tests, certifications, acceptances, and final inspections have been completed. The manufacturer's operation and maintenance manual will be used as a guide to insure that the requirements of 10 CFR 71.85 and 71.87 are met and that packages are in good condition, adequately secured on the transport vehicle, marked and labeled IAW DOT regulations and identified by model and package identification numbers.

15. Inspection, Test and Operating Status. Inspection, test and operating status of the RTGs will be IAW manufacturer's recommendations and conditions specified in USAF RAM Permit No. FL-00409-00/00AFP, Docket No. 030-00409.

16. Non-Conforming Materials, Parts or Components. RTGs are used as provided by the Manufacturer. Any non-conforming materials, parts or components important to QA will be identified and returned to the vendor or set aside for discard.

17. Corrective Action. The RSO or designated representative will conduct annual evaluation visits to RTG use or staorage locations authorized IAW USAF RAM Permit No. FL-00409-00/00AFP, Docket No. 030-00409. The written results of these visits will be provided to applicable headquarters, parent and subordinate units. The report will note any deviations or discrepancies, office of primary responsibility (OPR) for corrective action and abatement date, if applicable. Written response from the OPR is required to provide details of abatement. In addition, the RSO will report significant findings of staff visits to the AFTAC Commander (who is the Permitee).

18. Quality Assurance Records. Records of package approvals (including references and drawings, relating to the use of the packaging) test, audits, personnel training and qualifications, RTG shipments, and compliance inspections will be maintained by the RSO, or his alternate. Descriptions of RTGs, manufacturer's operation and maintenance manuals, and procedures pertinent to RTG activities will also be maintained. Records will be maintained and kept in such a manner as to be idenfiable and readily retrievable. Record types and retention items will be kept IAW 10 CFR Part 71.91 (a) and (c).

19. Audits. Individuals performing the audits will have not responsibility in the activity being conducted. Audit will be conducted using prepared checklists. Results of the audits will be maintained. Audit reports will be evaluated and deficient areas corrected.

MANUFACTURER MODEL NUMBERS AND CERTIFICATE OF COMPLIANCE

MANUFACTURER AND MODEL NO.	CERTIFICATE OF COMPLIANCE NO.
Teledyne Energy Systems Radioisotope Thermoelectric Generator Sentinel Model-25 Series	4888
Teledyne Energy Systems Radioisotope Thermoelectric Generator Sentinel Model-100 Series	5862

Attachment 1

Air Force Technical Applications Center (AFTAC)
Radiation Safety Program

The Safety Office (SE) is staffed by a Health Physicist who is appointed as the Radiation Safety Officer (RSO). The RSO reports to the Commander. The Commander is recognized as the Permitee for USAF RAM Permit No. FL-00409-00/00AFP, Docket No. 030-00409. The RSO reviews the Radiation Safety Program to include:

a. Adequacy of operation procedures, facilities and equipment.
b. Procedures for control and inventory of radioactive material.
c. Procedures for proper receipt and transfer of radioactive material.
d. Maintaining records of training of qualified users.

Records of significant actions of the RSO are maintained at AFTAC. When required, copies are submitted to the Radioisotope Committee (RIC)

Attachment 2

Simmons, Michelle

From:	Bhat, Ramachandra K CIV USAF AFMSA (US) (b)(6)
Sent:	Thursday, September 17, 2015 4:39 PM
To:	Eusebio, Linda
Cc:	NSTSHelp Resource; NSTSFaxResource@nrc.gov; Whitten, Jack; Simmons, Michelle; Cook, Jackie; Bhat, Ramachandra K CIV USAF AFMSA (US); Refosco, Craig A CTR USAF AFMSA (US); Talbert, Mark W CIV USAF (US); Morris, Belinda J CIV USAF (US); Cagle, Anthony J Lt Col USAF AFMSA (US); Abell, Clinton E Lt Col USAF (US); Lopez, Phillip M Capt USAF AFMSA (US)
Subject:	[External_Sender] Password

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Linda (HQ. NRC Rockville MD),

It was nice talking to you today. I sent the NRC From 748 on 3 Sep15 to NSTSFaxResource@nrc.gov and to the Region IV. I did not know your email address, otherwise, I would have sent you the NRC Form 748 on 3 Sep 15. Today, I am sending the NRC From 748 to you and NSTSHelp@nrc.gov also.

I will send the NRC form 748 on the encrypted email with in next hour and the password is given below:

Note to Mr. Lon (NSTSHelp@nrc.gov):

1. Please email me after you receive this email;

2. Please email me the updated USAF NSTS inventory after entering the data from the NRC form 748 to your database.

If you have any questions regarding this permit please contact me at (b)(6) or (b)(6) at (b)(6)
(b)(6)
Our web page address is
https://kx2.afms.mil/kj/kx5/radiationprograms/Pages/home.aspx.

The after hours / emergency phone number is (b)(6)
Please note that this number is for the Andrews Regional Command Post. When calling, inform them you are calling for the on-call member of the RIC Secretariat and be prepared (if asked) to give: your name, on/off duty phone number, location, and nature of emergency.

(b)(6)
Senior Health Physicist
USAF Radioisotope Committee Secretariat
AFMSA/SG3PB, 7700 Arlington Blvd Ste (b)(6) Falls Church VA 22042-5158

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~~PUBLIC~~
~~☐ Immediate Release~~
~~☐ Normal Release~~
~~NON-PUBLIC~~
~~☑ A.3 Sensitive-Security Related~~
~~☐ A.4 Sensitive Internal~~
~~☐ Other:~~
~~Reviewer: MS Date: 7/20/16~~

This electronic transmission contains internal matters that are deliberative in nature, are part of the agency decision-making process, and/or are otherwise legally privileged, each of which are protected from disclosure under the Freedom of Information Act, 5 USC 552. Do not release outside of the DoD channels without

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Submit by Email

NRC FORM 748 (5-2012) 10 CFR 20.2207

U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB: NO. 3150-0202 EXPIRES: 01/31/2016

NATIONAL SOURCE TRACKING TRANSACTION REPORT

1. LICENSEE INFORMATION

A. LICENSEE NAME	B. LICENSE NO.	C. LICENSEE STREET ADDRESS	D. CITY	E. STATE	F. ZIP CODE
Department of the US Air Force USAF Radioisotope Committee	42-23539-01AF	7700 Arlington Blvd Ste (b)(7)(F)	Falls Church	VA	22042-5158

2. TRANSACTION DATE

(Only transactions completed on the same date may be reported together on this form)

07/28/2015

3A. TRANSACTION INFORMATION

☒ NEW ☐ CORRECTION

IF CORRECTION, PREVIOUS TRANSACTION DATE:

3B. TRANSACTION TYPE (Check all that apply)

☐ REPORT SOURCE INVENTORY ☒ TRANSFER ☐ RECEIPT ☐ DISPOSAL

☐ NEW SOURCE MANUFACTURED ☐ IMPORT ☐ EXPORT ☐ DISASSEMBLE

4. PREPARER INFORMATION

A. NAME OF PREPARER	B. DATE PREPARED	C. PREPARER PHONE	D. PREPARER E-MAIL (REQUIRED FOR CONFIRMATION)
(b)(7)(F)	08/25/2015	(b)(7)(F)	(b)(7)(F)

5. SOURCE INVENTORY DATA (Note: Only use this section for reporting initial source inventory)

A1. SOURCE MAKE	B1. SOURCE MODEL	C1. SOURCE SERIAL NUMBER	D1. ISOTOPE	E1. ACTIVITY AND UNIT	F1. ACTIVITY DATE	G1. COMMENTS
See the Attachment 1						

H1. SOURCE LOCATION ADDRESS	I1. CITY	J1. STATE	K1. ZIP CODE	L1. SAME AS STREET ADDRESS
Burnt Mountain	Burnt Mountain	AK		☐

A2. SOURCE MAKE	B2. SOURCE MODEL	C2. SOURCE SERIAL NUMBER	D2. ISOTOPE	E2. ACTIVITY AND UNIT	F2. ACTIVITY DATE	G2. COMMENTS

H2. SOURCE LOCATION ADDRESS	I2. CITY	J2. STATE	K2. ZIP CODE	L2. SAME AS STREET ADDRESS
				☐

WARNING: FALSE STATEMENTS IN THIS CERTIFICATE MAY BE SUBJECT TO CIVIL AND/OR CRIMINAL PENALTIES. NRC REGULATIONS REQUIRE THAT SUBMISSIONS TO THE NRC BE COMPLETE AND ACCURATE IN ALL MATERIAL RESPECTS. 18 U.S.C. SECTION 1001 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

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NRC FORM 748 (5-2012) 10 CFR 20.2207	U.S. NUCLEAR REGULATORY COMMISSION	LICENSEE NAME	LICENSE NO.
	NATIONAL SOURCE TRACKING TRANSACTION REPORT (continued)	Department of the US Air Force USAF Radioisotope Committee	42-23539-01AF

5. SOURCE INVENTORY DATA (continued)

A3. SOURCE MAKE	B3. SOURCE MODEL	C3. SOURCE SERIAL NUMBER	D3. ISOTOPE	E3. ACTIVITY AND UNIT	F3. ACTIVITY DATE	G3. COMMENTS
H3. SOURCE LOCATION ADDRESS	I3. CITY		J3. STATE	K3. ZIP CODE	L3. SAME AS STREET ADDRESS ☐	
A4. SOURCE MAKE	B4. SOURCE MODEL	C4. SOURCE SERIAL NUMBER	D4. ISOTOPE	E4. ACTIVITY AND UNIT	F4. ACTIVITY DATE	G4. COMMENTS
H4. SOURCE LOCATION ADDRESS	I4. CITY		J4. STATE	K4. ZIP CODE	L4. SAME AS STREET ADDRESS ☐	
A5. SOURCE MAKE	B5. SOURCE MODEL	C5. SOURCE SERIAL NUMBER	D5. ISOTOPE	E5. ACTIVITY AND UNIT	F5. ACTIVITY DATE	G5. COMMENTS
H5. SOURCE LOCATION ADDRESS	I5. CITY		J5. STATE	K5. ZIP CODE	L5. SAME AS STREET ADDRESS ☐	
A6. SOURCE MAKE	B6. SOURCE MODEL	C6. SOURCE SERIAL NUMBER	D6. ISOTOPE	E6. ACTIVITY AND UNIT	F6. ACTIVITY DATE	G6. COMMENTS
H6. SOURCE LOCATION ADDRESS	I6. CITY		J6. STATE	K6. ZIP CODE	L6. SAME AS STREET ADDRESS ☐	

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NRC FORM 748 (5-2012) 10 CFR 20.2207	U.S. NUCLEAR REGULATORY COMMISSION NATIONAL SOURCE TRACKING TRANSACTION REPORT (continued)	LICENSEE NAME	LICENSE NO.
		Department of the US Air Force USAF Radioisotope Committee	42-23539-01AF

6. SOURCE TRANSFER DATA

A1. RECEIVING LICENSEE NAME	B1. RECEIVING LICENSEE LICENSE NO.	C1. RECEIVING LICENSEE SHIPPING ADDRESS	D1. CITY	E1. STATE	F1. ZIP CODE
Los Alamos National Laboratory		DOE National Nuclear Security Administration	Mercury	NV	89023

G1. SOURCE MAKE	H1. SOURCE MODEL	I1. SOURCE SERIAL NUMBER	J1. ISOTOPE	K1. ACTIVITY AND UNIT	L1. ACTIVITY DATE	M1. WASTE MANIFEST NO. (For waste shipments only)	N1. CONTAINER ID (For waste shipments only)
See the Attachment 1							

O1. ESTIMATED ARRIVAL DATE	P1. COMMENTS
07/28/2015	

A2. RECEIVING LICENSEE NAME	B2. RECEIVING LICENSEE LICENSE NO.	C2. RECEIVING LICENSEE SHIPPING ADDRESS	D2. CITY	E2. STATE	F2. ZIP CODE

G2. SOURCE MAKE	H2. SOURCE MODEL	I2. SOURCE SERIAL NUMBER	J2. ISOTOPE	K2. ACTIVITY AND UNIT	L2. ACTIVITY DATE	M2. WASTE MANIFEST NO. (For waste shipments only)	N2. CONTAINER ID (For waste shipments only)

O2. ESTIMATED ARRIVAL DATE	P2. COMMENTS

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NRC FORM 748 (5-2012) 10 CFR 20.2207 U.S. NUCLEAR REGULATORY COMMISSION **NATIONAL SOURCE TRACKING TRANSACTION REPORT (continued)**	LICENSEE NAME Department of the US Air Force USAF Radioisotope Committee	LICENSE NO. 42-23539-01AF

6. SOURCE TRANSFER DATA (continued)

A3. RECEIVING LICENSEE NAME	B3. RECEIVING LICENSEE LICENSE NO.	C3. RECEIVING LICENSEE SHIPPING ADDRESS	D3. CITY	E3. STATE	F3. ZIP CODE

G3. SOURCE MAKE	H3. SOURCE MODEL	I3. SOURCE SERIAL NUMBER	J3. ISOTOPE	K3. ACTIVITY AND UNIT	L3. ACTIVITY DATE	M3. WASTE MANIFEST NO. (For waste shipments only)	N3. CONTAINER ID (For waste shipments only)

O3. ESTIMATED ARRIVAL DATE	P3. COMMENTS

A4. RECEIVING LICENSEE NAME	B4. RECEIVING LICENSEE LICENSE NO.	C4. RECEIVING LICENSEE SHIPPING ADDRESS	D4. CITY	E4. STATE	F4. ZIP CODE

G4. SOURCE MAKE	H4. SOURCE MODEL	I4. SOURCE SERIAL NUMBER	J4. ISOTOPE	K4. ACTIVITY AND UNIT	L4. ACTIVITY DATE	M4. WASTE MANIFEST NO. (For waste shipments only)	N4. CONTAINER ID (For waste shipments only)

O4. ESTIMATED ARRIVAL DATE	P4. COMMENTS

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NRC FORM 748 (5-2012) 10 CFR 20.2207 U.S. NUCLEAR REGULATORY COMMISSION **NATIONAL SOURCE TRACKING TRANSACTION REPORT (continued)**	LICENSEE NAME Department of the US Air Force USAF Radioisotope Committee	LICENSE NO. 42-23539-01AF

7. SOURCE RECEIPT DATA

A1. SENDING LICENSEE NAME	B1. SENDING LICENSEE LICENSE NO.	C1. SENDING LICENSEE SHIPPING ADDRESS	D1. CITY	E1. STATE	F1. ZIP CODE
Department of the US Air Force USAF Radioisotope Commit	42-23539-01AF	Burnt Mountain	Burnt Mountain	AK	

G1. SOURCE MAKE	H1. SOURCE MODEL	I1. SOURCE SERIAL NUMBER	J1. ISOTOPE	K1. ACTIVITY AND UNIT	L1. ACTIVITY DATE	M1. WASTE MANIFEST NO. (For waste shipments only)	N1. CONTAINER ID (For waste shipments only)
See the Attachment 2							

O1. SOURCE LOCATION ADDRESS	P1. CITY	Q1. STATE	R1. ZIP CODE	S1. SAME AS STREET ADDRESS	T1. COMMENTS
Los Alamos National Laboratory DOE National Nuclear Security Administration	Mercury	NV	89023	☐	

A2. SENDING LICENSEE NAME	B2. SENDING LICENSEE LICENSE NO.	C2. SENDING LICENSEE SHIPPING ADDRESS	D2. CITY	E2. STATE	F2. ZIP CODE

G2. SOURCE MAKE	H2. SOURCE MODEL	I2. SOURCE SERIAL NUMBER	J2. ISOTOPE	K2. ACTIVITY AND UNIT	L2. ACTIVITY DATE	M2. WASTE MANIFEST NO. (For waste shipments only)	N2. CONTAINER ID (For waste shipments only)

O2. SOURCE LOCATION ADDRESS	P2. CITY	Q2. STATE	R2. ZIP CODE	S2. SAME AS STREET ADDRESS	T2. COMMENTS
				☐	

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NRC FORM 748 (5-2012) 10 CFR 20.2207 — U.S. NUCLEAR REGULATORY COMMISSION — NATIONAL SOURCE TRACKING TRANSACTION REPORT (continued)	LICENSEE NAME: Department of the US Air Force USAF Radioisotope Committee	LICENSE NO. 42-23539-01AF

7. SOURCE RECEIPT DATA (continued)

A3. SENDING LICENSEE NAME	B3. SENDING LICENSEE LICENSE NO.	C3. SENDING LICENSEE SHIPPING ADDRESS	D3. CITY	E3. STATE	F3. ZIP CODE

G3. SOURCE MAKE	H3. SOURCE MODEL	I3. SOURCE SERIAL NUMBER	J3. ISOTOPE	K3. ACTIVITY AND UNIT	L3. ACTIVITY DATE	M3. WASTE MANIFEST NO. (For waste shipments only)	N3. CONTAINER ID (For waste shipments only)

O3. SOURCE LOCATION ADDRESS	P3. CITY	Q3. STATE	R3. ZIP CODE	S3. SAME AS STREET ADDRESS	T3. COMMENTS
				☐	

A4. SENDING LICENSEE NAME	B4. SENDING LICENSEE LICENSE NO.	C4. SENDING LICENSEE SHIPPING ADDRESS	D4. CITY	E4. STATE	F4. ZIP CODE

G4. SOURCE MAKE	H4. SOURCE MODEL	I4. SOURCE SERIAL NUMBER	J4. ISOTOPE	K4. ACTIVITY AND UNIT	L4. ACTIVITY DATE	M4. WASTE MANIFEST NO. (For waste shipments only)	N4. CONTAINER ID (For waste shipments only)

O4. SOURCE LOCATION ADDRESS	P4. CITY	Q4. STATE	R4. ZIP CODE	S4. SAME AS STREET ADDRESS	T4. COMMENTS
				☐	

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NRC FORM 748 (5-2012) 10 CFR 20.2207 U.S. NUCLEAR REGULATORY COMMISSION NATIONAL SOURCE TRACKING TRANSACTION REPORT (continued)	LICENSEE NAME Department of the US Air Force USAF Radioisotope Committee	LICENSE NO. 42-23539-01AF

8. SOURCE DISPOSAL DATA (continued)

A3. WASTE MANIFEST NUMBER			B3. CONTAINER ID			C3. METHOD OF DISPOSAL	
D3. SOURCE MAKE	E3. SOURCE MODEL	F3. SOURCE SERIAL NUMBER	G3. ISOTOPE	H3. ACTIVITY AND UNIT	I3. ACTIVITY DATE	J3. COMMENTS	
K3. SOURCE DISPOSAL ADDRESS	L3. CITY		M3. STATE	N3. ZIP CODE	O3. SAME AS STREET ADDRESS ☐		
A4. WASTE MANIFEST NUMBER			B4. CONTAINER ID			C4. METHOD OF DISPOSAL	
D4. SOURCE MAKE	E4. SOURCE MODEL	F4. SOURCE SERIAL NUMBER	G4. ISOTOPE	H4. ACTIVITY AND UNIT	I4. ACTIVITY DATE	J4. COMMENTS	
K4. SOURCE DISPOSAL ADDRESS	L4. CITY		M4. STATE	N4. ZIP CODE	O4. SAME AS STREET ADDRESS ☐		

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Security-Related Information - Withheld Under 10 CFR 2.390

NRC FORM 748 (5-2012) 10 CFR 20.2207 U.S. NUCLEAR REGULATORY COMMISSION **NATIONAL SOURCE TRACKING TRANSACTION REPORT (continued)**	LICENSEE NAME Department of the US Air Force USAF Radioisotope Committee	LICENSE NO. 42-23539-01AF

8. SOURCE DISPOSAL DATA

A1. WASTE MANIFEST NUMBER	B1. CONTAINER ID	C1. METHOD OF DISPOSAL

D1. SOURCE MAKE	E1. SOURCE MODEL	F1. SOURCE SERIAL NUMBER	G1. ISOTOPE	H1. ACTIVITY AND UNIT	I1. ACTIVITY DATE	J1. COMMENTS
K1. SOURCE DISPOSAL ADDRESS	L1. CITY		M1. STATE	N1. ZIP CODE	O1. SAME AS STREET ADDRESS ☐	

A2. WASTE MANIFEST NUMBER	B2. CONTAINER ID	C2. METHOD OF DISPOSAL

D2. SOURCE MAKE	E2. SOURCE MODEL	F2. SOURCE SERIAL NUMBER	G2. ISOTOPE	H2. ACTIVITY AND UNIT	I2. ACTIVITY DATE	J2. COMMENTS
K2. SOURCE DISPOSAL ADDRESS	L2. CITY		M2. STATE	N2. ZIP CODE	O2. SAME AS STREET ADDRESS ☐	

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NRC FORM 748 (5-2012) 10 CFR 20.2207 U.S. NUCLEAR REGULATORY COMMISSION **NATIONAL SOURCE TRACKING TRANSACTION REPORT (continued)**	LICENSEE NAME Department of the US Air Force USAF Radioisotope Committee	LICENSE NO. 42-23539-01AF

9. NEW MANUFACTURED SOURCE DATA

A1. SOURCE MAKE	B1. SOURCE MODEL	C1. SOURCE SERIAL NUMBER	D1. ISOTOPE		E1. ACTIVITY AND UNIT	F1. COMMENTS
G1. SOURCE LOCATION ADDRESS	H1. CITY		I1. STATE	J1. ZIP CODE	K1. SAME AS STREET ADDRESS ☐	
A2. SOURCE MAKE	B2. SOURCE MODEL	C2. SOURCE SERIAL NUMBER	D2. ISOTOPE		E2. ACTIVITY AND UNIT	F2. COMMENTS
G2. SOURCE LOCATION ADDRESS	H2. CITY		I2. STATE	J2. ZIP CODE	K2. SAME AS STREET ADDRESS ☐	
A3. SOURCE MAKE	B3. SOURCE MODEL	C3. SOURCE SERIAL NUMBER	D3. ISOTOPE		E3. ACTIVITY AND UNIT	F3. COMMENTS
G3. SOURCE LOCATION ADDRESS	H3. CITY		I3. STATE	J3. ZIP CODE	K3. SAME AS STREET ADDRESS ☐	
A4. SOURCE MAKE	B4. SOURCE MODEL	C4. SOURCE SERIAL NUMBER	D4. ISOTOPE		E4. ACTIVITY AND UNIT	F4. COMMENTS
G4. SOURCE LOCATION ADDRESS	H4. CITY		I4. STATE	J4. ZIP CODE	K4. SAME AS STREET ADDRESS ☐	

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NRC FORM 748 (5-2012) 10 CFR 20.2207	U.S. NUCLEAR REGULATORY COMMISSION **NATIONAL SOURCE TRACKING TRANSACTION REPORT (continued)**	LICENSEE NAME Department of the US Air Force USAF Radioisotope Committee	LICENSE NO. 42-23539-01AF

10. SOURCE IMPORT DATA

A1. FOREIGN COMPANY NAME	B1. IMPORT LICENSE NO.	C1. FOREIGN COMPANY ADDRESS	D1. CITY	E1. COUNTRY

F1. SOURCE MAKE	G1. SOURCE MODEL	H1. SOURCE SERIAL NUMBER	I1. ISOTOPE	J1. ACTIVITY AND UNIT	K1. ACTIVITY DATE	L1. COMMENTS

M1. SOURCE LOCATION ADDRESS	N1. CITY	O1. STATE	P1. ZIP CODE	Q1. SAME AS STREET ADDRESS
				☐

A2. FOREIGN COMPANY NAME	B2. IMPORT LICENSE NO.	C2. FOREIGN COMPANY ADDRESS	D2. CITY	E2. COUNTRY

F2. SOURCE MAKE	G2. SOURCE MODEL	H2. SOURCE SERIAL NUMBER	I2. ISOTOPE	J2. ACTIVITY AND UNIT	K2. ACTIVITY DATE	L2. COMMENTS

M2. SOURCE LOCATION ADDRESS	N2. CITY	O2. STATE	P2. ZIP CODE	Q2. SAME AS STREET ADDRESS
				☐

WARNING: FALSE STATEMENTS IN THIS CERTIFICATE MAY BE SUBJECT TO CIVIL AND/OR CRIMINAL PENALTIES. NRC REGULATIONS REQUIRE THAT SUBMISSIONS TO THE NRC BE COMPLETE AND ACCURATE IN ALL MATERIAL RESPECTS. 18 U.S.C. SECTION 1001 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

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NRC FORM 748 (5-2012) 10 CFR 20.2207 U.S. NUCLEAR REGULATORY COMMISSION **NATIONAL SOURCE TRACKING TRANSACTION REPORT (continued)**	LICENSEE NAME **Department of the US Air Force USAF Radioisotope Committee**	LICENSE NO. **42-23539-01AF**

10. SOURCE IMPORT DATA (continued)

A3. FOREIGN COMPANY NAME	B3. IMPORT LICENSE NO.	C3. FOREIGN COMPANY ADDRESS	D3. CITY	E3. COUNTRY

F3. SOURCE MAKE	G3. SOURCE MODEL	H3. SOURCE SERIAL NUMBER	I3. ISOTOPE	J3. ACTIVITY AND UNIT	K3. ACTIVITY DATE	L3. COMMENTS

M3. SOURCE LOCATION ADDRESS	N3. CITY	O3. STATE	P3. ZIP CODE	Q3. SAME AS STREET ADDRESS
				☐

A4. FOREIGN COMPANY NAME	B4. IMPORT LICENSE NO.	C4. FOREIGN COMPANY ADDRESS	D4. CITY	E4. COUNTRY

F4. SOURCE MAKE	G4. SOURCE MODEL	H4. SOURCE SERIAL NUMBER	I4. ISOTOPE	J4. ACTIVITY AND UNIT	K4. ACTIVITY DATE	L4. COMMENTS

M4. SOURCE LOCATION ADDRESS	N4. CITY	O4. STATE	P4. ZIP CODE	Q4. SAME AS STREET ADDRESS
				☐

WARNING: FALSE STATEMENTS IN THIS CERTIFICATE MAY BE SUBJECT TO CIVIL AND/OR CRIMINAL PENALTIES. NRC REGULATIONS REQUIRE THAT SUBMISSIONS TO THE NRC BE COMPLETE AND ACCURATE IN ALL MATERIAL RESPECTS. 18 U.S.C. SECTION 1001 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

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NRC FORM 748 (5-2012) 10 CFR 20.2207 U.S. NUCLEAR REGULATORY COMMISSION **NATIONAL SOURCE TRACKING TRANSACTION REPORT (continued)**	LICENSEE NAME Department of the US Air Force USAF Radioisotope Committee	LICENSE NO. 42-23539-01AF

11. SOURCE EXPORT DATA

A1. FOREIGN COMPANY NAME	B1. EXPORT LICENSE NO.	C1. ULTIMATE CONSIGNEE ADDRESS			D1. CITY	E1. COUNTRY
F1. SOURCE MAKE	G1. SOURCE MODEL	H1. SOURCE SERIAL NUMBER	I1. ISOTOPE	J1. ACTIVITY AND UNIT	K1. ACTIVITY DATE	L1. CONTAINER ID
M1. COMMENTS						
A2. FOREIGN COMPANY NAME	B2. EXPORT LICENSE NO.	C2. ULTIMATE CONSIGNEE ADDRESS			D2. CITY	E2. COUNTRY
F2. SOURCE MAKE	G2. SOURCE MODEL	H2. SOURCE SERIAL NUMBER	I2. ISOTOPE	J2. ACTIVITY AND UNIT	K2. ACTIVITY DATE	L2. CONTAINER ID
M2. COMMENTS						

WARNING: FALSE STATEMENTS IN THIS CERTIFICATE MAY BE SUBJECT TO CIVIL AND/OR CRIMINAL PENALTIES. NRC REGULATIONS REQUIRE THAT SUBMISSIONS TO THE NRC BE COMPLETE AND ACCURATE IN ALL MATERIAL RESPECTS. 18 U.S.C. SECTION 1001 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

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NRC FORM 748 (5-2012) 10 CFR 20.2207 U.S. NUCLEAR REGULATORY COMMISSION **NATIONAL SOURCE TRACKING TRANSACTION REPORT (continued)**	LICENSEE NAME **Department of the US Air Force** **USAF Radioisotope Committee**	LICENSE NO. **42-23539-01AF**

12. SOURCE DISASSEMBLE DATA

A1. SOURCE MAKE	B1. SOURCE MODEL	C1. SOURCE SERIAL NUMBER	D1. ISOTOPE	E1. ACTIVITY AND UNIT	F1. ACTIVITY DATE	G1. DISASSEMBLE DATE	H1. COMMENTS
I1. SOURCE LOCATION ADDRESS	J1. CITY		K1. STATE	L1. ZIP CODE		M1. SAME AS STREET ADDRESS ☐	
A2. SOURCE MAKE	B2. SOURCE MODEL	C2. SOURCE SERIAL NUMBER	D2. ISOTOPE	E2. ACTIVITY AND UNIT	F2. ACTIVITY DATE	G2. DISASSEMBLE DATE	H2. COMMENTS
I2. SOURCE LOCATION ADDRESS	J2. CITY		K2. STATE	L2. ZIP CODE		M2. SAME AS STREET ADDRESS ☐	
A3. SOURCE MAKE	B3. SOURCE MODEL	C3. SOURCE SERIAL NUMBER	D3. ISOTOPE	E3. ACTIVITY AND UNIT	F3. ACTIVITY DATE	G3. DISASSEMBLE DATE	H3. COMMENTS
I3. SOURCE LOCATION ADDRESS	J3. CITY		K3. STATE	L3. ZIP CODE		M3. SAME AS STREET ADDRESS ☐	
A4. SOURCE MAKE	B4. SOURCE MODEL	C4. SOURCE SERIAL NUMBER	D4. ISOTOPE	E4. ACTIVITY AND UNIT	F4. ACTIVITY DATE	G4. DISASSEMBLE DATE	H4. COMMENTS
I4. SOURCE LOCATION ADDRESS	J4. CITY		K4. STATE	L4. ZIP CODE		M4. SAME AS STREET ADDRESS ☐	

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11. SOURCE EXPORT DATA (continued)

A3. FOREIGN COMPANY NAME	B3. EXPORT LICENSE NO.	C3. ULTIMATE CONSIGNEE ADDRESS	D3. CITY	E3. COUNTRY

F3. SOURCE MAKE	G3. SOURCE MODEL	H3. SOURCE SERIAL NUMBER	I3. ISOTOPE	J3. ACTIVITY AND UNIT	K3. ACTIVITY DATE	L3. CONTAINER ID

M3. COMMENTS

A4. FOREIGN COMPANY NAME	B4. EXPORT LICENSE NO.	C4. ULTIMATE CONSIGNEE ADDRESS	D4. CITY	E4. COUNTRY

F4. SOURCE MAKE	G4. SOURCE MODEL	H4. SOURCE SERIAL NUMBER	I4. ISOTOPE	J4. ACTIVITY AND UNIT	K4. ACTIVITY DATE	L4. CONTAINER ID

M4. COMMENTS

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NATIONAL SOURCE TRACKING TRANSACTION REPORT (continued)	**Department of the US Air Force USAF Radioisotope Committee**	**42-23539-01AF**

12. SOURCE DISASSEMBLE DATA (continued)

A5. SOURCE MAKE	B5. SOURCE MODEL	C5. SOURCE SERIAL NUMBER	D5. ISOTOPE	E5. ACTIVITY AND UNIT	F5. ACTIVITY DATE	G5. DISASSEMBLE DATE	H5. COMMENTS
I5. SOURCE LOCATION ADDRESS	J5. CITY		K5. STATE	L5. ZIP CODE		M5. SAME AS STREET ADDRESS ☐	
A6. SOURCE MAKE	B6. SOURCE MODEL	C6. SOURCE SERIAL NUMBER	D6. ISOTOPE	E6. ACTIVITY AND UNIT	F6. ACTIVITY DATE	G6. DISASSEMBLE DATE	H6. COMMENTS
I6. SOURCE LOCATION ADDRESS	J6. CITY		K6. STATE	L6. ZIP CODE		M6. SAME AS STREET ADDRESS ☐	
A7. SOURCE MAKE	B7. SOURCE MODEL	C7. SOURCE SERIAL NUMBER	D7. ISOTOPE	E7. ACTIVITY AND UNIT	F7. ACTIVITY DATE	G7. DISASSEMBLE DATE	H7. COMMENTS
I7. SOURCE LOCATION ADDRESS	J7. CITY		K7. STATE	L7. ZIP CODE		M7. SAME AS STREET ADDRESS ☐	
A8. SOURCE MAKE	B8. SOURCE MODEL	C8. SOURCE SERIAL NUMBER	D8. ISOTOPE	E8. ACTIVITY AND UNIT	F8. ACTIVITY DATE	G8. DISASSEMBLE DATE	H8. COMMENTS
I8. SOURCE LOCATION ADDRESS	J8. CITY		K8. STATE	L8. ZIP CODE		M8. SAME AS STREET ADDRESS ☐	

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INSTRUCTIONS TO NRC AND AGREEMENT STATE LICENSEES FOR REPORTING HIGH-RISK SEALED SOURCE TRANSACTIONS

The completed form is considered to be Official Use Only – Security Related Information; it is not considered to be Safeguards Information.
Use an addendum sheet for reporting additional sources.

Note to Licensees: This form may be used to report source transactions in lieu of using the NSTS online application. Sections 1-4 on Page 1 of the form are required for all source transaction types. Sections 5-12 should only be populated for the associated Transaction Type (3B) selected. For example, when reporting a Source Transfer and a Source Export, Sections 6 and 11 should be populated. Multiple Transaction Types may be selected if they occur on the same Transaction Date, and should be reported on NRC Form 748. Licensees reporting only one transaction type may use the condensed form for the Transaction Type. For example, when reporting a Source Receipt, NRC Form 748c should be used.

1. **Licensee Information** – Enter the name, license number, and street address of the licensed facility.
2. **Transaction Date** – Enter the date the transaction occurred, which would be the date of the transfer, receipt, manufacture, etc.
3. **Transaction Information and Transaction Type** – Indicate if this is a new transaction or a correction. For corrections, select the date of the previously submitted transaction that the correction should be associated with. Select the Transaction Type. Report Source should only be used for initial inventory submissions, or to report a source excluded from the initial inventory submission. Dispose Source should only be used by a Disposal Licensee. If you are sending your source back to the manufacturer, or sending it to a disposal facility, the transaction should be recorded as a Transfer. Multiple Transaction Types may be selected if they occur on the same Transaction Date.
4. **Preparer Information** – An email address is required for a confirmation. For regulatory purposes, your source transaction report is not considered complete without a confirmation from the NSTS Help Desk that the transaction report has been received.
5. **Source Inventory Data** – This section should only be used for initial inventory submissions. The Make, Model, and Serial Number refer to the Source, not the Device. All fields are required in Section 5 EXCEPT G. Comments. If the licensee is reporting multiple sources on the Source Inventory transaction at the same Source Location Address, the location address information may be populated once, and referenced in the Comments block for the additional sources.
6. **Source Transfer Data** – For Transfer transaction reports, all fields in Section 6 are required EXCEPT M. Waste Manifest Number, N. Container ID, and P. Comments. If the licensee is reporting multiple sources on the Transfer transaction to the same Receiving Licensee, the receiving licensee information may be populated once, and referenced in the Comments block for the additional sources.
7. **Source Receipt Data** – For Receipt transaction reports, all fields in Section 7 are required EXCEPT M. Waste Manifest Number, N. Container ID, and T. Comments. If the licensee is reporting multiple sources on the Receipt transaction at the same Source Location Address, the location address information may be populated once, and referenced in the Comments block for the additional sources.
8. **Source Disposal Data** – For Disposal transaction reports, all fields in Section 8 are required EXCEPT J. Comments. If the licensee is reporting multiple sources on the Disposal transaction at the same Source Disposal Address, the source disposal address information may be populated once, and referenced in the Comments block for the additional sources.
9. **New Manufactured Source Data** – For New Manufactured Source transaction reports, all fields in Section 9 are required EXCEPT F. Comments. If the licensee is reporting multiple sources on the Manufacturer transaction at the same Source Location Address, the location address information may be populated once, and referenced in the Comments block for the additional sources.
10. **Source Import Data** – For Import Source transaction reports, all fields are required EXCEPT L. Comments. If the licensee is reporting multiple sources on the Import transaction at the same Source Location Address, the location address information may be populated once, and referenced in the Comments block for the additional sources.
11. **Source Export Data** – For Export Source transaction reports, all fields are required EXCEPT M. Comments. If the licensee is reporting multiple sources on the Export transaction to the same Foreign Company/Foreign Address, the information in cells A-E may be populated once, and referenced in the Comments block for the additional sources.
12. **Source Disassemble Data** – For Disassemble Source transaction reports, all fields are required EXCEPT H. Comments. If the licensee is reporting multiple sources on the Disassemble transaction at the same Source Location Address, the location address information may be populated once, and referenced in the Comments block for the additional sources.

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U.S. NRC 5040	42-23539-01AF	3028641	AIR FORCE, DEPARTMENT OF THE		DANIEL SHAW	703-681-7855

INVENTORY VERIFICATIONOF PATRICK AND DOE RECEIPT DATED 28 JUL15 AND RAM'S VERIFICATION WITH EXCEL DATA SHEET

CONCLUSION; PATRICK'S AND RAM'S CACULATION AGREE WITH IN 0.007 %.

THE PATRICK AND DOE INVENTORY IS GOOD AND CAN SUBMIT THIS INVENTORY WITH NRC FORM 748

R K. BHAT
21 AUG 15.

					INITIAL ACTIVITY IN Ci	INITIAL ACTIVITY DATE	RAM'S COMPUTATION AS OF 7/10/2015		PATRICK INVENTORY IN Ci AS OF 7/10/2015	CONCUR
25	Teledyne Energy System	Sentinel 100F	RTG1	(b)(7)(F)	328400.0	03/01/1972	115692.46	7/10/2015	(b)(7)(F)	
26	Teledyne Energy System	Sentinel 25A	RTG4		94000.0	04/01/1968	30138.02	7/10/2015		
27	Teledyne Energy System	Sentinel 25E	RTG10		105900.0	02/01/1969	34644.80	7/10/2015		
28	Teledyne Energy System	Sentinel 25E	RTG17		109300.0	04/01/1971	37664.92	7/10/2015		
29	Teledyne Energy System	Sentinel 25E	RTG18		106500.0	04/01/1971	36700.04	7/10/2015		
30	Teledyne Energy System	Sentinel 25E	RTG19		105700.0	04/01/1971	36424.36	7/10/2015		
31	Teledyne Energy System	Sentinel 25E	RTG20		105600.0	04/01/1971	36389.90	7/10/2015		
32	Teledyne Energy System	Sentinel 25E	RTG8		105200.0	02/01/1969	34415.80	7/10/2015		
33	Teledyne Energy System	Sentinel 25E	RTG9		108300.0	02/01/1969	35429.96	7/10/2015		
34	Teledyne Energy System	Sentinel 25F	RTG14		107800.0	12/01/1970	36853.07	7/10/2015		

L:\SGZR\FILE PLAN\7. MASTER MATERIALS LICENSE MANAGEMENT\7-03 MML-Master Materials License\NRC INVENTORY OF SOURCES OF CONCE 2015\20150821

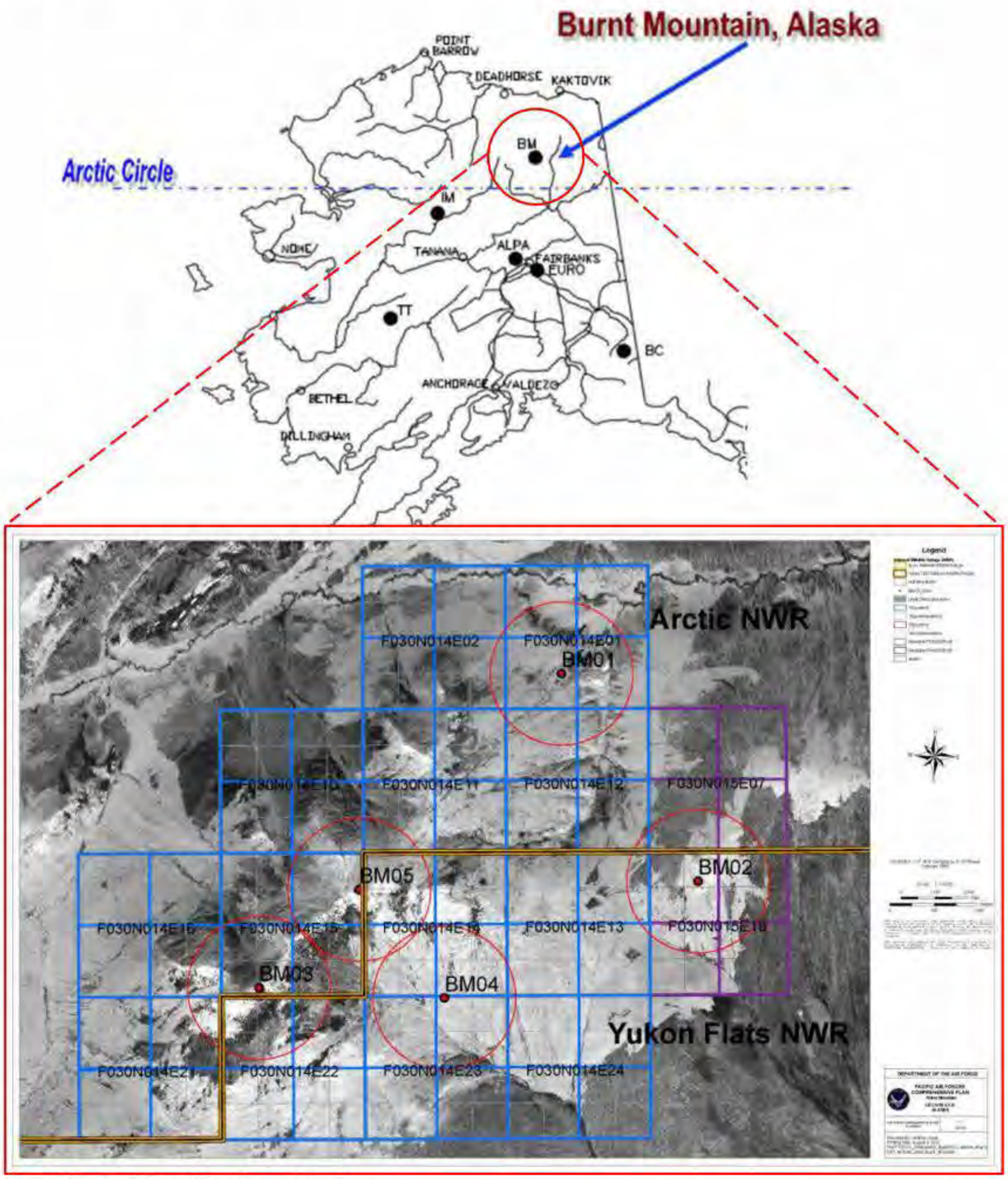
Attachment 1

AFTAC Transportation Plan for RTG

APPENDIX A – Site Description and Pictures

Site Description

The Burnt Mountain Seismic Observatory is located in the Yukon River Valley south of the Brooks Mountain Range at 67.42° north latitude and 144.61° west longitude. The two nearest settlements are Arctic Village, approximately 50 miles to the northwest, and Fort Yukon, approximately 56 miles south of the observatory. Fort Yukon is also the principal staging area for Air Force service operations to Burnt Mountain.



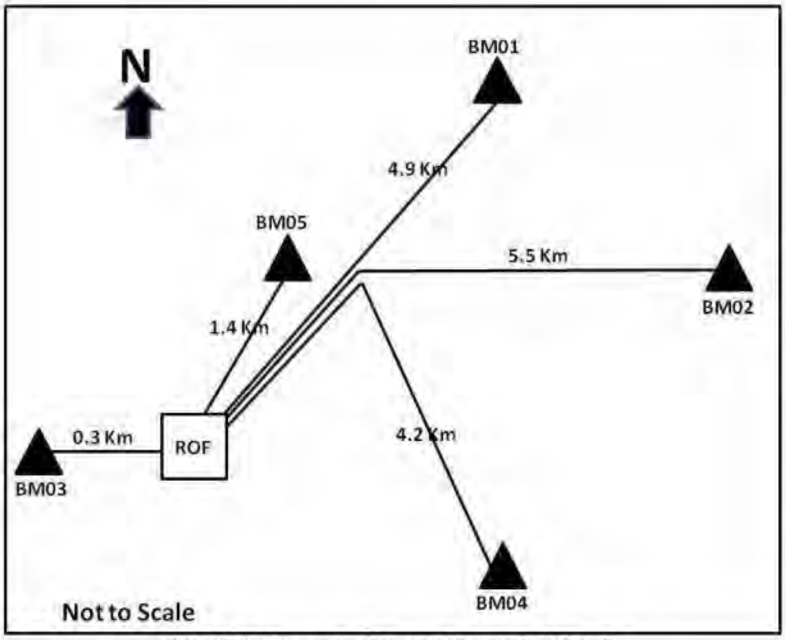


FIGURE A.1 Layout of Burnt Mountain Seismic Observatory Showing Distance Between Sites

The seismic observatory is made up of five individual sensor sites, which are identified as BM01, BM02, BM03, BM04, and BM05. Each site consists of a borehole for the seismic sensor and a wooden frame shelter for housing two RTGs and associated electronic equipment. For the purpose of data transmission, surface laid cables connect the five Remote Terminals (RTs) to the Remote Operating Facility (ROF), which is located near site BM03. Data from the RT sites is collected at the ROF and transmitted to Ft Yukon via line-of-sight UHF radio. Figure A.1 shows the layout of the Burnt Mountain Seismic Observatory. Security fences surround each equipment shelter and the area around each site is cleared to a diameter of approximately 100 feet. Two additional shelters are located at the ROF near site BM03. One serves as lodging for maintenance crews and the second shelters the all terrain service vehicle based at Burnt Mountain.

The terrain at Burnt Mountain varies from barren rocky ground to areas of considerable overhead and ground cover. Permafrost in the area is discontinuous, which requires detailed soil surveys be performed before embarking on construction projects. The elevation at Burnt Mountain is approximately 2000 feet above mean sea level (MSL). The nearest weather observatory is at Fort Yukon. Typical weather characteristics recorded at Fort Yukon are:

- Temperature: -71°F to +100°F
- Precipitation: 17 inches annually
- Wind Speed: Average < 5 kts (5.75 MPH), gusts to 35 kts (40 MPH), measured between Jan. 80 and Dec. 89.

Site Pictures

Site 1 (RTG S/N 8 & 10)

Site 2 (RTG S/N 9 & 20)

Looking from Site 5

Site 3 (RTG S/N 1 & 14)

Site 4 (RTG S/N 10 & 18)

Site 4 Between the trees

Site 5 (RTG S/N 4 & 19)

APPENDIX B – Radioisotope Thermoelectric Generator Descriptions

The following paragraphs are general descriptions of Teledyne RTGs. Actual weights of the RTGs associated with this transport will differ slightly due to variances in the manufacturing process. The serial numbers include here are provided to assist in understanding RTG design, not to establish specific RTG weights and dimensions.

1) SENTINEL 25A (S/N 004)

The Sentinel 25A generator is comprised of the following components: the fuel capsule assembly or heat source; an inner radiation shield; thermal insulation; a thermoelectric module; pressure housing and lid; and a finned radiator assembly. It is designed to operate within the following range of environmental conditions:

- Ambient air temperature -40°F to + 120°F*
- Ambient air pressure 20 to 32 inch Hg
- Seawater temperature + 28 ° F to + 90 ° F
- Seawater pressure Up to 500 psi
- Humidity 100% relative humidity in salt water atmosphere

* Will operate at rated power up to approximately 80°F.

The heat source for the Sentinel 25A is strontium-90, fabricated as SMO_3 and encased in a Hastelloy C capsule. The tungsten inner shield and cast iron housing reduce radiation levels to less than 10 mR/hr at one meter from the generator's surface. Approximately 5 percent of the heat produced by the decay of the radionuclide is converted to electricity by the thermo-electric module. The remainder of the heat is rejected as waste. Thermal insulation is used in the space between the inner shield and housing to channel the heat through the module.

The generator is a right circular cylinder with a cast iron housing. Its principle dimensions are shown in a following figure. The housing has four lugs spaced at 50 degree intervals on its bottom. Each lug has a hole that serves as a lifting and/or tie-down point. There is an additional lifting lug on the side of the generator. The generator will operate in either of the positions. Waste heat is partially dissipated through cooling fins which are an integral part of the generator's cover. The balance of the heat is rejected through the sides and bottom end.

The generator's electrical power outlet is a sealed 4-pin connector located on the side of the housing. One positive and one negative pin are provided. The connector is keyed by non-symmetrical pin spacing so that the shorting plug and RTG-PCU interconnecting cable cannot be mated incorrectly.

A shipping pallet is provided with the generator to facilitate handling and to provide a means of securing the generator during transport. The generator is attached to the pallet by four bolts. The generator weighs 3000 pounds and its shipping pallet weighs 285 pounds.

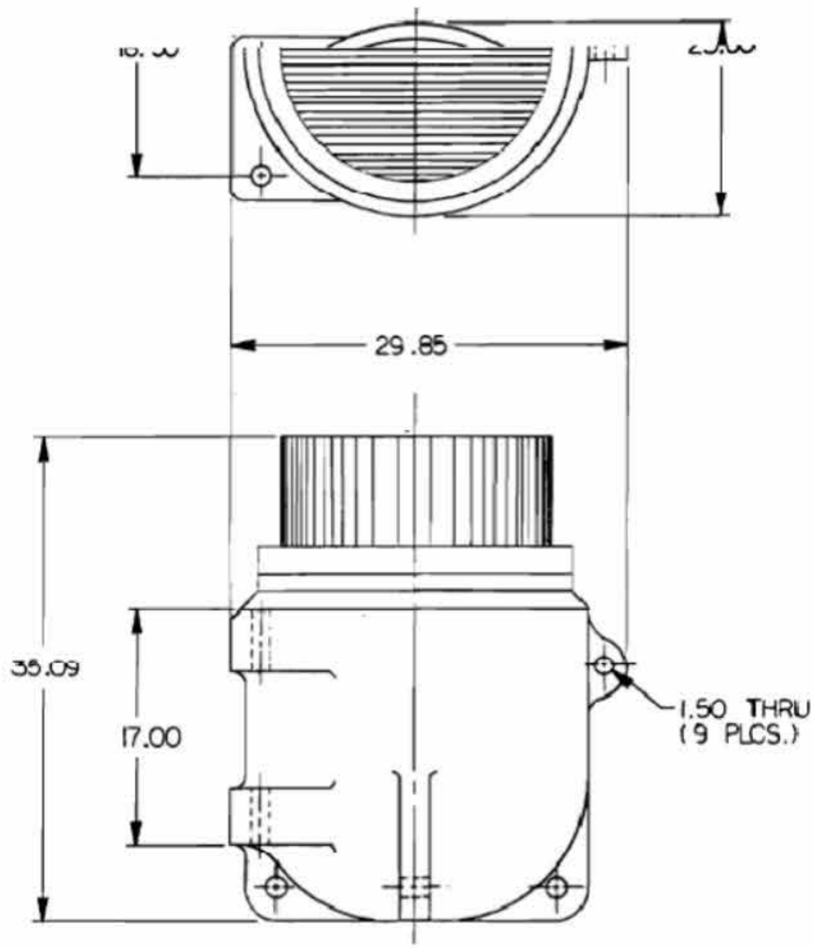
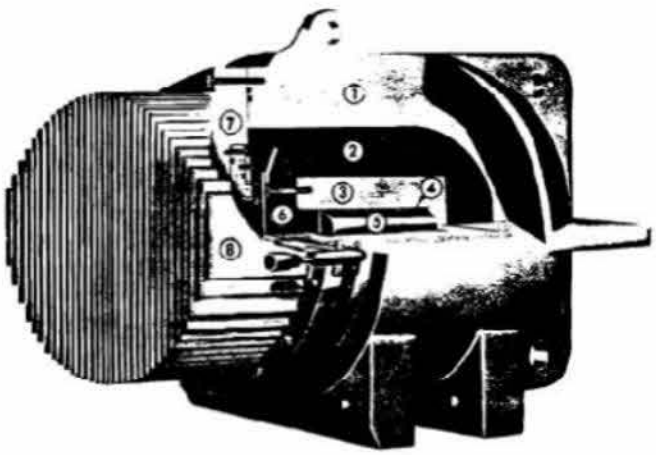


FIGURE II-2. SENTINEL 25A EXTERNAL DIMENSIONS (IN INCHES)



1 Housing
2 Insulation
3 Inner shield
4 Fuel capsule
5 $SrTiO_3$ fuel
6 Thermoelectric module
7 Lid
8 Auxiliary radiator

FIGURE II-1. SENTINEL -25A

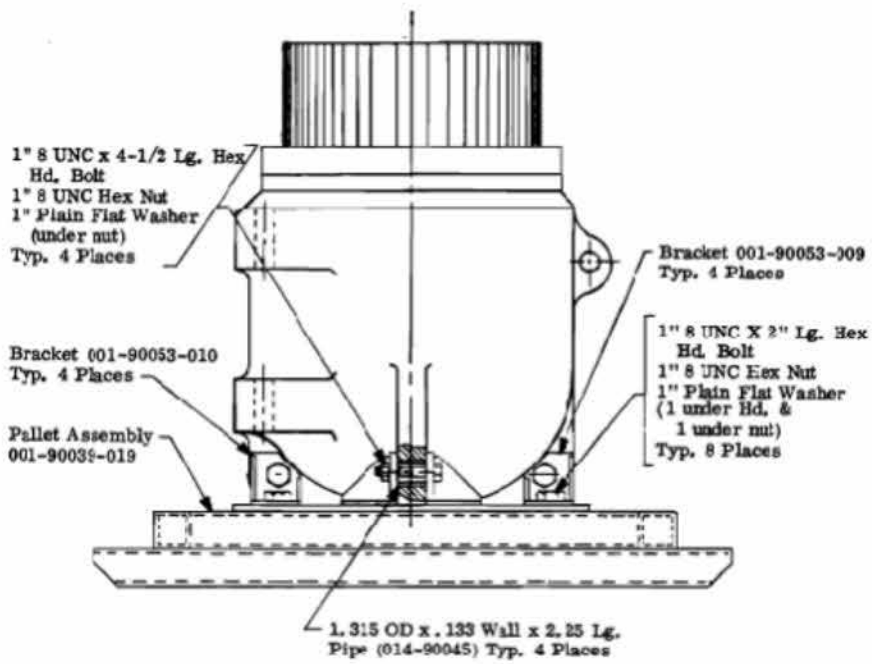


FIGURE II-4. SENTINEL 25A GENERATOR/SHIPPING PALLET MOUNTING HARDWARE

2) SENTINEL 25E (S/N's 008-010 and 017-020)

The Sentinel 25E generator consists of the following components: the fuel capsule assembly or heat source; an inner radiation shield; thermal insulation; a thermoelectric module; a pressure container consisting of a housing and lid; and a finned radiator assembly. It is designed to operate within the following range of environmental conditions:

• Ambient air temperature	-40°F to + 120°F*
• Ambient air pressure	0. 9 to 4 atmospheres
• Seawater temperature	28°F to 88°F
• Seawater pressure	Up to 10, 000 psi
• Humidity	0 to 100 percent in saltwater atmosphere

* Will operate at rated power up to approximately 80°F.

The heat source for the RTG is strontium 90 fabricated as strontium titanate and encased in nickel base superalloy capsule. (A fuel capsule using simulated fuel has successfully completed hydrostatic pressure tests to 17,500 psi.)

A tungsten shield block, into which the fuel capsule is inserted, provides the bulk of the unit's radiation shielding. This inner shield, coupled with the shielding provided by the generator housing, reduces radiation levels to less than 10 mR/hr at one meter from the generator's surface.

Approximately 5 percent of the heat produced by the decay of the radionuclide is converted to electricity by the thermoelectric module. Thermal insulation is used in the space between the inner shield and the housing to channel the heat through the module. The module is self-contained and sealed with its own inert atmosphere. The housing and the lid form the complete pressure containment for all of the components previously mentioned. The housing is in the form of a right circular cylinder and is machined from forged carbon steel. Its principle dimensions are shown on a following Figure. Threaded holes are provided in the housing for the purpose of attaching the generator to its shipping pallet via mounting brackets. The lid is also machined from forged carbon steel and is fastened to the housing by 16 alloy steel socket head bolts. The lid is machined with a flange, 27 inches in diameter and one inch thick that can be utilized as a mounting interface. The lid to housing interface is sealed with two Viton 'O' rings. (The pressure housing assembly has been successfully tested at external pressures up to 15, 000 psi with no detectable leakage.) Since only 5 percent of the decay heat is converted into electrical power, the remainder of the heat must be rejected. To accomplish this, the Sentinel 25E is provided with a finned radiator assembly. This assembly is fabricated from an

aluminum alloy and is bolted to the lid with 8 aluminum alloy bolts.

The electric power and instrumentation outlet for Sentinel 25 E Serial Nos. 017, 018, 019, and 020 is a sealed 8 -pin connector located on the side of the lid. Four of the connector pins are used for power connections (two positive leads and two negative leads) and the remaining four pins are used for two chromel-alumel thermocouples. Both thermocouples are located on the hot plate of the thermoelectric module. Receptacles on S/N's 008, 009, and 010 DO NOT have pins for thermocouple outputs. All receptacles are keyed by nonsymmetrical pin spacing so that the shorting plugs and RTG-PCU interconnecting cables cannot be mated incorrectly.

The Sentinel 25E weighs 4165 pounds and its shipping pallet weighs 285 pounds.

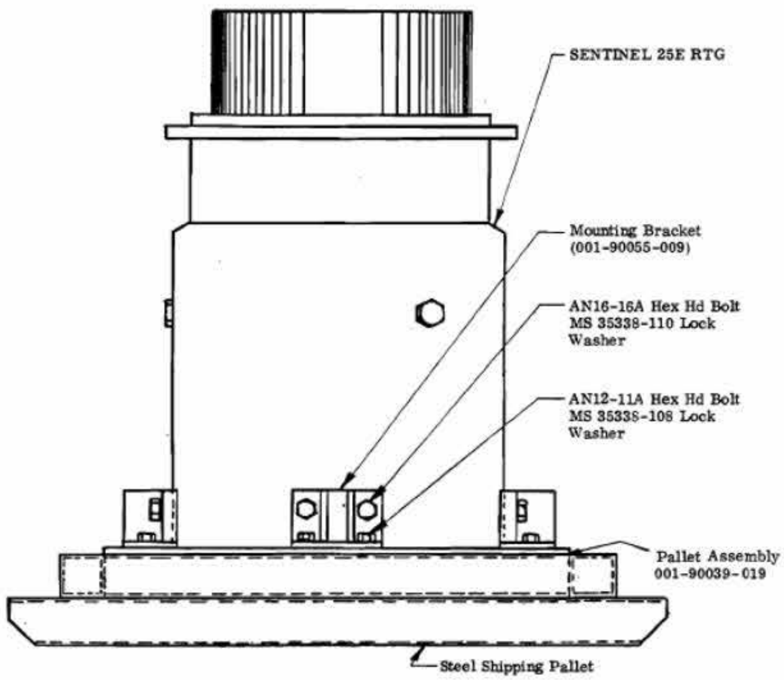
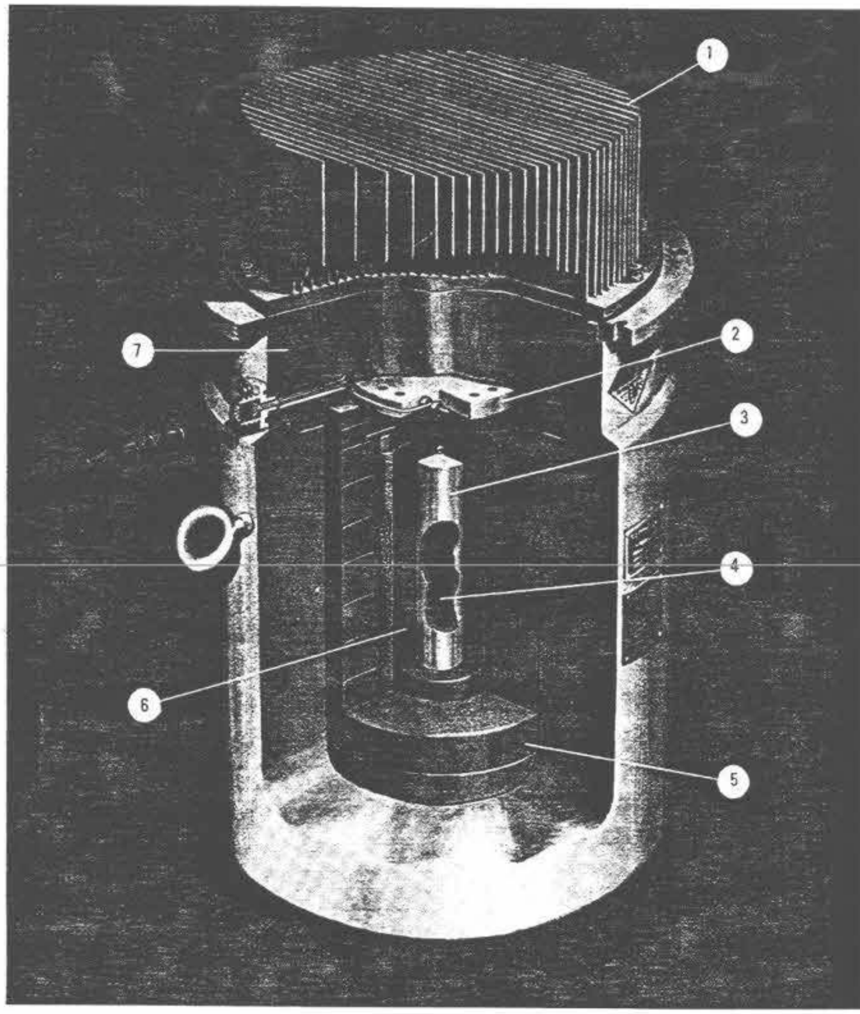


FIGURE II-7. SENTINEL 25E GENERATOR/SHIPPING PALLET MOUNTING HARDWARE



(1) Auxiliary Finned Cooling Head (2) Thermoelectric Converter (3) Fuel Capsule (4) Radioisotope Heat Source (5) Thermal Insulation (6) Radiation Shield (7) Pressure Vessel Housing Lid

FIGURE II-5. SENTINEL 25E GENERATOR

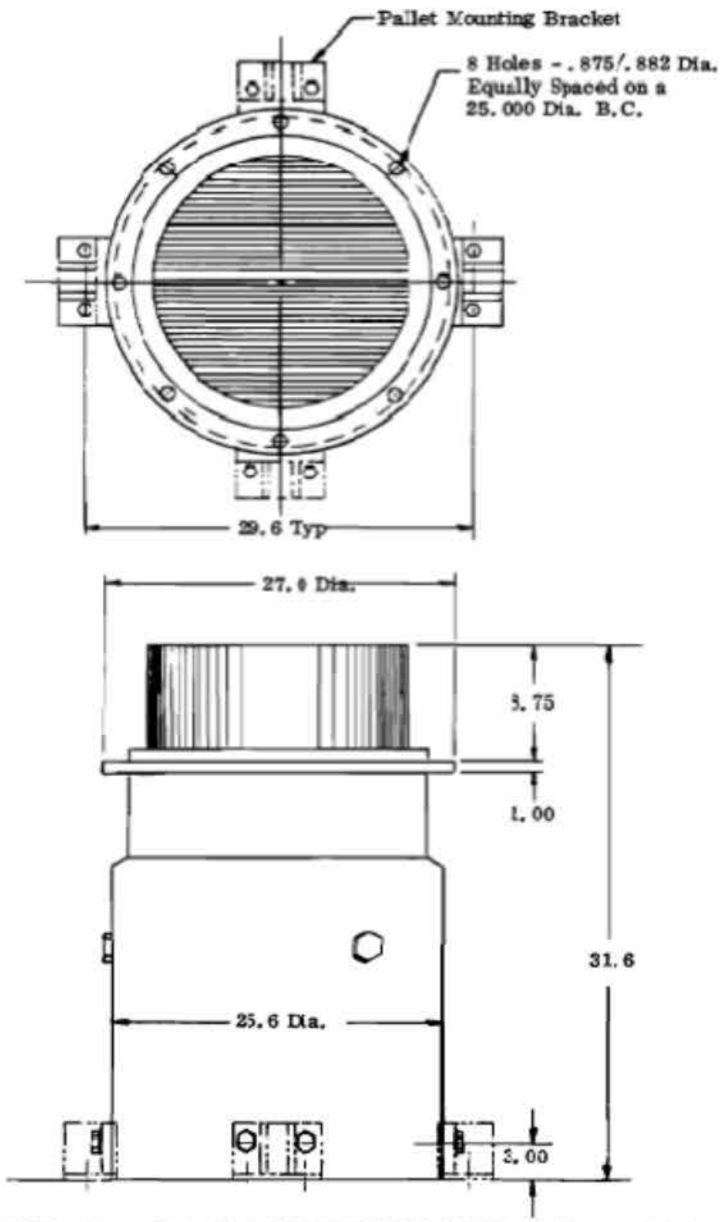


FIGURE II-6. SENTINEL 25E EXTERNAL DIMENSIONS (IN INCHES)

3) SENTINEL 25F (S/N 014)

The Sentinel 25F generator is comprised of the following components: the fuel capsule assembly or heat source; a radiation shield; thermal insulation; a thermoelectric module; a pressure housing; a lid; and a finned radiator assembly. It is designed to operate within the following range of environmental conditions

- Ambient air temperature -40°F to + 120°F*
- Ambient air pressure 0. 9 to 4 atmospheres
- Seawater temperature 28*F to 88'F
- Seawater pressure Up to 500 psi
- Humidity 0 to 100 percent in saltwater atmosphere

* Will operate at rated power up to approximately 80^0 F.

The fuel or heat source for the RTG is strontium 90, fabricated as strontium titanate, and encased in a stainless steel liner and then in a nickel base superalloy fuel capsule.

A tungsten shield block, into which the fuel capsule is inserted, provides the unit's radiation shielding. This shield, coupled with the inherent spacing provided inside the generator housing, reduces radiation levels to less than 10 mR/hr at one meter from the generator's surface.

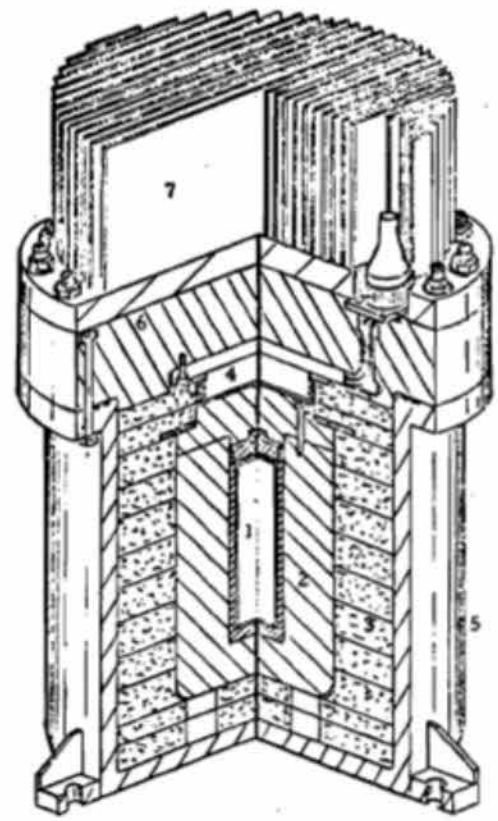
Approximately 5 percent of the heat produced by the decay of the radionuclide is converted to electricity by the thermoelectric module. Thermal insulation is used in the space between the shield and the housing to channel the heat through the module. The module is self-contained and sealed with its own inert atmosphere.

The housing and the lid form the complete pressure containment for all of the components previously mentioned. The housing is in the form of a right circular cylinder. Its principle dimensions are shown on a following Figure. The housing is machined from a welded assembly of 6061-T6 aluminum. Four welded brackets are provided on the housing base for the purpose of attaching the generator to its shipping pallet. The lid is also machined from 6061-T6 aluminum and is fastened to the housing by 14 aluminum alloy bolts. The lid to housing interface is sealed with two Viton 'O' rings. A similar housing assembly has been successfully tested at external pressures up to 750 psi with no detectable leakage or deformation.

Since only 5 percent of the decay heat is converted into electrical power, the remainder of the heat must be rejected. To accomplish this, the Sentinel 25F is provided with a finned radiator assembly. This assembly is also fabricated from an aluminum alloy and is bolted to the lid and

vessel flange with 16 aluminum alloy bolts. The generator's electric power and instrumentation outlet is a sealed 8-pin connector located on the top surface of the lid. Four of the connector pins are used for power connections (two positive leads and two negative leads) and the remaining four pins are used for two chromel-alumel thermocouples. Both thermocouples are located on the hot plate of the thermoelectric module. The connector is keyed by non-symmetrical pin spacing so that the shorting plugs and RTG-PCU interconnecting cable cannot be mated incorrectly.

The Sentinel 25F weighs 1360 pounds and its shipping pallet weighs 285 pounds.



1. Heat Source
2. Biological Shield
3. Thermal Insulation
4. Thermoelectric Module
5. Pressure Housing
6. Lid
7. Finned Radiator Assembly

FIGURE II-9. SENTINEL 25F GENERATOR

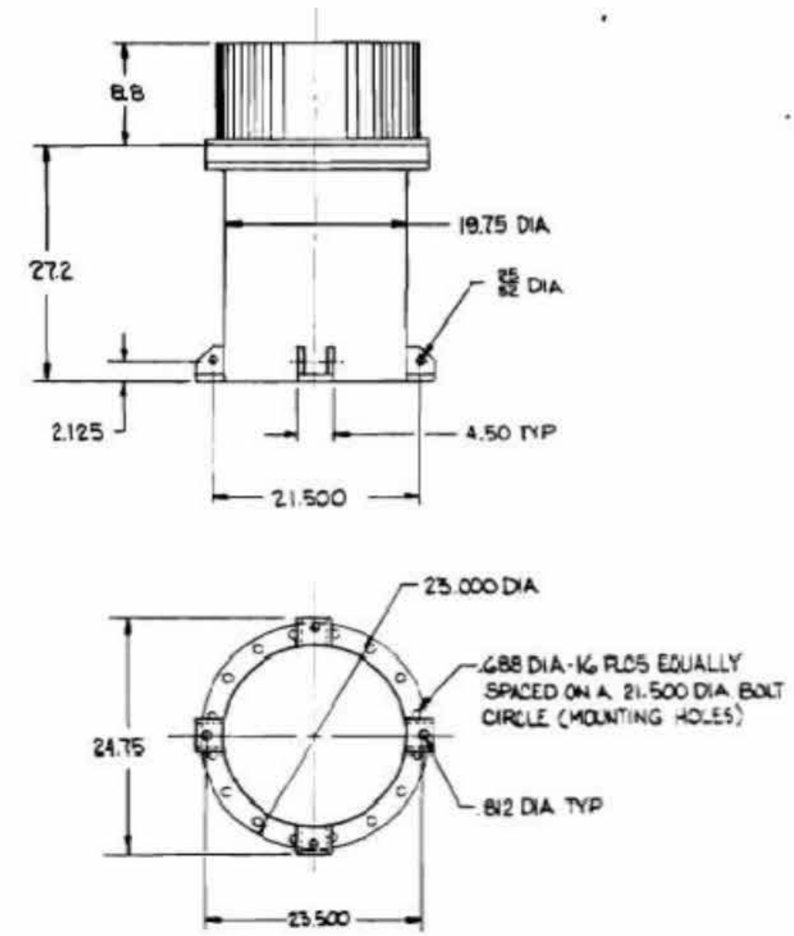


FIGURE II-10. SENTINEL 25F EXTERNAL DIMENSIONS (IN INCHES)

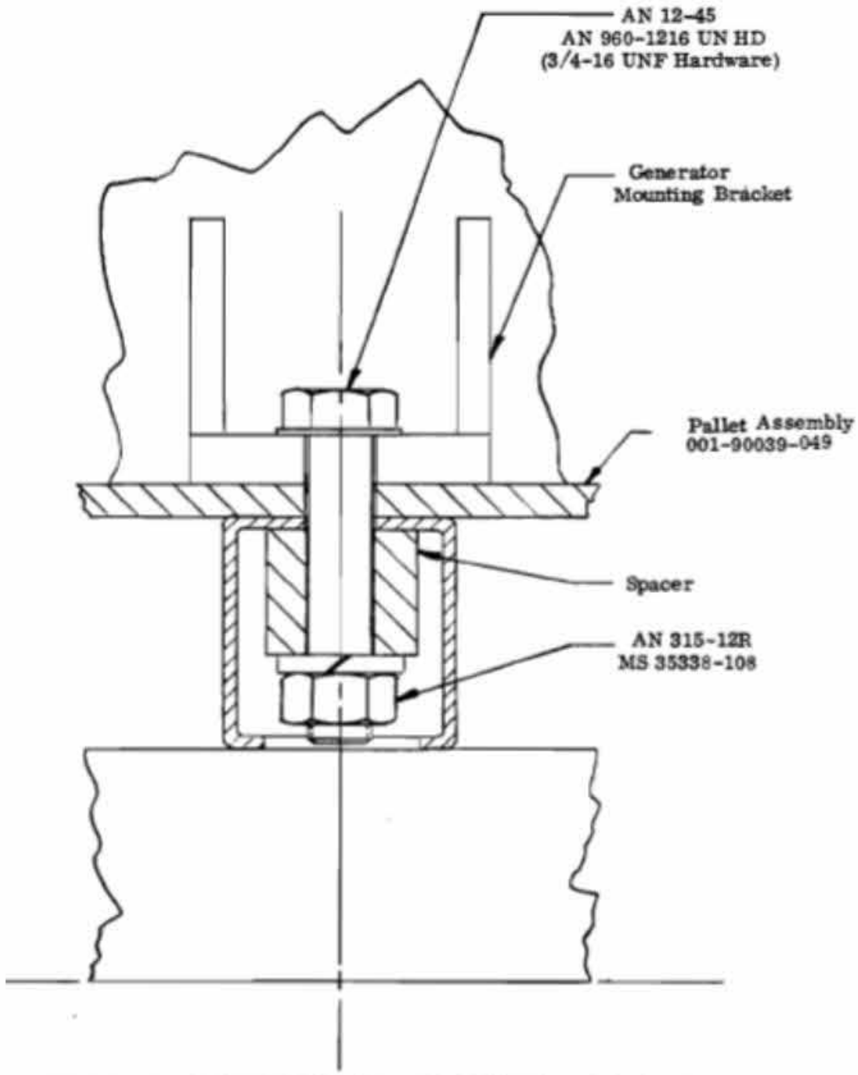


FIGURE II-11. SENTINEL 25F GENERATOR/SHIPPING PALLET MOUNTING HARDWARE

4) SENTINEL 100F (S/N 001)

The Sentinel 100F generator is comprised of the following components: a fuel capsule assembly or heat source; a radiation shield; thermal insulation; a thermoelectric module, a housing and lid, and a finned radiator. It is designed to operate within the following range of environmental conditions:

- Ambient air temperature -10° F to + 120° F*
- Ambient air pressure 0. 9 to 4 atmospheres
- Seawater temperature 28° F to 88° F
- Seawater pressure Up to 500 psi
- Humidity 0 to 100 percent in saltwater atmosphere

* Will operate at rated power up to approximately 80°F.

The fuel capsule assembly is the RTG's heat source. The assembly consists of pelletized strontium 90 in the titanate form, encased in a nickel base superalloy capsule.

The RTG's radiation shield is a tungsten assembly which houses the fuel capsule. The assembly consists of a shield body and end plug and is fabricated from pressed and sintered tungsten. The shield, coupled with the inherent spacing inside the generator housing, reduces radiation levels to less than 10 mR/hr at one meter from the generator's surface.

Approximately six percent of the heat produced by the decay of the radionuclide is converted to electricity by the thermoelectric module. The module is self-contained and sealed with its own inert atmosphere.

Thermal insulation is used in the space between the shield and the housing to direct most of the heat through the thermoelectric module. The thermal insulation material is Min-K, a Johns Manville Corporation product. The insulation is "baked out" prior to installation to drive off water vapor and organic binder materials. Getter materials are utilized in the RTG to capture long-term out gassing products.

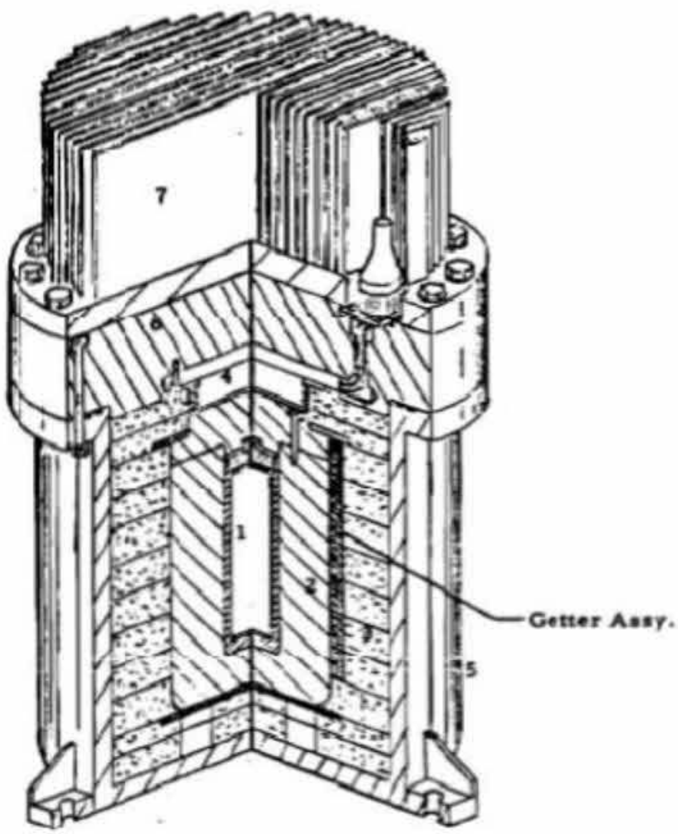
The housing and lid form the complete pressure vessel containing all of the components previously discussed. The housing is in the form of a right circular cylinder. Its principle dimensions are shown on a following Figure. The housing is machined from a welded assembly of 6061-T6 aluminum. Four welded brackets are provided on the housing base for the purpose of attaching the RTG to its shipping pallet. The lid is also machined from 6061-T6 aluminum

and is fastened to the housing by 18 aluminum alloy bolts. The lid to housing interface is sealed with two Viton O-rings.

Since only about six percent of the decay heat is converted into electrical power, the remainder of the heat must be rejected. The heat rejection is accomplished by means of a finned radiator bolted to the RTG lid. The radiator is comprised of a number of fins made from 1/8 inch thick aluminum sheet welded to a 6061-T6 aluminum alloy plate. The assembly is bolted through the lid with 16 aluminum alloy bolts and nuts.

The generator's electric power and instrumentation outlet is a sealed eight-pin connector located on the top surface of the lid. Four of the connector pins are used for power connections (two positive leads and two negative leads) and the remaining four pins are used for two chromel alumel thermocouples. Both thermocouples are located on the hot plate of the thermoelectric module. The connector is keyed by non-symmetrical pin spacing so that the shorting plug and RTG-PCU interconnecting cable cannot be mated incorrectly.

The Sentinel 100F weighs 2728 pounds and its shipping pallet weighs 385 pounds.



1. Heat Source
2. Biological Shield
3. Thermal Insulation
4. Thermoelectric Module
5. Pressure Housing
6. Lid
7. Finned Radiator

FIGURE II-13. SENTINEL 100F GENERATOR

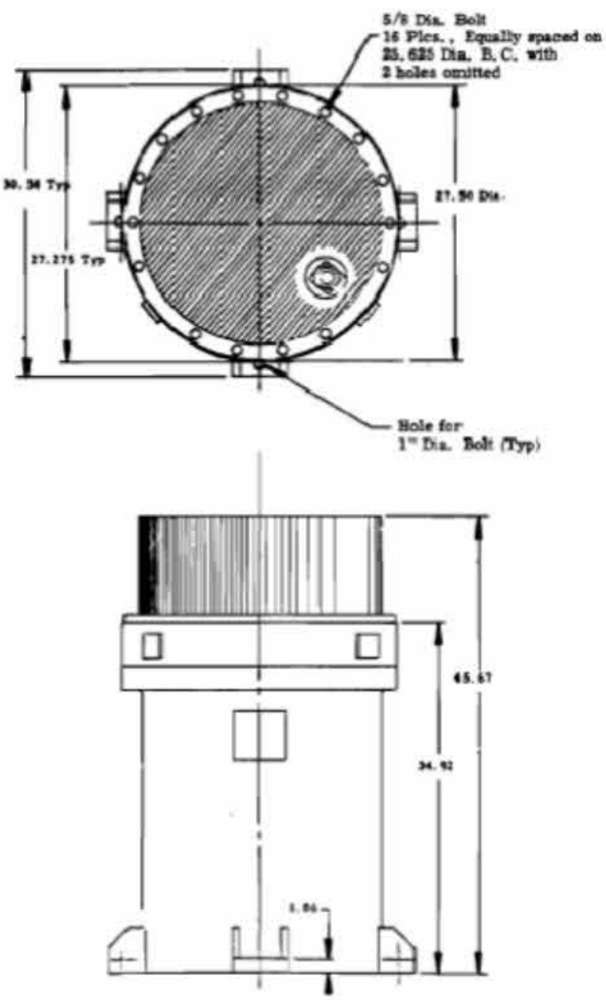


FIGURE II-14. SENTINEL 100F EXTERNAL DIMENSIONS (IN INCHES)

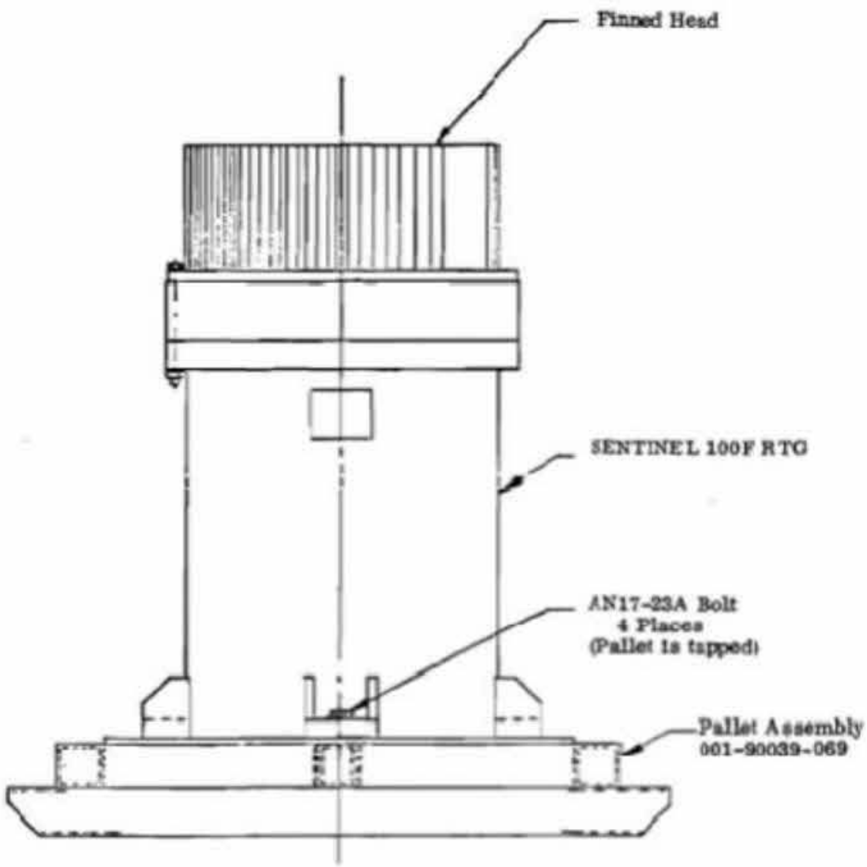


FIGURE II-15. SENTINEL 100F GENERATOR/SHIPPING PALLET MOUNTING HARDWARE

RTG Location and Characteristics				
	Sentinel 25A	**Sentinel 25E**	**Sentinel 25F**	**Sentinel 100F**
Burnt Mountain Site Location and number of RTGs	BM05 -1	BM01 - 2 BM02 -2 BM04 - 2 BM05 - 1	BM03 - 1	BM03 -1
Fuel	Strontium 90	Strontium 90	Strontium 90	Strontium 90
Housing material	Cast iron	Steel	Aluminum	Aluminum
Weight with the pallet (lbs)	3,285 each	4,450 each	1,645 each	3,113 each
Dimensions on the pallet, length x width x height (inches) for each of the RTGs. (Note 1: Rounded up to the nearest inch.) (Note 2: RTGs must not be covered and they should be kept at least one foot from bulkheads, other cargo, and any other obstructions, which might restrict the flow of air around the generators.)	51"L 44"W 43"H	51"L 44"W 50"H	51"L 43"W 47"H	56"L 44"W 57"H
Housing pressure rating (PSI)	500	10,000	750	500

APPENDIX C – Radioisotope Thermoelectric Generator Safety Summary

1) Safety Overview

A. Container Durability Requirements

To qualify as Type B containers, the RTGs must be able to withstand severe accidents without compromise in addition to normal transportation handling and minor accidents. They must meet all the performance requirements of Type A packages as defined in 49 CFR Parts 173.24, 173.411, and 173.412 and also survive the hypothetical accident conditions defined by the NRC in 10 CFR Part 71.73:

1. A free drop of nine meters (30 feet) onto a flat, unyielding horizontal surface, striking the surface in a position that would be expected to produce maximum damage
2. Impact by one meter by one meter (40 inches by 40 inches) 500 kilograms (1100 pounds) steel plate dropped from nine meters (30 feet) in a horizontal position onto the Type B package positioned on a flat, unyielding horizontal surface such that maximum damage would be expected to occur
3. A free drop of one meter (40 inches) in a position expected to produce maximum damage onto a vertical steel spike 15 centimeters (6 inches) in diameter and at least 20 centimeters (8 inches) long
4. A fully engulfing fire of at least 800 oC (1475 oF) for 30 minutes
5. Immersion in 15 meters (50 feet) of water, or, under a water pressure of 150 kPa (21.7 lb/in2)

B. Shielding Description and Background

The top cover, or shield plug, that encloses the fuel capsule assembly is fastened to the fuel capsule body with CRES-A-286 (corrosion resistant enhanced steel) plated bolts. The shield, coupled with the inherent material and spacing within the generator, combine to provide nominal radiation dose rates no greater than 10 mRem/hr at a distance of three feet. This level of radiation is in compliance with DOT requirements (49 CFR 173). A noticeable difference between the Sentinel 25 RTGs is the thickness of the tungsten biological shield. For example, in examining the engineering drawings 001E10000 (Sentinel 25E) and 001F10000 (Sentinel 25F), it is obvious that the tungsten biological shield is significantly thicker for the Sentinel 25F than it is for the Sentinel 25E. The primary reason for this is that the five inch thick steel housing on the Sentinel 25E contributed to the radiation attenuation, whereas the one inch thick aluminum used on for the Sentinel 25F housing does not help nearly as much for radiation attenuation. Consequently, there needs to be more tungsten on the F-series Sentinel RTGs (Sentinel 25F and Sentinel 100F) than any other design.

C. Summary of Safety Analyses

The NRC previously certified (NRC certificate numbers 4888 and 5862) the 10 RTGs as Type B containers. Each of the Sentinel RTGs at the BM sites were designed, and licensed, to act as their own shipping container, as seen in the Figure 1 below. As such, the design for the generators was subjected to significant review and analysis to ensure that the generator design complied with 10 CFR 71.79. Each generator was demonstrated, through various analyses, to be able to withstand the prescribed hypothetical accident scenarios. From the August 2011 Teledyne site inspection, it is believed that the generators at the BM array are in original transport condition and would satisfy the requirements of 10 CFR 71.79 (as the code existed when the generators were last certified as type-B( ) packages). Additionally, certain design aspects required further testing during the initial design/build of the

generator lifetime. Such analysis and studies are presented below, segregated by model type.

Figure 1. Shipment of Sentinel 25E RTGs from Teledyne Energy Systems to AFTAC.

2) Model Specific Summaries

A. Model 25A Safety Summary

Unfortunately, at this time, very limited information regarding the safety analyses of the Sentinel 25A can be found. This is partly due to the fact that the design of this model predates the other Sentinel RTGs by several years. It can be stated, however, that the Sentinel 25A RTG was licensed as its own type-B( ) shipping container (package certificate of compliance 4888). As such, the Sentinel 25A was shown to be able to survive the hypothetical accident conditions stipulated in 10 CFR 71. The Sentinel 25A RTG is a robust pressure vessel – marked by a thick cast-iron housing enshrouding a tungsten biological shield. The tungsten shield contains a stainless steel encased heat source that is doubly-encapsulated with Hastelloy C-276. The heat source contained, at beginning of life (BOL), approximately 95,000 Ci of $^{90}SrTiO_3$.

The heat source is a robust pressure vessel by itself. Rated for 10,000 psi external pressure with no predicted seal integrity failure, the Hastelloy C-276 encapsulation is well suited to withstand any of the hypothetical accident scenarios. Even though the fuel capsule is rated for 10,000 psi external pressure capability, the actual device was subjected to hydrostatic testing and demonstrated successful capability of up to 11,000 psi with no leaks or visible deformation and up to 17,500 psi without compromise of the containment capability (ref: INSD-3015). Each of the Sentinel 25 RTGs has the same heat source encapsulation. The same is true for the Sentinel 100F heat source, except for the size difference.

B. Model 25E Safety Summary

The Sentinel model 25E RTG is the single most robust RTG at the BM array. Constructed with a five inch thick steel housing, the RTG is rated for operation in deep ocean applications with an external pressure

of up to 5,000 psi with no impact on performance. The fuel capsule assembly in the RTG is doubly-encapsulated with Hastelloy C-276 and is rated for 10,000 psi external pressure with no significant deformation or leaks, although the fuel capsule has demonstrated capability of withstanding 11,000 psi without yielding and 17,500 psi without impacting the containment capability. As such, each Sentinel 25E in the possession of AFTAC was licensed as its own USA/B( ) shipping container and is documented on the certificate of compliance number 4888.

Due to the design differences of the Sentinel 25E, as well as the availability of documentation, two additional safety analyses are available – hydrostatic test report of the generator housing and a report on the housing impact capability (ref: INSD-3021). The Sentinel 25E RTG housings were successfully hydrostatically tested up to 15,000 psi with no visible leaks or deformation of the structure. The housings were subjected to four different pressure loadings (200 psi; 5,000 psi; 10,000 psi; and 15,000 psi) with a 15 minute hold at each pressure level.

The housing impact capability study (ref: INSD-3075) is the work performed in part to certify the Sentinel 25E as a USA/4888/B( ) package; specifically, the report summarizes analysis of the 9 meter drop onto a flat, unyielding surface and the 1 m drop onto a blunt, 15 cm diameter rigid cylinder. These are two of the four hypothetical accident scenarios spelled out in 10 CFR 71. As can be seen in the report, the Sentinel 25E RTG is fully capable of withstanding such impacts with no loss of integrity.

C. Model 25F Safety Summary

As with the Sentinel models 25A and 25E RTGs, the Sentinel model 25F RTG was designed, built, and licensed as its own shipping container – on the USA/4888/B( ) certificate of compliance. As such, it was demonstrated, through test and analysis, to be capable of withstanding the possible damage induced through the hypothetical accident scenarios as per 10 CFR 71 without loss of fuel containment. Furthermore, the fuel capsule present in the Sentinel 25F RTG is the same design as the ones present in the Sentinel 25A and 25E RTGs – one that is a stainless steel cladded heat source doubly-encapsulated in Hastelloy C-276 and was demonstrated, via hydrostatic pressure tests, to be able to withstand 11,000 psi of external pressure with no visible leaks or deformation and can withstand 17,500 psi without compromising the containment capability of the fuel capsule.

The Sentinel 25F RTG was analyzed for capability of satisfying the hypothetical accident scenarios as per 10 CFR 71. Specifically, the 9 meter drop requirement with no loss of fuel containment was of particular interest. Unlike the Sentinel 25E, which was shown to be capable of surviving the physical impacts with a safety factor of approximately 3, the one inch thick aluminum housing of the Sentinel 25F is not sufficiently robust to be able to survive all the damages induced by the 10 CFR 71 hypothetical accidents. Instead, the analyses assumed that the housing was absent from any impacts (only that it kept the insulation surrounding the tungsten biological shield). Still, the biological shield was determined to not be breached – and, consequently, the fuel capsule would have suffered no containment issues.

As is typical with other such licensed shipping containers, the Sentinel 25F (and, indeed, all the Sentinel model 25 RTGs) is designed such that the maximum dose rate at the surface of the generator is less than 200 mRem/hr. In fact, the maximum surface dose rate, at beginning of life (BOL), was expected to be 148 mRem/hr, easily satisfying the 200 mRem/hr requirement. At the time of last measurements (in early August, 2011), the surface dose rate for the Sentinel 25F RTG had a maximum of 50 mRem/hr.

D. Model 100F Safety Summary

Similar to the Sentinel 25 generators, the Sentinel 100F utilizes a $^{90}Sr_2TiO_4$ radioisotopic heat source to power the RTG. Initially loaded with 2167 Watts (328,400 Ci) of radioactive fuel, the heat source for the Sentinel 100F is pelletized strontium orthotitanate encased in a stainless steel liner – acting as a contamination protection barrier. These pellets are loaded together in a doubly-encapsulated Hastelloy C-276 fuel capsule. The fuel capsule is contained within a thick tungsten biological shield in order to minimize the radiation field at the surface of the generator. One notable difference between the Sentinel 25 RTGs and the Sentinel 100F is that, due to the significant size of the tungsten biological shield, a lower support plate was required in order to fully distribute the load on the fusil foam support structure. This analysis is fully presented in memo TPS-GG-065 (refer to section 7.2).

Like the Sentinel 25 RTGs, the Sentinel model 100F generator was designed to act as its own licensed shipping container – the USA/5862/B( ) shipping package. As such, it was designed, tested, analyzed, and demonstrated to be capable of withstanding the hypothetical accident scenarios in 10 CFR 71 while still maintaining containment of the radioisotopic fuel. Recognizing that the Sentinel 100F housing is a relatively thin 6061 aluminum shell affording little in the way of damage mitigation, the intent was to design the tungsten biological shield to be able to completely withstand the accidents and to provide the requisite protection to the fuel source encapsulation containment barrier. Thus, the analysis and testing of the tungsten biological shield were based upon the International Atomic Energy Agency (IAEA) Safety Series No. 33. This document requires that the shield be able to withstand a total of two drops: a 9 meter free fall drop onto a flat, unyielding surface and a 1 meter drop onto the flat edge of a 15 cm diameter mild steel bar. In both cases, the attitude of the shield must be oriented such as to cause maximum damage. In all cases, the Sentinel 100F tungsten shield assembly was demonstrated to satisfy the imposed requirements.

Finally, the Sentinel 100F RTG was designed to comply with 49 CFR 173; measurements taken around beginning of life (BOL) indicate that the maximum dose rate at the surface of the generator was less than 200 mRem/hr. Recent measurements (early August 2011) showed that the radiation dose rate at the surface of the generator is approximately 30 mRem/hr.

3) Safety Analyses Docs

INSD-3021	Hydrostatic Pressure Test; Sentinel 25E Housing Assembly
INSD-3051	Sentinel 25F Structural and Thermal Evaluation
INSD-3072	Hydrostatic Pressure Test; Sentinel 25 Fuel Capsule
INSD-3075	Sentinel 25E Generator Housing; An Evaluation of Impact Capability
INSD-3076	Structural Analysis; 100 Watt Sentinel RTG Fuel Capsule
INSD-3080	Structural and Thermal Evaluation of Sentinel 100F
S-VRL-142	Sentinel 25 Fuel Temperature Analysis
TPS-GG-065	100 Watt RTG Shield Support Analysis
Memo	100 Watt RTG Shield Impact Analysis

4) Unit Condition Summary

A. Pallet Condition

Figure 2. RTG Pallet Inspection Summary

Inspection		RTG		Structure Integrity Rating					Corrosion Protection Rating				
							Pallet/RTG Interface					Pallet/RTG Interface	
Site	Date	Model	S/N	Pallet Base	Eye Hooks & Shackles	Tie Down Tongue	Brackets	Fasteners	Pallet Base	Eye Hooks & Shackles	Tie Down Tongue	Brackets	Fasteners
BM1	8/1/2011	25E	008	V	E	N/A	E	E	V	E	N/A	E	V
		25E	017	G	E	N/A	E	E	V	E	N/A	E	V
BM2	7/31/2011	25E	009	V	E	N/A	E	E	V	E	N/A	E	V
		25E	020	V	E	N/A	E	E	V	E	N/A	E	V
BM3	7/28/2011	25F	014	V	E	N/A	N/A	E	G	E	N/A	N/A	E
		100F	001	V	E	E	N/A	E	V	E	E	N/A	E
BM4	7/30/2011	25E	010	V	E	N/A	E	E	V	V	N/A	E	V
		25E	018	V	E	N/A	E	E	V	E	N/A	E	V
BM5	7/29/2011	25A	004	G	E	N/A	E	G	G	N/A	N/A	E	P
		25E	019	V	E	N/A	E	E	V	V	N/A	E	V

Structural Ratings

E	No defects
V	Structurally insignificant defects on noncritical structure
G	Structurally significant defects on noncritical structure
P	Structurally insignificant defects on critical structure
U	Structurally significant defects on critical structure
N/A	Not Applicable

Corrosion Protective Ratings

E	Protective coating intact with no discernable corrosion
V	Cosmetic corrosion and/or isolated nicks & abrasions
G	Light localized corrosion
P	Moderate generalized corrosion with light pitting
U	Heavy generalized corrosion and pitting
N/A	Not Applicable

1. Structural Inspection Results (based upon Teledyne Inspection performed in 2011)

All structural pallet features were inspected for signs of damage, weakness, and problematic corrosion. None of the pallets' structural members were found to be structurally compromised. All welds appeared to be structurally sound with no significant corrosion damage. The steel structural members and lifting elements all appear to be in excellent shape with little more than superficial surface corrosion. Threaded fastener oxidation was found to range from negligible to light (on the model 25A pallet) corrosion, but the most severe corrosion case was not predicted to significantly degrade the strength of these fasteners. The inspection results suggest that the pallets' present structural capabilities roughly approximate their original "as built" strength capabilities. The pallets are structurally acceptable for RTG handling and transport.

Spot Welded Assemblies are particularly corrosion prone due to entrapment of corrosive agents between the parts of the assemblies. Corrosive attack causes skin buckling or spot weld bulging (refer to Figure 3), and eventual spot weld fracture. Skin and spot weld bulging may be detected in their early stages by sighting or feeling along spot welded seams. This condition is prevented by keeping potential moisture entry points such as gaps, seams, and holes created by broken spot welds filled with a sealant or a suitable preservative or CPC.

Figure 3. Model 25A RTG S/N 004 Frame Weld Corrosion

2. Structural Differences

   The 001-90039 drawing suggests that the standard model 25F pallet should look similar to the model 100F pallet. The fielded unit, however, appears to be mounted on a modified model 25E pallet without the model 25E Pallet/RTG interface brackets.

   The model 25A pallet design (Figure 4) shares many features with the 001-90039-019 pallet (Figure 5), but appears to pre-date this design. This speculation was based on the weld joining the pallet/RTG interface brackets to the base plate, which is a feature not found on any other 001-90039 pallet design. Additionally, the model 25A pallet has no lifting eyes.

Figure 4. Model 25A Pallet

Figure 5. 001-90039-019 Pallet

B. Generator Condition

Each generator was also structurally assessed. Some minor corrosion and damage to fins exists, but engineers determined it did not degrade the capability of the RTG for transport. The Teledyne Energy Solutions Trip Report provides detailed inspections results. Summaries from this report for each unit are included here.

1. Site BM 01; Model 25E S/N 008

   The inspection results suggest that the pallet assembly for the model 25E RTG S/N 008 is structurally acceptable for continued generator handling and transportation. The pallet structure was found to be in excellent shape other than minor handling nicks and abrasions, which are not predicted to measurably degrade the original load carrying capability of this structure.

2. Site BM 01; Model 25E S/N 017

   The inspection results suggest that the pallet assembly for the model 25E RTG S/N 017 is structurally acceptable for continued generator handling and transportation. The pallet structure was found to be in excellent shape with minor handling nicks, abrasions, and dings which are not predicted to measurably degrade the original load carrying capability of this structure. The flame-cut base plate holes (Figure 6.) will have little influence on structural capability because the base plate is primarily a redundant load path for all lifting and handling operations.

Figure 6. Model 25E RTG S/N 017 Flame Cut-Out Through Pallet Base Plate (8 Places)

3. Site BM 02; Model 25E; S/N 009

   The inspection results suggest that the pallet assembly for the model 25E S/N 009 is structurally acceptable for continued generator handling and transportation. The pallet structure was found to be in excellent shape other than minor handling nicks and abrasions, which are not predicted to measurably degrade the original load carrying capability of this structure.

4. Site BM 02; Model 25E; S/N 020
   The inspection results suggest that the pallet Assembly for the model 25E RTG S/N 020 is structurally acceptable for continued generator handling and transportation. The pallet structure was found to be in excellent shape other than minor handling nicks and abrasions, which are not predicted to measurably degrade the original load carrying capability of this structure.

5. Site BM 03; Model 25F; S/N 014
   The inspection results suggest that the pallet assembly for the model 25F RTG S/N 014 is structurally acceptable for continued generator handling and transportation. The pallet structure was found to be in excellent shape other than minor handling nicks and abrasions, which are not predicted to measurably degrade the original load carrying capability of this structure.

6. Site BM 03; Model 100F; S/N 001
   The inspection results suggest that the pallet assembly for the model 100F RTG S/N 001 is structurally acceptable for continued generator handling and transportation. The pallet structure was found to be in excellent shape other than minor handling nicks and abrasions, which are not predicted to measurably degrade the original load carrying capability of this structure.

7. Site BM 04; Model 25E; S/N 010
   The inspection results suggest that the pallet assembly for the model 25E RTG S/N 010 is structurally acceptable for continued generator handling and transportation. The pallet structure was found to be in excellent shape other than minor handling nicks and abrasions, which are not predicted to measurably degrade the original load carrying capability of this structure.

8. Site BM 04; Model 25E; S/N 018
   The inspection results suggest that the pallet assembly for the model 25E RTG S/N 018 is structurally acceptable for continued generator handling and transportation. The pallet structure was found to be in excellent shape other than minor handling nicks and abrasions, which are not predicted to measurably degrade the original load carrying capability of this structure.

9. Site BM 05; Model 25A; S/N 004
   The inspection results suggest that the pallet Assembly for the model 25A RTG S/N 004 is structurally acceptable for continued generator handling and transportation. The pallet structure shows some signs of corrosion and minor handling nicks and abrasions, but none of these are predicted to measurably degrade the original load carrying capability of this structure.

10. Site BM 05; Model 25E; S/N 019
    The inspection results suggest that the pallet assembly for the model 25E RTG S/N 019 is structurally acceptable for continued generator handling and transportation. The pallet structure was found to be in excellent shape other than minor handling nicks and abrasions, which are not predicted to measurably degrade the original load carrying capability of this structure.

C. Shorting Plug Condition

Inspection was performed on each RTG's shorting plug. A full visual examination was conducted as well as physically evaluating the condition of the shorting plug, pins, mating collar, rubber mating interface, and, where applicable, the shorting connection on the back end of the plug. Each shorting plug exhibited proper electrical continuity through the power pins and the resistance was appropriate for a shorting plug (sufficiently low). The rubber mating interface for each plug was in excellent condition – sufficiently pliable and showed no signs of dry rot or other deterioration. All the plugs had proper electrical isolation between the power pins and the backshell of the connector (ensuring personnel safety during the installation/removal of the shorting plug). One anomaly was observed – the mating collar on the shorting plug for RTG S/N 018 (25E at BM 05) seemed a bit rough. There is no indication that the plug would not properly mate to the generator, only that there may be slightly more resistance in tightening the collar of that shorting plug. It was noted, however, that due to the slight design variations in the RTG design from 1968 through 1971, there were some notable differences in the output power connectors for some of the RTGs; as such, it is recommended that the shorting plugs not be confused with each other and be maintained with the proper RTG. Some of the output power connectors on the RTGs do not have thermocouple sockets – making mating with a shorting plug with thermocouple pins impossible.

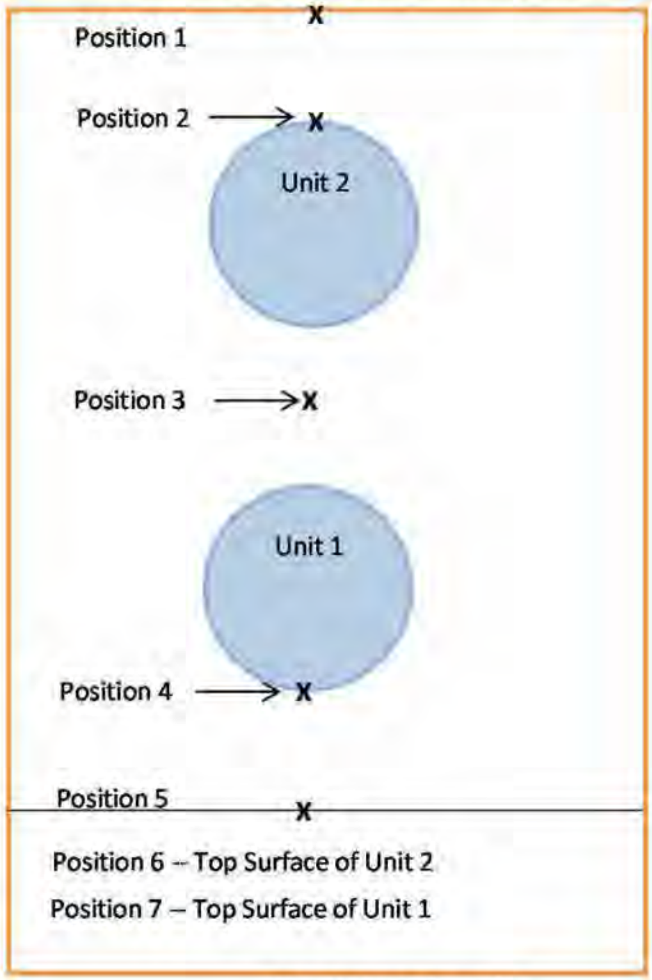
5) Unit Radiation Summary

Radiation Field Exposure Rates (mRem/hr) as of Dec 11

Site	Model	Units	Pos. 1	Pos. 2	Pos. 3	Pos. 4	Pos. 5	Pos. 6	Pos. 7
BM 01	25E	1 - 017	4.5	28	13	20	0.8	0.4	0.5
	25E	2 - 008							
BM 02	25E	1 - 020	4.5	14	12	14	0.8	1	0.3
	25E	2 - 009							
BM 03	100F	1 - 001	5.8	50	14	28	1.1	1.1	4.7
	25F	2 - 014							
BM 04	25E	1 - 010	5	22	11	13	0.8	0.5	0.6
	25E	2 - 018							
BM 05	25E	1 - 019	6	28	12	29	0.5	15	11
	25A	2 - 004							

AFTAC Transportation Plan for RTG

Radiation Field Measurement Points



Drawing not to scale

Date of Activity: 15-Aug-14

Site Location	ISOTOPE	INITIAL ACTIVITY (Ci)	DATE OF INITIAL ACTIVITY	CURRENT ACTIVITY (Ci)	MANUF	MODEL NUMBER	SERIAL NUMBER
BM1	Sr-90	72,300.0	1-Aug-85	33,645	Teledyne	Sentinel 25E	8
BM1	Sr-90	81,100.0	1-Aug-85	36,899	Teledyne	Sentinel 25E	17
BM2	Sr-90	74,400.0	1-Aug-85	34,637	Teledyne	Sentinel 25E	9
BM2	Sr-90	81,100.0	1-Aug-85	35,650	Teledyne	Sentinel 25E	20
BM3	Sr-90	328,400.0	1-Aug-85	127,657	Teledyne	Sentinel 100F	1
BM3	Sr-90	79,900.0	1-Aug-85	36,092	Teledyne	Sentinel 25F	14
BM4	Sr-90	72,900.0	1-Aug-85	33,869	Teledyne	Sentinel 25E	10
BM4	Sr-90	81,100.0	1-Aug-85	35,956	Teledyne	Sentinel 25E	18
BM5	Sr-90	87,100.0	1-Aug-85	29,439	Teledyne	Sentinel 25A	4
BM5	Sr-90	81,100.0	1-Aug-85	35,688	Teledyne	Sentinel 25E	19
			TOTAL:	439,532			

AFTAC RTG Transportation Plan

APPENDIX F – Transportation Elements

The transportation of licensed radioactive material by the Department of Defense requires the adherence to the following requirements:

Department of Transportation (DOT): 49 CFR Parts 171 – 178, 379
Nuclear Regulatory Commission (NRC): 10 CFR Part 37 and 71
Department of Defense (DoD): DTR 4500.9-R
USAF: AF Manual 24-204

1) RTG Characteristics (Activity, Weight and Dose Rates)

Site	RTG S/N	Model	Beginning of Life (BOL)	Initial Activity (Ci)	Current Activity1 (Ci)	Current Activity1 (TBq)	Sr-90 Weight (lbs.)
BM 01	017	25E	Apr. 1971	109,300	37,664	1,394	0.58
	008	25E	Feb. 1969	105,200	34,414	1,273	0.53
BM 02	020	25E	Apr. 1971	105,600	36,389	1,346	0.55
	009	25E	Feb. 1969	108,300	35,428	1,311	0.54
BM 03	001	100F	Mar. 1972	328,400	115,693	4,281	1.78
	014	25F	Dec. 1970	107,800	36,852	1,364	0.57
BM 04	010	25E	Feb. 1969	105,900	34,643	1,282	0.53
	018	25E	Apr. 1971	106,500	36,699	1,357	0.57
BM 05	019	25E	Apr. 1971	105,700	36,424	1,357	0.57
	004	25A	Apr. 1968	94,000	30,136	1,115	0.46

Note 1: Activity of Sr-90 fuel as of 1 July 2015

WEIGHTS AND DIMENSIONS

Model	Serial Number	Isotope	Half life yrs	Pallet Dimensions	RTG Dimensions	Volume	Weight
25A	RTG4	Sr-90 (Y-90)	28.78	51"Lx44"Wx43"H	29.85"Wx35.09"H		3245 lbs
25E	RTG9	Sr-90 (Y-90)	28.78	51"Lx44"Wx50"H	27.0"Wx31.6"H	65 ft^2	4415 lbs
25E	RTG8	Sr-90 (Y-90)	28.78	51"Lx44"Wx50"H	27.0"Wx31.6"H	65 ft^2	4415 lbs
25E	RTG20	Sr-90 (Y-90)	28.78	51"Lx44"Wx50"H	27.0"Wx31.6"H	65 ft^2	4415 lbs
25E	RTG19	Sr-90 (Y-90)	28.78	51"Lx44"Wx50"H	27.0"Wx31.6"H	65 ft^2	4415 lbs
25E	RTG18	Sr-90 (Y-90)	28.78	51"Lx44"Wx50"H	27.0"Wx31.6"H	65 ft^2	4415 lbs
25E	RTG17	Sr-90 (Y-90)	28.78	51"Lx44"Wx50"H	27.0"Wx31.6"H	65 ft^2	4415 lbs
25E	RTG10	Sr-90 (Y-90)	28.78	51"Lx44"Wx50"H	27.0"Wx31.6"H	65 ft^2	4415 lbs
100F	RTG1	Sr-90 (Y-90)	28.78	56"Lx44"Wx57"H	27.94"Wx45.67"H	73 ft^2	3025 lbs
25F	RTG14	Sr-90 (Y-90)	28.78	51"Lx43"Wx47"H	23"Wx45"H	57 ft^2	1598 lbs
						Total	**38773 lbs**

RTG Measured Radiation Dose Rates (as of 14 July 2009)

Location: Burnt Mtn	Action Limit: mR/hr	Site: BM05		Site: BM01		Site: BM04		Site: BM03		Site: BM02	
RTG Serial Numbers:	-	019	004	017	008	010	018	001	014	020	009
30' from gate (BACKGROUND)	0.05	0.1 mR/hr		0.1 mR/hr		0.1 mR/hr		0.1 mR/hr		0.1 mR/hr	
Outside entrance gate	0.5	BKG		BKG		BKG		BKG		BKG	
Outside building door	1.0	BKG		BKG		BKG		BKG		BKG	
Outside inner cage (work area)	2.0	0.1 mR/hr		0.1 mR/hr		0.1 mR/hr		0.1 mR/hr		0.1 mR/hr	
1 meter from generator end	10	1.4 mR/hr	2.25 mR/hr	0.5 mR/hr	0.5 mR/hr	0.2 mR/hr	0.5 mR/hr	0.1 mR/hr	2.2 mR/hr	0.5 mR/hr	0.5 mR/hr
1 meter from junction of	20	2.0 mR/hr		0.2 mR/hr		3.0 mR/hr		8.0 mR/hr		2.3 mR/hr	
On contact with side	50	15 mR/hr	15 mR/hr	15 mR/hr	14 mR/hr	12 mR/hr	10 mR/hr	20 mR/hr	28 mR/hr	11 mR/hr	22 mR/hr
RTG Surface Temp in degrees F	-	96.2	98.1	99.5	98.0	100.9	102.1	114.9	103.1	81.9	80.3
Ambient Air Temp in degrees F	-	76.2		86.8		95.4		67.1		63.3	

2) PACKAGING

The RTGs contain radioactive material in quantities requiring approved packaging. The RTGs were designed as certified Type B packaging. The packaging was previously certified by NRC to the B( ) package standards in 10 CFR Part 71. Although NRC certification expired 1 October 2008, NRC authorized limited use of the package based on the history of safe use and absence of unfavorable operational data and in accordance with NRC's Regulatory Issue Summary (RIS) 2008-18, Information in Requests for Extending Use of Expiring Transportation Packages. The package was designed, fabricated, and certified (by NRC) to meet the requirements and standards applicable for B( ).

IAW Title 49 CFR 173.7(a) of the Department of Transportation (DOT) hazardous materials regulations, and under the authority established in AFI 24-210_IP (DLAD 4145.41, AR 700-143), Packaging of Hazardous Material, the DOD has issued a Certificate of Equivalency (AF 14-19) for the RTG packaging. Each of the Sentinel RTGs were designed, and licensed, to act as their own shipping container. The RTG's packaging has been evaluated by DOE and was found to meet the requirements of 10 CFR Part 71 with respect to containment, shielding, and criticality. The RTG packaging and transportation controls provide a level of safety equivalent to compliant packaging (i.e. Type B(M)-96)

3) CLASSIFICATION AND PROPER SHIPPING NAME

Proper Shipping Name: Radioactive Material, Type B (M) package
Hazard Class: Class 7
UN Identification Number: UN2917
Form: Solid (Normal Form), Oxide
Packing Group: N/A
Label: Radioactive Yellow III (Highway Route Controlled Quantity)
Special Permit: USAF issued Certificate of Equivalency AF 14-19

4) SHIPPING PAPERS / MARKING

See USAF issued Certificate of Equivalency AF 14-19 for specific requirements of shipping papers:

SHIPPING PAPER		Page 1 of 1
To: DOE Nevada National Security Site		From: USAF Burnt Mountain, Alaska
QUANTITY	10 packages	
HAZARDOUS MATERIAL	RQ	
DESCRIPTION	ID Number	UN2917
	Shipping Name	Radioactive material, type B(M) package
	Hazard Class	7 - HRCQ
	Physical Form	Normal Form
	Chemical Form	Strontium Titanate ($SrTiO_3$)
	DOD Package ID	AF 14-19
	Radionuclide	Strontium-90
	Label	Radioactive Yellow-III (HRCQ)

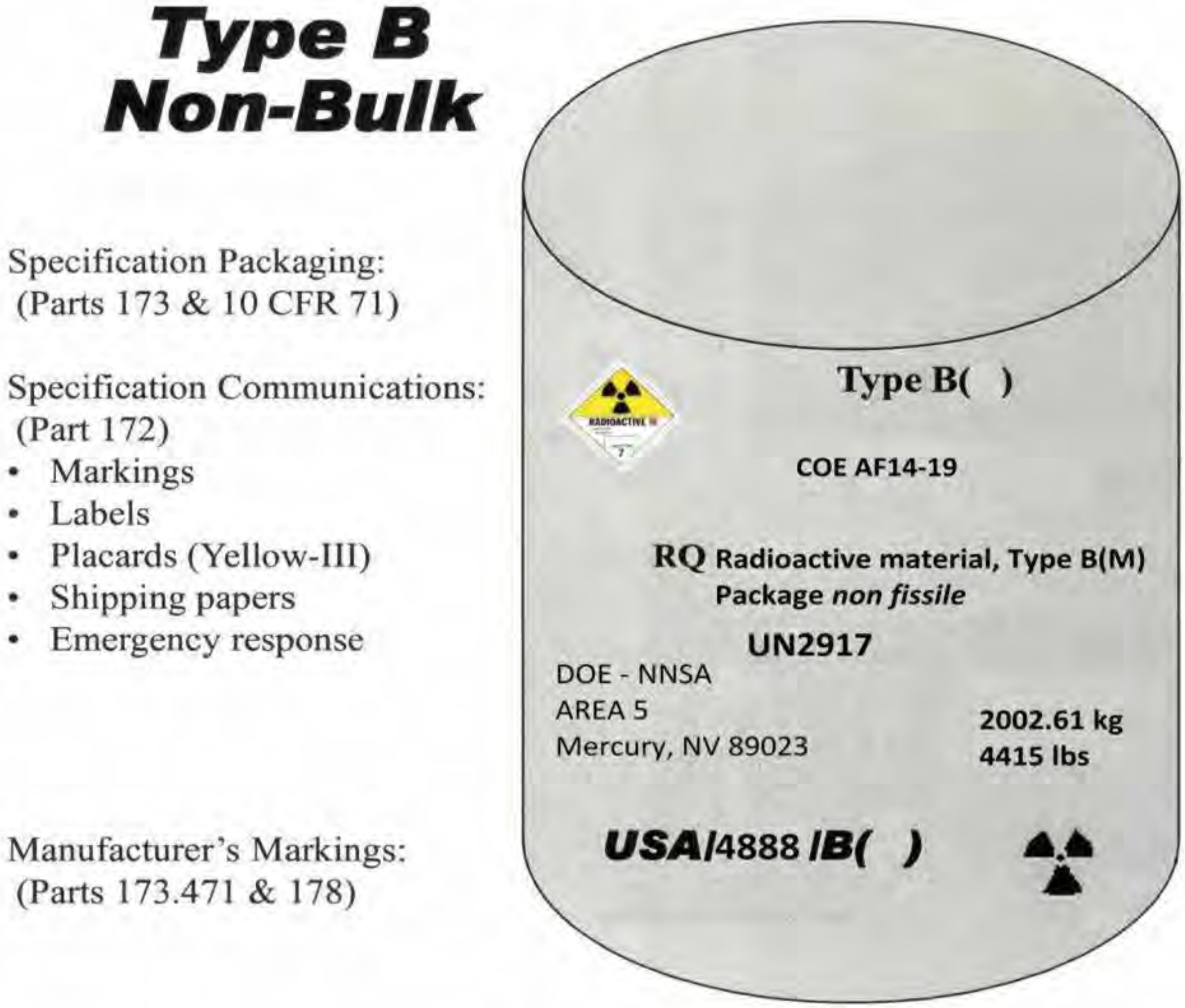


Figure 1 Example Markings

DoD direction is to comply with communication markings as required by the Defense Transportation Regulation, AFMAN 24-204 and 49 CFR to the fullest extent possible. It may be unreasonable to apply certain markings dependent on location of the RTGs due to site restrictions. The final determination for markings will be determined by the hazardous material shipper, permit RSO and DOE Sandia National Labs personnel.

A. Packages with a gross mass greater than 50 Kg must have the gross mass marked on the outside of the package, include the units of measurement §172.310(a)
B. Each package that conforms to the requirement of Type B must be marked on the outside of the package "TYPE B(M)" or "TYPE B(U)" in letters 13 mm high as appropriate §172.310(b)
C. Type B package must be marked with the international vehicle registration code of the country of origin (USA) §172.310(c)
D. Trefoil symbol for Type B packages §172.310(d)

5) LABELING

DoD direction is to comply with labeling as required by the Defense Transportation Regulation, AFMAN 24-204 and 49 CFR to the fullest extent reasonable. It may be unreasonable to apply certain labels dependent on location of the RTGs due to site restrictions. The final determination for labeling will be determined by the hazardous material shipper, permit RSO and DOE Sandia National Labs personnel.

A. "Radioactive Yellow-III"
B. Highway Route Controlled Quantity must be labeled Radioactive Yellow-III §172.403 Table – Footnote 1
C. Two labels required on opposing sides of package §172.403(f)
D. The blank spaces on the label must contain the following:
   1. Radionuclide §172.403(g)(1)
   2. Activity in SI units (Bq, MBq, TBq, etc.) §172.403(g)(2)
   3. Transport Index §172.403(g)(3)

6) PLACARDING

RADIOACTIVE warning placards will be displayed such that each placard will be clearly visible.

For air travel the RTGs are being transported in an aircraft but not in a freight container or unit load device. The labeling will be completely visible; therefore, placarding will not be required during air transport.

A. Placards required for any conveyance with a package with a Yellow-III label §172.504 Table 1
B. Special placard required for Highway Route Controlled Quantity (HRCQ) §172.507

7) Highway Route Controlled Quantity (HRCQ)

A. Routing regulations for (HRCQ) §397.101
B. Drivers of HRCQ must have a route plan in his possession. The route plan must have specific information §397.101(d)(1)(2)
C. The Driver must have specific training and have a training certificate in his possession with this information §397.101(e)(1)(2)

8) CONTAMINATION CONTROL

Radioactive contamination limits as specified in 49 CFR §173.443 Contamination Control, Table 9:

Table 9—Non-Fixed External Radioactive Contamination Limits for Packages

Contaminant	Maximum permissible limits		
	Bq/cm^2	uCi/cm^2	dpm/cm^2
1. Beta and gamma emitters and low toxicity alpha emitters	4	10^{-4}	220
2. All other alpha emitting radionuclides	0.4	10^{-5}	22

Contamination measurements will be taken at each location during transportation in accordance with the methods specified in 49 CFR § 173.443 Contamination Control. Locations include all five Burnt Mountain sites, Eielson AFB, Creech AFB, and NNSS. See Appendix G - Transport and Handling for the details of the contamination measurements.

9) TRAINING

A. Radiological safety training will include the following:
   1. General awareness/familiarization training. Each employee will be provided general training designed to provide familiarity with the requirements of handling radiological material to include radiation control, monitoring, and reporting.
   2. Function-specific training. Employees performing specific activities, such as testing radiation levels, moving the RTG packages, providing site security, etc, will be trained in the risks associated with each activity and the appropriate handling methods.
   3. Safety training. Employees will receive training as detailed in Appendix M concerning:
      - Emergency response information
      - Measures to protect the employee from the hazards associated with the RTGs
      - Methods and procedures for avoiding accidents with the RTGs.

B. Security training. Each employee will receive training that provides an awareness of security risks associated with the RTG transport and methods designed to enhance transportation security.

C. OSHA, EPA, and other training. Employee training will comply with Occupational Safety and Health Administration (OSHA) standards.

D. A record of current training will be retained by AFTAC for the duration of the RTG transfer effort. The record will include:
   1. The hazmat employee's name;
   2. The most recent training completion date of the hazmat employee's training;
   3. A description, copy, or the location of the training materials used to meet the training requirements of this section;
   4. The name and address of the person providing the training; and
   5. Certification that the hazmat employee has been trained and tested.

APPENDIX G – RTG Transport and Handling (Implementation Plan)

1) EMERGENCY NOTIFICATION INFORMATION:

LOCATION	COMMAND POST	POLICE DEPT	FIRE DEPT	RAD SAFETY OFFICER
AFTAC	321-494-4333	N/A	N/A	Mark Talbert: 321-494-4851 (cell: (b)(6)
Eielson AFB	907-377-1500	907-377-5130	907-377-2178	Maj Scott Boyd: 907-377-6690 Lt Robyn Pack: 907-377-6687/6602 (On Call Cell: (b)((b)(6)
Creech AFB	702-652-2446	702-652-2311	702-404-0864	Maj Richard Kice: 702-653-3316 (On Call Cell: (b)(6)
Indian Springs	N/A	702-879-3333	702-879-3330	N/A
NNSS	702-295-0311	Operations Coordination Center		

2) OVERVIEW

A total of ten RTGs will be transported from Burnt Mountain (BM) to the Nevada National Security Site (NNSS) using multiple modes of transport. The ten RTGs are comprised of four types varying in weight, quantity of radioactive material and radiation dose rates. RTG weights range from 1598 – 4415 pounds (See Appendix F for specific weights). Transport is planned for approximately 10 days; however, contingency planning to account for weather, mechanical, or logistical delays includes temporary storage, on-site security, etc.

The RTG was designed and manufactured as a certifiable package IAW Nuclear Regulatory requirements. The RTG is comprised of multiple containments to include a bioshield to reduce personnel exposures to radiation.

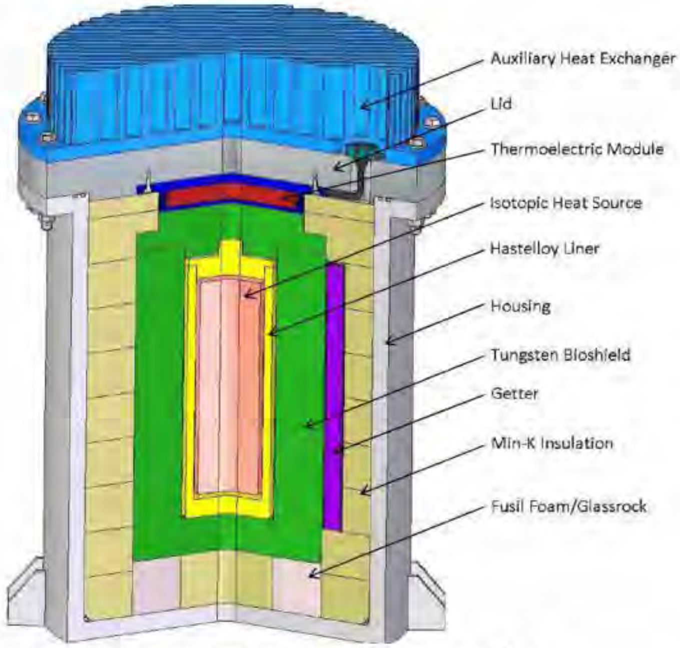


Figure 1. Cross-Section View of Sentinel 25F

3) PROCEDURES

A. Radiation Surveys and RTG Contamination Survey Procedures

1. All personnel working in close proximity of the RTGs will be issued and wear dosimetry, as required by the RSO, and have received radiation safety training. This includes:
   a. DOD personnel
   b. DOE personnel
2. The maximum radiation dose on contact with any single RTG does not exceed 50 milirem per hour. When stored in close proximity, aggregate dose rates may exceed 50 millirem per hour. Dose rate measurements will be performed by trained personnel, who have the knowledge to identify abnormal dose rate conditions. Equipment used to conduct surveys must be approved by the RSO.
3. Prior to entering the RTG area , a background radiation check is performed as follows:
   a. At a minimum of 50 ft from the RTGs take a one minute survey to establish background.
   b. The measurement should be less than 0.05 milliroentgen per hour (mR/hr).
   c. Approach the RTGs until 2 mR/hr is measured. Personnel within this area will be trained in Radiation Safety and will require dosimetry.
   d. Surveys will be conducted around the surrounding area to establish a zone for dose rates above 2 mR/hr, or where dose rates may allow an untrained/not monitored individual to exceed 100 mREM in a calendar year.
   e. Additional surveys will be conducted to document exposure rates to personnel.
   f. All surveys will be documented on forms provided by the AFTAC RSOs.
4. Contamination surveys will be conducted and documented to ensure damage has not occurred to the RTG and to provide documented analysis of RTG capsule integrity.
   a. Following satisfactory radiation measurements, swipes will be taken on each RTG as follows (ensure each swipe is placed into a sealed bag):
   b. Use a clean filter paper disc to perform three swipes of each RTG.
      i. Use one filter disc to swipe 180 degrees of the generator seam. The seam is where the lid joins the housing.
      ii. Use another filter disc to swipe the remaining circumference of the generator.
      iii. Use a third filter disc to swipe around the seam where the power plug enters the generator.
   c. Swipes will be counted on a portable instrument provided by AFTAC RSOs IAW iSolo Alpha/Beta Counter Procedure.

B. Burnt Mountain (AK) RTG Disconnect Procedures

1. Current configuration
   a. External electrical connections to each RTG are made through a single, multi-pin, threaded connector.
   b. The two RTGs in each shed are currently connected to a power conditioning unit (PCU) in each shed by two connecting cables: one cable connects one RTG to one input of the PCU; a

second cable connects the second RTG to the second input of the PCU. The PCUs in all of the sheds are identical and will work with any of the RTG pairs.

2. Electrical disconnection
   a. Unscrew both RTG cables from the PCU.
   b. Disconnect all wires from the terminal block located on top of the PCU.
   c. Remove PCU from wall and place with other PCUs for shipment with the RTGs.
   d. Label each RTG cable to identify the RTG to which it is connected.
   e. Unscrew multi-pin connecting cable from each RTG.
   f. Coil the cable and place with other cables for shipment with the RTGs.
   g. Install the RTG's 'shorting plug' on the RTG connector.
      i. The shorting plug is required per Teledyne document 'Operation manual for Sentinel Radioisotope Thermoelectric Generators used in AFTAC Seismic Sensor Stations, Burnt Mountain, Alaska', Report No. TES-3198, Revised June 1985. Page II-25 states "RTGs must be placed on "short-circuit" whenever they are shipped, during periods of storage, and whenever they are disconnected from their PCUs for more than 2 hours."
      ii. The connector is keyed by nonsymmetrical pin spacing so the shorting plug and RTG-PCU connecting cable cannot be mated incorrectly.

C. Handling Procedures

1. General.
   a. Sentinel RTGs will be handled by forklifts with the forks fully engaged under the attached RTG pallet.
   b. When secured to a 463L pallet, RTGs will be handled by forklifts with the forks fully engaged under the 463L pallet.
   c. All handling equipment will have a safe working load sufficiently greater than the weight of the RTG/pallet combination and have been weight-tested.
   d. RTGs will be secured to the forklift when transported without the 463L pallet.
   e. When transported on 463L pallets, the RTGs will be secured to the pallet using approved tie-down configuration.
   f. When transported by K Loader, aircraft, flatbed trailer etc, the RTG will be secured to the vehicle whether on or off the 463L pallet using manufacturer provided tie-down procedures for the RTGs.
   g. Always place adequate support dunnage under 463L pallets by installing a minimum of three 4-inch by 4-inch pieces at least as long as the pallet. This will aid in the movement of the pallets and will protect the lower surface from damage.
   h. 463L pallets will be handled in accordance with Technical Order 35D33-2-2-2 463L Air Cargo Pallets.
2. Cautions.
   a. RTGs should be handled with reasonable care as their thermoelectric modules are relatively brittle and open/short circuits can develop if the RTG is handled roughly.
   b. RTGs should never be dropped or pulled along a surface.
   c. Forklift operators shall use extreme care when lifting, transporting and placement of RTGs.

d. Forklift operators should be certified, be familiar/practiced with the specific forklift for this operation, and know how to traverse inclines and rough terrain.
e. Ground transportation drivers will avoid rough roads whenever possible.
f. RTGs should not be covered and should be kept at least 1 foot from bulkheads, other cargo, and any other obstructions that might restrict the flow of air around the generators.
g. Use caution when working around the cooling fins to avoid damage.
h. Avoid placing any items on top of the cooling fins.

D. Tie-down Procedures

1. 49 CFR 393, Federal Motor Carrier Safety Regulations, tie-down requirements.
   a. The aggregate working load limit (WLL) of tie-downs used to secure an article or group of articles against movement must be at least one-half times the weight of the article or group of articles.
   b. A minimum of two tie-downs if the article is 5 ft or less in length and more than 1,100 lbs in weight; or greater than 5 ft but less than 10 ft, regardless of weight.
2. Tie-down specifications
   a. RTGs will be secured with tie-down straps or chains and secured to vehicles while being transported.
   b. Chains will have 10,000lb load capability.
   c. Tensioners will be Style A MB-1 MIL-DTL-25959 Type1.
   d. Straps will be rated to a load of at least 10,000 lbs.
   e. Chains will be tensioned by hand until secured with a maximum deflection of ¾ inch.
   f. The aggregate WLL is 20,000 pounds. Credit can only be given for 1/2 the WLL of each strap because the straps will go from an anchor point on the RTG to an anchor point on the vehicle/463L. Thus 10,000 x 1/2 x 4 = 20,000.
3. Tie-down configurations
   a. Forklift tie-down procedures/configuration.
   Straps will secure the RTG to the forklift as indicated in Figure 2.

Figure 2. Forklift Tie-down Configuration

b. 463L pallet tie-downs should be attached as shown in Figure 3.
RTG will be centered on the 463L pallet, with a sheet of plywood between the 463L and the RTG pallets, and chains will be fastened at each corner of the generator pallet and attached to a suitable anchor point on the 463L pallet.

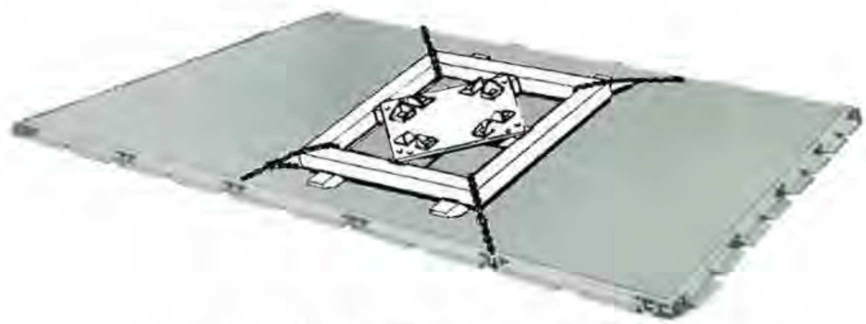


Figure 3. 463L Pallet Tie-down Configuration

c. Flatbed trailer tie-downs should be attached as shown in Figure 4 if the 463L pallet is not used and Figure 5 if the 463L pallet is used. Chains will be fastened at each corner of the generator pallet and attached to a suitable anchor point on the flatbed trailer. Or Chains will be fastened to a suitable attachment point on the 463L pallet and attached to a suitable anchor point on the flatbed trailer.

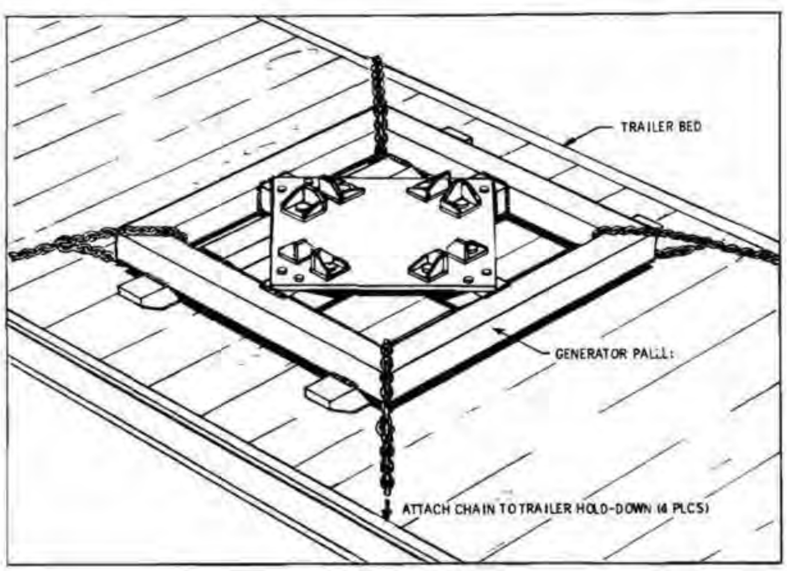


Figure 4. RTG - Flatbed Trailer Tie-down Configuration

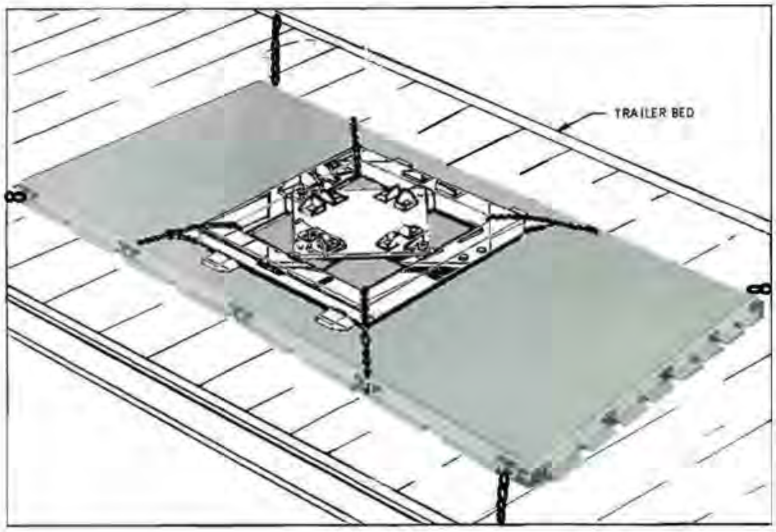


Figure 5. 463L – Flatbed Trailer Tie-down Configuration

E. 463L Pallet Inspection Procedures

1. Inspect pallets to assure serviceability.
   a. Do not use pallets if the aluminum skin is separating.
   b. Use pallets with minor dents, gouges, and scratches that do not fracture the skin.
   c. Extensive damage such as bent rails or damaged/missing tie-down rings, the pallet will not be accepted for use.

F. RTG Inspection Procedures

All RTGs must be inspected before and after transport. Inspections will be performed by DOD or DOE personnel. Personnel will ensure to maintain their exposures As Low As Reasonably Achievable and may be required to wear personal dosimetry.

1. Pallet Assembly Inspection (Structural Integrity/Welds)
   a. Wipe down pallets to remove loose dust/dirt/debris while performing cursory visual inspection for obvious structural defects, damage, wear, corrosion, and design anomalies.
   b. Perform thorough visual pallet inspection. Use mirrors and illumination to inspect underside surfaces and welds. Record all findings.
      i. The frame welds should be inspected for cracking, pitting and paint debonding.
      ii. Any paint debonding in the weld zones should be more closely inspected.
      iii. Scrape away the loose paint to determine the cause of the debond.
      iv. If the debond is corrosion-related then evaluate the extent of the corrosion.
      v. If the corrosion is primarily cosmetic (no pitting) then the weld is considered structurally sound.
   c. Record any structural defects, damage, wear, corrosion and design anomalies.
      i. Cracks in pallet welds greater than 0.75 inches require DOD and DOE personnel evaluation.
      ii. Missing reinforcement brackets require DOD and DOE personnel evaluation.

iii. Weld separations (sometimes appearing as cracked or broken welds) require DOD and DOE personnel evaluation.
iv. Any cracking or severe pitting in the weld zones would be justification for further investigation.

d. Document the physical condition of pallets.

2. Generator Inspection
   a. Housing
      i. Visually examine the condition of the RTG housing.
      ii. Check for dents and gouges.
      iii. Check for missing or obscured markings.
      Note: Minor paint flecks and chips have been noted and do not degrade the capability of the RTGs for transport.
   b. Cooling Fins
      i. Visually examine the condition of the cooling fins.
      ii. Check for broken or bent fins.
      iii. Examine fins for excessive corrosion.
      Note: Minor corrosion and damage to fins exists, but Teledyne engineers determined it did not degrade the capability of the RTGs for transport.
   c. Shorting plug
      i. Visually examine the condition of the shorting plug, pins, mating collar, rubber mating interface.
      ii. Check for broken or bent pins.
      iii. Confirm the mating collar is free of corrosion.
      iv. Examine the rubber mating interface for pliability and integrity - no signs of dry rot or other deterioration.
   d. Document the physical condition of the RTG.
3. Inspection results for each RTG will be documented on forms provided by the AFTAC RSOs.

Example Form

RTG #____ Inspection Results		
Inspected Component	**Structurally Acceptable Y / N**	**Comments**
Pallet Assembly		
Tube Frame		
Skids		
Base Plate		
Tie-Down Tongue		
RTG/Pallet Interface Brackets		
Generator		
Housing		
Cooling Fins		
Shorting Plugs		
Notes:		
NAME:__________________________**DATE:**__________		

G. AFTAC Systems Control Monitoring Procedures

1. Responsibilities during removal and transport:
   a. Systems Control will monitor the RTG status using current methods until the RTGs are disconnected from radios and the site. On-site personnel will take responsibility for RTG monitoring until the removal and transport is complete.
   b. Systems Control will receive daily phone calls indicating the health of the team and status of the removal actions, to include any deviations.

4) TRANSPORT ACTIVITIES

A. Preparatory Actions

Preparatory actions include required notifications, aircraft support, package approvals, equipment/vehicle procurement, personnel training, radiation dosimetry issuance, prepositioning of personnel and development of paperwork.

1. The following offices will be required to perform actions listed per time lines issued by the project officer:
   a. Det 460
      i. Request and confirm CH-47 support
      ii. Preposition I-Trac at Site 1
      iii. Acquire 463L pallet support dunnage
      iv. Request serviceable 463L pallets from Eielson AFB
      v. Coordinate delivery of 463L pallets to Ft Wainwright
      vi. Preposition plywood at all sites
      vii. Preposition steel plating at all sites
      viii. Obtain packaging for PCUs and associated cabling and ensure it goes to each site as RTGs are removed
      ix. Gather and pre-stage support equipment
      x. Conduct forklift driver training
      xi. Provide visitor personnel with BM overview to include provisions required
      xii. Prepare staging location with support dunnage for 463L pallets
      xiii. Remove shed fences at each site shortly before arrival by onsite Det 460 personnel
      xiv. Provide two-way radios in Alaska to ensure communication between participating personnel
   b. AFTAC Radiation Safety Officer (RSO)/Hazmat Shipping Certifier
      i. Provide notification to AF Radioisotope Committee to ensure 120 day NRC notification is accomplished
      ii. AF RIC will ensure state officials have been notified per 10 CFR and AFI 40-201
      iii. Pre-coordinate shipping paperwork for shipment of hazardous cargo
      iv. Identify and perform radiation safety training for all personnel
      v. Ensure adequate dosimetry is available for all personnel

- vi. Ensure adequate radiation safety instruments are available, operational, and calibrated
- vii. Coordinate with Army for radiation training and personnel dosimetry
- viii. Ensure Army POC for Hazmat shipment is notified
- ix. Develop overview of hazards for delivery to Wing Command Post
- x. Train Wing Command Post on emergency notification requirements
- xi. Coordinate with Installation RSOs
- xii. Amend permit as required
- xiii. Develop paperwork for transfer of RTGs to DOE

c. AFTAC/LS
- i. Coordinate and request SAAM

d. Eielson
- i. Prepare Crisis Action Center (CAC) to receive RTGs
- ii. Clear hanger or a minimum of 45 x 35 ft of staging space within hanger
- iii. Remove hazardous material from facility (if applicable)
- iv. Enable alarm system or ensure guard will be present 24/7 once RTGs arrive
- v. Conduct baseline radiological survey
- vi. Provide logistical support during off-loading and on-loading operations
- vii. Provide logistical support for aircraft manifest
- viii. Prepare flight line
- ix. Prepare parking area for the CH-47s and C-17 to ensure radiation safety area of at least 30 ft from aircraft
- x. Support CH-47 refueling, if required
- xi. Clear landing time with flight line operations
- xii. Ensure emergency response personnel available and trained
- xiii. Ensure 10,000 lb forklift and operator availability and conduct operator training
- xiv. Ensure K-loader and operator availability and conduct operator training
- xv. Ensure Flight line support is available (mechanics, emergency, transportation, etc)
- xvi. Arrange Eielson access for receiving team (AFTAC, DOE and SNL Personnel and AF Liaison)
- xvii. Provide dosimetry to Eielson AFB personnel
- xviii. Installation RSOs will assist the AFTAC RSO with radiation protection training
- xix. Installation RSOs will provide logistical support for TLDs for base personnel
- xx. Installation RSOs will provide TLD training to involved Eielson/Creech personnel

e. Creech
- i. Prepare facility for a minimum of 45 x 35 ft of staging space
- ii. Remove hazardous material from facility (if applicable)
- iii. Enable alarm system or ensure guard will be present 24/7 once RTGs arrive
- iv. Conduct baseline radiological survey
- v. Provide logistical support during off-loading and on-loading operations
- vi. Prepare parking area for C-17 to ensure radiation safety area of at least 30 ft from aircraft
- vii. Clear landing time with flight line operations
- viii. Ensure emergency response personnel available and trained

ix. Ensure 10,000 lb forklift and operator availability and conduct operator training
x. Ensure K-loader and operator availability and conduct operator training
xi. Ensure flight line support is available
xii. Prepare staging location with appropriate dunnage for 463L pallets
xiii. Arrange Creech access for receiving team (AFTAC, DOE and SNL Personnel and AF Liaison)
xiv. Provide two-way radios in Nevada to ensure communication between participating personnel
xv. Provide dosimetry to Creech AFB personnel

f. DOE (SNL)
   i. Ensure required documentation is filed/prepared for RTG hand-off at NNSS.
   ii. Inspect RTGs at each staging location.

g. DOE (HQ/SRS)
   i. Provide COC for non-transport
   ii. Provide exemption for package requirements in 49 and 10 CFR.

B. BM to Eielson AFB Transport

- Two CH-47s will be used in the extraction (three will be used on Day 5)
- CH-47s will carry personnel and any equipment not already pre-staged at BM
- CH-47 (B) will carry **two 463L pallets**
- 10K Forklift will need to be in place at Eielson AFB

1. Day 1 (**BM03**)
   a. 0600 Showtime at Det 460 - Extraction team receives radios, performs comm check, and RSO ensures shipping papers are present/accomplished
   b. 0615 Depart Det 460 for Ft. Wainwright (FWW)
   c. 0700 Arrive at FWW and load gear (to include **two 463L pallets and dunnage)**, flight prep
      i. CH-47 (A) – Forklift and operator
      ii. CH-47 (B) – Personnel and all other gear
   d. 0800 Depart FWW via (2) CH-47s (A & B) for Burnt Mt.
   e. 1000 Arrive at BMAR
      i. CH-47s (A & B) land at BM03 at the pre-designated landing zone. CH-47 (B) should land closest to the RTG shed.
      ii. Implement Radiation and Contamination Survey (AFTAC RSO)
      iii. On-site SNL representative performs visual inspection of RTGs (fill out documentation)
   f. 1015 Site Prep
      i. Det 460 personnel put support dunnage on ground. One 463L pallet will be unloaded onto support dunnage in accordance with the T.O.
      ii. The second pallet will be rolled to the ramp of the CH-47 and a sheet of 4' x 8' x 3/4" plywood will be placed on 463L to accept the first RTG
      iii. Cover fencepost holes with a section of I-Trac and two pieces of plywood
   g. 1045 Remove First RTG (A)

   i. On-site Commander notifies AFTAC Systems Control of pending RTG disconnect
   ii. Implement RTG Disconnect Procedures
   iii. F/L maneuvers to rear of shed—ensure plywood is in place if required
   iv. Maneuver forks under RTG A
   v. Implement tie-down procedures for F/L
   vi. Lift RTG A and transport to CH-47 (B)
   vii. Place RTG A on 463L pallet, centered on plywood —secure RTG A IAW tie down procedures (Army Load Master and AFTAC RSO)
   viii. Pull RTG/pallet A to Load Master approved location on CH-47 (B) and secure (Army Load Master)

h. 1125 Remove Second RTG (B)
   i. Place second 463L on CH-47 (B) ramp in accordance with the T.O.
   ii. Place steel plating in shed under RTG B
   iii. Use pallet jack on steel plating
   iv. **WARNING: Use caution when positioning RTG at front edge of shed, position no closer than 12 inches from edge.**
   v. Pick up RTG B using pallet jack and maneuver it to shed opening
   vi. Lower RTG B and remove pallet jack
   vii. F/L maneuvers to rear of shed—make sure plywood is in place if required
   viii. Maneuver forks under RTG B
   ix. Implement tie-down procedures for F/L
   x. Lift RTG B and transport to CH-47 (B)
   xi. Place RTG B on 463L pallet, centered on plywood —secure RTG B IAW applicable directives
   xii. Pull RTG/pallet B to Load Master approved location on CH-47 (B) and secure (Army Load Master)
   xiii. Load box containing PCU and cables on to CH-47 (B) and secure.
   xiv. Perform Radiation survey around exterior/interior of helo —document results (AFTAC RSO)

i. 1200 BM03 to BM01 Forklift Transition
   i. Load F/L into CH-47 (A)
   ii. CH-47 (A) Transitions to BM01 to off load F/L.
   iii. Offload F/L onto plywood. BMAR personnel will reposition after helo departs.
   iv. **Note:** All personnel not staying at BMAR for the night need to board CH-47 (A) before it leaves BM01.

j. 1215 CH-47 (A) Transitions back to BM03 (Engines running)
   i. Load all personnel returning to Eielson AFB
   ii. Load all gear (including pallet jack) returning to Eielson AFB

k. 1230 CH-47s (A & B) transport personnel and RTGs to Eielson AFB

l. 1430 Eielson AFB (354 LRS operates F/L)
   i. CH-47s land at Eielson AFB and shut down
   ii. Implement Radiation Survey Procedures (Procedures section, para A) (AFTAC RSO)

iii. F/L maneuvers to rear of CH-47 (B)
iv. RTG/pallet B is rolled to position on CH-47 (B) ramp (Army Load Master)
v. F/L maneuvers forks under 463L pallet
vi. F/L picks up RTG/pallet B and transports to the staging facility
vii. RTG/pallet A is rolled to position on CH-47 (B) ramp (Army Load Master)
viii. F/L maneuvers to rear of CH-47 (B)
ix. F/L maneuvers forks under 463L pallet
x. F/L picks up RTG/pallet A and transports to staging facility

m. 1600 - CH-47s (A & B) depart for FWW and transport personnel to FWW as required
n. AFTAC RSO ensures adequate security for RTGs
o. Implement Contamination Survey Procedures (AFTAC RSO)
p. Implement Pallet and RTG Inspection Procedures (DOE/AFTAC RSO)
q. If contamination detected Implement Emergency Response procedures (AFTAC RSO)

2. Day 2 (**BM01**)
   a. 0600 Showtime at Det 460 - Extraction team receives radios, performs comm check, and RSO ensures shipping papers are present/accomplished
   b. 0615 Depart Det 460 for Ft. Wainwright (FWW)
   c. 0700 Arrive at FWW and load gear (to include two 463L pallets and dunnage), flight prep
      i. CH-47 (A) – Forklift and operator
      ii. CH-47 (B) – Personnel and all other gear
   d. 0800 CH-47s (A & B) depart FWW
   e. 1000 Arrive at BMAR
      i. CH-47 (A) lands at BM01 and hot drops personnel/gear. It then transitions to BM03 and shuts down.
      ii. CH-47 (B) waits for CH-47 (A) to clear landing zone
      iii. CH-47 (B) lands at the BM01 designated landing zone and shuts down. Note: A new area was cleared in back of the shed to ease RTG movement.
      iv. F/L will be in place from Day 1 operations
      v. **I-TRAC IS NEEDED AT THIS SITE. USE PLYWOOD AT THE ENTRANCE TO THE SHED AND AT THE BACK OF THE CH-47 (all available personnel to assist with I-Trac)**
      vi. Implement Radiation and Contamination Survey (AFTAC RSO)
      vii. On-site SNL Representative performs visual inspection of RTG and fills out report
   f. 1015 Site Prep
      i. Install I-Trac and/or plywood (all personnel)
      ii. Det 460 personnel put support dunnage on ground. One 463L pallet will be unloaded onto support dunnage in accordance with the T.O.
      iii. The second pallet will be rolled to the ramp of the CH-47 and a sheet of 4' x 8' x 3/4" plywood will be placed on 463L to accept the first RTG
      iv. Cover fencepost holes with a section of I-Trac and two pieces of plywood
   g. 1115 Remove First RTG (A)
      i. On-site Commander notifies AFTAC Systems Control of pending RTG disconnect

    ii. Implement RTG Disconnect Procedures
    iii. F/L maneuvers to rear of shed—ensure plywood is in place
    iv. Maneuver forks under RTG A
    v. Implement tie-down procedures for forklift
    vi. Lift RTG A and transport to CH-47 (B)
    vii. Place RTG A on 463L pallet, centered on plywood —secure RTG A IAW applicable directives
    viii. Pull RTG/pallet A to Load Master approved location on CH-47 (B) and secure (Army Load Master)

h. 1200 Remove Second RTG (B)

    i. Place second 463L on CH-47 ramp in accordance with the T.O.
    ii. Place steel plating in shed under RTG B
    iii. Use pallet jack on steel plating
    iv. **WARNING: Use caution when positioning RTG at front edge of shed, position no closer than 12 inches from edge.**
    v. Pick up RTG B using pallet jack and maneuver it to shed opening
    vi. Put RTG B down and remove pallet jack
    vii. F/L maneuvers to rear of shed—make sure plywood is in place
    viii. Maneuver forks under RTG B
    ix. Implement tie-down procedures for forklift
    x. Lift RTG B and transport to CH-47 (B)
    xi. Place RTG B on 463L pallet, centered on plywood —secure RTG B IAW applicable directives
    xii. Pull RTG/pallet B to Load Master approved location on CH-47 (B) and secure (Army Load Master)
    xiii. Load box containing PCU and cables on to CH-47 (B) and secure
    xiv. Perform Radiation survey around exterior/interior of helo —document results (AFTAC RSO)
    xv. Remove I-Trac such that CH-47 (B) can take-off without risk

i. 1300 BM01 to BM02 Forklift Transition

    i. CH-47 (B) transitions to BM03 to await CH-47 (A)
    ii. CH-47 (A) lands at BM01 after CH-47 (B) departs
    iii. Replace I-Trac/plywood (If needed to Load F/L in CH-47 (A)
    iv. Load F/L CH-47 (A)
    v. Remove I-Trac **Note:** I-Trac remains at BM01 until the following day
    vi. CH-47 (A) transitions to BM02 to off load F/L. **Note:** All personnel not staying at BMAR for the night need to board CH-47 (A) before it leaves BM02 1230

j. 1330 CH47 (A) transition back to BM01 (engines running)

    i. Load all personnel returning to Eielson AFB
    ii. Load all gear (including pallet jack) returning to Eielson AFB

k. 1345 CH-47s (A&B) transport personnel and RTGs to Eielson AFB

l. 1545 Eielson AFB (354 LRS operates F/L)

i. CH-47s (A&B) land at Eielson AFB and shut down
ii. Implement Radiation Survey Procedures (Procedures section, para A)
iii. F/L maneuvers to rear of CH-47 (B)
iv. RTG/pallet B is rolled to position on CH-47 (B) ramp (Army Load Master)
v. F/L maneuvers forks under 463L pallet
vi. F/L picks up RTG/pallet B and transports to the staging facility
vii. RTG/pallet A is rolled to position on CH-47 (B) ramp (Army Load Master)
viii. F/L maneuvers to rear of CH-47 (B)
ix. F/L maneuvers forks under 463L pallet
x. F/L picks up RTG/pallet A and transports to staging facility

m. 1715 - CH-47s (A & B) depart for FWW and transports personnel to FWW as required
r. AFTAC RSO ensures adequate security for RTGs
n. Implement Contamination Survey Procedures (AFTAC RSO)
o. Implement Pallet and RTG Inspection Procedures (DOE/AFTAC RSO)
p. If contamination detected Implement Emergency Response procedures (AFTAC RSO)

3. Day 3 (**BM02**)

a. 0600 Showtime at Det 460 - Extraction team receives radios, performs comm check, and RSO ensures shipping papers are present/accomplished
b. 0615 Depart Det 460 for Ft. Wainwright (FWW)
c. 0700 Arrive at FWW and load gear (to include two 463L pallets and dunnage), flight prep
   i. CH-47 (A) – Forklift and operator
   ii. CH-47 (B) – Personnel and all other gear
d. 0800 CH-47s (A & B) depart FWW
e. 1000 Arrive at BMAR
   i. CH-47 (A) lands at BM02 and hot drop personnel/gear. It then transitions to BM01.
   ii. CH-47 (B) waits for CH-47 (A) to clear landing zone
   iii. CH-47 (B) lands at the BM02 designated landing and shuts down
   iv. CH-47 (A) lands at BM01 and shuts down to load I-Trac (Det 460 provides Rangers and personnel to help load I-Trac)
   v. F/L will be in place from Day 2 operations
   vi. Implement Radiation and Contamination Survey (AFTAC RSO)
   vii. On-site SNL Representative performs visual inspection of RTGs and fills out report
f. 1015 Site Prep
   i. Det 460 personnel put support dunnage on ground. One 463L pallet will be unloaded onto support dunnage in accordance with the T.O.
   ii. The second pallet will be rolled to the ramp of the CH-47 and a sheet of 4' x 8' x 3/4" plywood will be placed on 463L to accept the first RTG
   iii. Cover fencepost holes with a section of I-Trac and two pieces of plywood
   iv. Concurrently, I-Trac at BM01 is loaded onto CH-47 (A) and moved to BM04
   v. CH-47 (A) shuts down at BM04 to offload I-Trac and waits there until needed
   vi. I-Trac will be stored away from landing zone as to not pose a FOD hazard

g. 1045 Remove First RTG (A)
   i. On-site Commander notifies AFTAC Systems Control of pending RTG disconnect
   ii. Implement RTG Disconnect Procedures
   iii. F/L maneuvers to rear of shed—ensure plywood is in place
   iv. Maneuver forks under RTG A
   v. Implement tie-down procedures for forklift
   vi. Lift RTG A and transport to CH-47 (B)
   vii. Place RTG A on 463L pallet, centered on plywood —secure RTG A IAW applicable directives
   viii. Pull RTG/pallet A to Load Master approved location on CH-47 (B) and secure(Army Load Master)

h. 1125 Remove Second RTG (B)
   i. Place second 463L on CH-47 ramp in accordance with the T.O.
   ii. Place steel plating in shed under RTG B
   iii. Use pallet jack on steel plating
   iv. **WARNING: Use caution when positioning RTG at front edge of shed, position no closer than 12 inches from edge.**
   v. Pick up RTG B using pallet jack and maneuver it to shed opening
   vi. Put RTG B down and remove pallet jack
   vii. F/L maneuvers to rear of shed—make sure plywood is in place
   viii. Maneuver forks under RTG B
   ix. Implement tie-down procedures for forklift
   x. Lift RTG B and transport to CH-47 (B)
   xi. Place RTG B on 463L pallet, centered on plywood —secure RTG B IAW applicable directives
   ix. Pull RTG/pallet B to Load Master approved location on CH-47 (B) and secure(Army Load Master)
   x. Load box containing PCU and cables on to CH-47 (B) and secure.
   xi. Perform Radiation survey around exterior/interior of helo – document results (AFTAC RSO)

i. 1300 BM02 to BM04 Forklift Transition
   i. CH-47 (B) transitions to BM03 to await CH-47 (A)
   ii. CH-47 (A) lands at BM02 after CH-47 (B) departs
   iii. Load F/L into CH-47 (A)
   iv. CH-47 (A) transitions to BM04 to off load F/L and other equipment.
   v. Forklift will be offloaded onto plywood. BMAR personnel will reposition after helo departs. **Note**: Before departing BM04, all personnel not staying at BMAR for the night need to board CH-47 (A).

j. 1330 CH-47s transport personnel and RTGs to Eielson AFB

k. 1345 CH-47 (A) transitions back to BM02 (engines running)
   a. Load all personnel going back to Eielson AFB
   b. Load all gear (including pallet jack) going back to Eielson AFB

l. 1545 Eielson AFB (354 LRS operates F/L)
   i. CH-47s land at Eielson AFB and shut down
   ii. Implement Radiation Survey Procedures (Procedures section, para A)
   iii. F/L maneuvers to rear of CH-47 (B)
   iv. RTG/pallet B is rolled to position on CH-47 (B) ramp (Army Load Master)
   v. F/L maneuvers forks under 463L pallet
   vi. F/L picks up RTG/pallet B and transports to the staging facility
   vii. RTG/pallet A is rolled to position on CH-47 (B) ramp (Army Load Master)
   viii. F/L maneuvers to rear of CH-47 (B)
   ix. F/L maneuvers forks under 463L pallet
   x. F/L picks up RTG/pallet A and transports to staging facility

m. 1715 - CH-47s (A & B) depart for FWW and transports personnel to FWW as required

s. AFTAC RSO ensures adequate security for RTGs

n. Implement Contamination Survey Procedures (AFTAC RSO)

o. Implement Pallet and RTG Inspection Procedures (DOE/AFTAC RSO)

p. If contamination detected Implement Emergency Response procedures (AFTAC RSO)

4. Day 4 (**BM04**)
   a. 0600 Showtime at Det 460 - Extraction team receives radios, performs comm check, and RSO ensures shipping papers are present/accomplished
   b. 0615 Depart Det 460 for Ft. Wainwright (FWW)
   c. 0700 Arrive at FWW and load gear (to include two 463L pallets and dunnage), flight prep
      i. CH-47 (A) – Forklift and operator
      ii. CH-47 (B) – Personnel and all other gear
   d. 0800 CH-47s (A & B) depart FWW
   e. 1000 Arrive at BMAR
      i. CH-47 (A) lands at BM04 and hot drop personnel/gear. It then transitions to BM03.
      ii. CH-47 (B) waits for CH-47 (A) to clear landing zone
      iii. CH-47 (B) lands at the BM04 designated landing zone and shuts down
      iv. F/L will be in place from Day 3 operations
      v. **I-TRAC IS NEEDED AT THIS SITE. USE PLYWOOD AT THE ENTRANCE TO THE SHED AND AT THE BACK OF THE CH-47**
      vi. Implement Radiation and Contamination Survey (AFTAC/RSO)
      vii. On-site SNL Representative performs visual inspection of RTGs and fill out report
   f. 1015 Site Prep
      i. Install I-Trac and/or plywood (all personnel)
      ii. Det 460 personnel put support dunnage on ground. One 463L pallet will be unloaded onto support dunnage in accordance with the T.O.
      iii. The second pallet will be rolled to the ramp of the CH-47 and a sheet of 4' x 8' x 3/4" plywood will be placed on 463L to accept the first RTG
      iv. Cover fencepost holes with a section of I-Trac and two pieces of plywood
   f. 1045 Remove First RTG (A)

i. On-site Commander notifies AFTAC Systems Control of pending RTG disconnect
ii. Implement RTG Disconnect Procedures
iii. F/L maneuvers to rear of shed—ensure plywood is in place
iv. Maneuver forks under RTG A
v. Implement tie-down procedures for forklift
vi. Lift RTG A and transport to CH-47 (B)
vii. Place RTG A on 463L pallet, centered on plywood —secure RTG A IAW applicable directives
viii. Pull RTG/pallet A to Load Master approved location on CH-47 (B) and secure(Army Load Master)

g. 1125 Remove Second RTG (B)
i. Place second 463L on CH-47 ramp in accordance with the T.O.
ii. Place steel plating in shed under RTG B
iii. Use pallet jack on steel plating
iv. **WARNING: Use caution when positioning RTG at front edge of shed, position no closer than 12 inches from edge.**
v. Pick up RTG B using pallet jack and maneuver it to shed opening
vi. Put RTG B down and remove pallet jack
vii. F/L maneuvers to rear of shed—make sure plywood is in place
viii. Maneuver forks under RTG B
ix. Implement tie-down procedures for forklift
x. Lift RTG B and transport to CH-47 (B)
xii. Place RTG B on 463L pallet, centered on plywood —secure RTG B IAW applicable directives
xii. Pull RTG/pallet B to Load Master approved location on CH-47 (B) and secure(Army Load Master)
xiii. Load box containing PCU and cables on to CH-47 (B) and secure.
xiv. Perform Radiation survey around exterior/interior of helo – document results (AFTAC RSO)

h. 1300 BM04 to BM05 Forklift transition
i. CH-47 (B) transitions to BM03 and shuts down to await CH-47 (A)
ii. CH-47 (A) lands at BM04 and shuts down after CH-47 (B) departs
iii. Replace plywood
iv. Load F/L into CH-47 (A)
v. Remove plywood
vi. CH-47 (A) transitions to BM05 to off load F/L. **Note**: Before departing BM05, all personnel not staying at BMAR for the night need to board CH-47 (A).

i. 1330 CH-47 (A) transitions back to BM04 (engines running)
i. Load all personnel headed to Eielson AFB
ii. Load all gear (including pallet jack) headed to Eielson AFB

j. 1345 CH-47s (A&B) transport personnel and RTGs to Eielson AFB

k. 1545 Eielson AFB (354 LRS operates F/L)

i. CH-47s land at Eielson AFB and shut down
ii. Implement Radiation Survey Procedures (Procedures section, para A)
iii. F/L maneuvers to rear of CH-47 (B)
iv. RTG/pallet B is rolled to position on CH-47 (B) ramp (Army Load Master)
v. F/L maneuvers forks under 463L pallet
vi. F/L picks up RTG/pallet B and transports to the staging facility
vii. RTG/pallet A is rolled to position on CH-47 (B) ramp (Army Load Master)
viii. F/L maneuvers to rear of CH-47 (B)
ix. F/L maneuvers forks under 463L pallet
x. F/L picks up RTG/pallet A and transports to staging facility

l. 1715 - CH-47s (A & B) depart for FWW and transports personnel to FWW as required
t. AFTAC RSO ensures adequate security for RTGs
m. Implement Contamination Survey Procedures (AFTAC RSO)
n. Implement Pallet and RTG Inspection Procedures (DOE/AFTAC RSO)
o. If contamination detected Implement Emergency Response procedures (AFTAC RSO)

5. Day 5 (**BM05**)
   a. 0600 Showtime at Det 460 - Extraction team receives radios, performs comm check, and RSO ensures shipping papers are present/accomplished
   b. 0615 Depart Det 460 for Ft. Wainwright (FWW)
   c. 0700 Arrive at FWW and load gear (to include two 463L pallets and dunnage), flight prep
      i. CH-47 (A) – Forklift and operator
      ii. CH-47 (B) – Personnel and all other gear
      iii. CH-47 (C) - Empty
   d. 0800 CH-47s (A, B, and C) depart FWW
   e. 1000
      i. CH-47 (A) lands at BM05 and hot drop personnel/gear, then transitions to BM03 and shuts down
      ii. CH-47 (B) waits for CH-47 (A) to clear landing zone
      iii. CH-47 (B) lands at BM05 and shuts down
      iv. CH-47 (C) lands at BM03 and shuts down
      v. F/L will be in place from Day 4 operations
      vi. Implement Radiation and Contamination Survey (AFTAC/RSO)
      vii. On-site SNL Representative performs visual inspection of RTGs and fills out report
   f. 1015 Site Prep
      i. Det 460 personnel put support dunnage on ground. One 463L pallet will be unloaded onto support dunnage in accordance with the T.O.
      ii. The second pallet will be rolled to the ramp of the CH-47 and a sheet of 4' x 8' x 3/4" plywood will be placed on 463L to accept the first RTG
      iii. Cover fencepost holes with a section of I-Trac and two pieces of plywood
   g. 1045 Remove First RTG (A)
      i. On-site Commander notifies AFTAC Systems Control of pending RTG disconnect

ii. Implement RTG Disconnect Procedures
iii. F/L maneuvers to rear of shed—ensure plywood is in place
iv. Maneuver forks under RTG A
v. Implement tie-down procedures for forklift
vi. Lift RTG A and transport to CH-47 (B)
vii. Place RTG A on 463L pallet, centered on plywood —secure RTG A IAW applicable directives
viii. Pull RTG/pallet A to Load Master approved location on CH-47 (B) and secure (Army Load Master)

h. 1125 Remove Second RTG (B)
   i. Place second 463L on CH-47 ramp in accordance with the T.O.
   ii. Place steel plating in shed under RTG B
   iii. Use pallet jack on steel plating
   iv. **WARNING: Use caution when positioning RTG at front edge of shed, position no closer than 12 inches from edge.**
   v. Pick up RTG B using pallet jack and maneuver it to shed opening
   vi. Put RTG B down and remove pallet jack
   vii. F/L maneuvers to rear of shed—make sure plywood is in place
   viii. Maneuver forks under RTG B
   ix. Implement tie-down procedures for forklift
   x. Lift RTG B and transport to CH-47 (B)
   xi. Place RTG B on 463L pallet, centered on plywood —secure RTG B IAW applicable directives
   xii. Pull RTG/pallet B to Load Master approved location on CH-47 (B) and secure (Army Load Master)
   xiii. Load box containing PCUs and cables on to CH-47 (B) and secure
   xiv. Perform Radiation survey around exterior/interior of helo – document results (AFTAC RSO)

i. 1200 BM05 F/L and PAX pickup
   i. CH-47 (B) transitions to BM0$ to await CH-47 (A&C)
   ii. CH-47 (C) lands at BM05 after CH-47 (B) has cleared landing zone
   iii. Load F/L into CH-47 (C)

j. 1215 CH-47 (C) transitions back to BM03 to await CH-47 A

k. 1215 CH-47 (A) transitions to BM05 (engines running) after CH-47 (C) has cleared landing zone
   i. Load all returning personnel, not Det 460 BMAR technicians
   ii. Load all gear related to RTG Removal for return to Eielson AFB

l. 1230 CH-47s (A,B&C) transport personnel, equipment, and RTGs to Eielson AFB

m. 1430 Eielson AFB
   i. CH-47s land at Eielson AFB and shut down
   ii. Implement Radiation Survey Procedures (Procedures section, para A) (AFTAC RSO)
   iii. F/L maneuvers to rear of CH-47 (B)

iv. RTG/pallet B is rolled to position on CH-47 (B) ramp (Army Load Master)
v. F/L maneuvers forks under 463L pallet
vi. F/L picks up RTG/pallet B and transports to the staging facility
vii. RTG/pallet A is rolled to position on CH-47 (B) ramp (Army Load Master)
viii. F/L maneuvers to rear of CH-47 (B)
ix. F/L maneuvers forks under 463L pallet
x. F/L picks up RTG/pallet A and transports to staging facility
xi. Offload box containing PCUs and cables and move to staging location
xii. CH-47 (C) off-loads F/L

n. 1600 CH-47s (A,B&C) depart for FWW and transports personnel to FWW as required
u. AFTAC RSO ensures adequate security for RTGs
o. Implement Contamination Survey Procedures (AFTAC RSO)
p. Implement Pallet and RTG Inspection Procedures (DOE/AFTAC RSO)
q. If contamination detected Implement Emergency Response procedures (AFTAC RSO)

C. Eielson AFB to Creech AFB

- Personnel transitioning to Creech AFB will depart Alaska at least 24 hours prior to RTG departure
- Radiation surveys will be conducted during loading operations

1. C-17 lands at Eielson AFB day prior to loading operations and taxis to south ramp, shuts down
   Note: Arrival date and time is notional, actual will be dictated by TRANSCOM
2. 0700 Begin RTG loading
   a. Place and secure 3 RTGs/pallets on K-loader
   b. K-Loader moves to awaiting C-17 and loads 3 RTGs/pallets
   c. Load Master secures RTGs/pallets IAW applicable directives
   d. Repeat process until all 10 RTGs are loaded on C-17
   e. Load box containing PCUs and cables on C-17 and secure
   f. Load all radiation support equipment on C-17 ands secure

3. 1000 C-17 Departs for Creech AFB

D. Creech AFB to NNSS

1. Receiving Operations
   a. Receiving team arrives on site at Creech AFB
      i. All team members must have emergency response information, security information, and team contact information
      ii. 99th MSG distributes radios and performs comm check
      iii. Ensure all participants have cellular telephones as a means of back-up comms
   b. Two tractor trailers arrive and are prepositioned near staging location
      i. AFTAC/RSOs perform radiation survey of tractor and trailer

ii. Confirm presence of required documentation (shipping papers, emergency response information, security information, and team contact information)

c. Preposition forklift and operator near flight line
d. C-17 parks / security establishes cordon and ECP
e. AFTAC/RSOs perform radiation dose rate surveys on exterior of aircraft
f. Off-load three RTGs on to Halverson loader and secure
g. Transport RTGs to staging facility
h. Place RTG/pallets on to support dunnage
i. Repeat for all RTG/pallets
j. Off-load box containing PCUs and associated cabling and move to staging location
k. AFTAC/RSOs perform RTG dose rate and contamination surveys
l. AFTAC RSOs post area signs and ensure adequate security
m. AFTAC performs RTG inspection procedures
n. SNL personnel inspect RTGs for acceptance
o. Secure staging location and monitor for security

2. Loading/Ground Transport Operations
   a. Move RTG/pallets from staging location and load on to flatbeds using forklift – utilize handling procedures
   b. Secure each RTG as it is loaded onto the flatbeds – utilize Tie Down Procedures
   c. Load box containing PCUs and cables into support vehicle
   d. Placard tractor trailers
   e. Perform radiation surveys of tractor trailer
   f. Reconfirm required documentation is with tractor trailer
   g. Perform comm check to ensure radios and cell phones are functioning properly
   h. Tractor trailers and escort vehicles depart Creech AFB
   i. Drive to NNSS via preplanned route (execute emergency response procedures if necessary)
   j. Stop at NNSS gate for inspection and transfer of ownership
   k. SNL personnel accept ownership of RTGs
   l. RTGs transferred to NNSS designated location
   m. PCUs and cables transferred
   n. RTGs off-loaded

E. Post Transport Activities
   1. Transport 463L pallets to Creech AFB for disposition
   2. Turn-in comm equipment and vehicles
   3. Ship all support equipment to home station

Appendix K

[redacted]

BY ORDER OF THE COMMANDER
AIR FORCE TECHNICAL APPLICATIONS CENTER

CENTER INSTRUCTION 40-201

21 MAY 2008

Medical Command

RADIATION PROTECTION

COMPLIANCE WITH THIS PUBLICATION IS MANDATORY

ACCESSIBILITY: This publication is available digitally on the AFTAC Intranet. If you lack access, contact your directorate Client Support Administrator.

RELEASABILITY: There are no releasability restrictions on this publication.

OPR: AFTAC/RSO

Certified by: AFTAC/CC (Colonel Mark W. Westergren)
Pages: 17

This CENI implements AFPD 40-2, *Radioactive Materials (Non-Nuclear Weapons)*. It applies to all personnel assigned to the AFTAC, its detachments, operating locations, and individual mobilization augmentees. It also applies to units who possess/use Radioactive Material (RAM) permitted by AFTAC. This instruction discusses control of RAM including procurement, receipt, transfer, storage, use, handling, accountability, and disposal of RAM. Furthermore, it provides radiation safety guidance to users of RAM. Implementation of this instruction will ensure users are in compliance with pertinent directives. This instruction does not apply to electronic devices producing either ionizing or non-ionizing radiation. Operations, activities, and procedures peculiar and unique to a particular location or mission should be addressed in local Operating Instructions (OI's). There should be consistency between OI's, this instruction, and other governing directives. Copies of all applicable OI's should be provided to the AFTAC Radiation Safety Officer (RSO). This publication does not apply to Air Force Reserve Command (AFRC), and other individual reservists administered by HQ AFRC. It does not apply to the ANG. Refer recommended changes and questions about this publication to the Radiation Protection Office, AFTAC/CVX, using the AF IMT 847, *Recommendation for Change of Publication*; route AF IMT 847 from your directorate through Publications and Content Management, AFTAC/LSCII. Maintain records created as a result of prescribed processes IAW AFMAN 33-363, Management of Records, and dispose of the IAW the AF Records Disposition Schedule at https://AFRIMS.amc.af.mil.

1.1. Responsibilities

1.1.1. The AFTAC Commander

1.1.1.1. Ensure all personnel comply with this instruction. This includes military personnel, civilian employees, contractor personnel, and visitors.

1.1.1.2. Ensure all activities comply with applicable local, state, and federal directives covering the use of radioactive materials to include permitting, procuring, storing,

[redacted]

handling, accounting for, and disposing of radioactive material and the reporting of incidents or accidents to the appropriate authorities.

1.1.1.3. Appoint AFTAC RSO and delegate authority as outlined in AFI 40-201, *Managing Radioactive Materials in the US Air Force*, and this instruction. In AFTAC there will be two RSOs assigned in writing by the AFTAC/CC to manage the radiation protection program.

1.1.1.4. Conduct an organization radiation protection program under the direction of the AFTAC RSO.

1.1.1.5. Certify, in writing, AFTAC is committed to the successful implementation of an As Low As Reasonably Achievable (ALARA) program.

1.1.1.6. Ensure the AFTAC RSO is notified of all planned uses of radioactive material within the organization.

1.1.1.7. Ensure that non-Air Force organizations have proper authorization to use radioactive materials within AFTAC.

1.1.1.8. Review and approve the training and experience qualifications of a proposed AFTAC RSO before submission to the Air Force Radioisotope Committee (AF RIC) for final approval.

1.1.1.9. Review and recommend corrective actions for deficiencies identified by the US Nuclear Regulatory Commission (NRC) and AF Inspector General inspections.

1.1.1.10. Appoint Radiation Protection Technicians (RPT's) to perform specific duties based on mission requirements.

1.1.1.11. Ensure that an annual audit of the AFTAC Radiation Protection Program is completed.

1.1.2. AFTAC RSO

1.1.2.1. Implements the AFTAC Radiation Protection Program under the authority of the AFTAC/CC. Establish policy and provide guidance on conduct of the AFTAC Radiation Program.

1.1.2.2. Advise the AFTAC Commander on all significant radiation protection program activities.

1.1.2.3. Suspend any operation involving the use of RAM determined to be unnecessarily hazardous to human health or may adversely impact the environment under the authority of the AFTAC/CC. In such an event, the AFTAC RSO must seek timely resolution of substantive issues with the assistance of the RPT and the AFTAC Commander.

1.1.2.4. Act as the single focal point for AFTAC on radiation protection program matters. Act as the single point of contact with the AF Medical Operating Agency and the Air Force Radioisotope Committee.

1.1.2.5. Provide guidance and consultation to supervisors, users, and RPTs prior to them engaging with Installation Radiation Protection Officers, program managers, Department of Defense/Department of Energy officials, or civilian agencies when discussing activities pertaining to the AFTAC Radiation Protection Program.

1.1.2.6. Investigate, evaluate, and initiate corrective actions and report noncompliance items relating to radioactive material.

1.1.2.7. Enforce all local, state, and federal directives relating to radiation protection.

1.1.2.8. Ensure personnel and area dosimetry monitoring is accomplished as required.

1.1.2.9. Review and approve procedures involving the use of radioactive material.

1.1.2.10. Identify training requirements for occupational workers and supervisors, per AFI 40-201, Title 10 CFR Part 19, local guidance, and applicable Nuclear Regulatory Commission Guides (NUREG).

1.1.2.11. Recommend remedial action to correct deficiencies in the radiation protection program.

1.1.2.12. Review plans and modifications to facilities utilizing radioactive material.

1.1.2.13. Provide preliminary hazard evaluations for proposed uses of radioactive material.

1.1.2.14. Manage the receipt, shipment, and transfer of radioactive material as required by NRC and AF regulations.

1.1.2.15. Prepare and maintain all necessary records of the AFTAC radiation protection program.

1.1.2.16. Identify to the individual users and their supervisors the protective equipment and facilities necessary for the safe conduct of projects involving the use of radiation.

1.1.2.17. Coordinate activities involving radioactive materials with Installation Radiation Protection Officers.

1.1.2.18. Provide direction and oversight for all radiological decontamination and recovery operations.

1.1.2.19. Review radiation protection training programs for RPT's, supervisors, and users of radioactive material. Radiation protection training provided by others, such as military public health, external vendors, DoE Laboratories, or supervisors shall be approved by the AFTAC RSO.

1.1.2.20. Manage and update the AFTAC radioactive material inventory.

1.1.2.21. Maintain "sign-in/out" logs as a means of keeping track of sources which are removed for more than 24 hours from RAM designated storage areas. The log must include the building location and exact location of sources to ensure RAM can be located at all times, indicating absolute control of the materials.

1.1.2.22. Provide emergency response guidance in the event of accidents involving contamination of personnel or the environment or exposure of personnel to radioactive material.

1.1.2.23. Provide consultation, advice, assistance, and direction on the hazards associated with radiation and the methods to control these hazards as well as response to emergency incidents or accidents involving radioactive material.

1.1.2.24. Manage an inventory of calibrated radiation monitoring equipment and dedicated check sources for use in routine radiological surveillance and compliance surveys as well as immediate response to emergency situations.

1.1.2.25. Establish the required frequency of area surveys.

1.1.2.26. Ensure qualified RPT's are designated for each functional area authorized to possess and use RAM.

1.1.2.27. Ensure timely reporting of accidents or incidents involving radioactive material to the AFTAC Commander.

1.1.2.28. Ensure an ALARA training program is in place.

1.1.3. AFTAC Radiation Protection Technicians

1.1.3.1. Suspend any operation involving the use or RAM determined to be unnecessarily hazardous to human health or may adversely impact the environment under the authority of the AFTAC RSO. In such an event, the RPT must seek timely resolution with the assistance of the RSO and the AFTAC Commander.

1.1.3.2. Complete a minimum of 24 hours of formal radiation safety/health physics training and complete work center specific on the job training.

1.1.3.3. Ensure users are properly monitored for exposure to radiation and RAM. Monitors RAM use areas following direction provided by the AFTAC RSO.

1.1.3.4. Ensure appropriate radiation/RAM warning labels are posted.

1.1.3.5. Ensure sufficient number of the NRC Form 3, *Notice to Employees*, are posted where employees can view them (Title 10 CFR Part 19). Attach a supplemental notice of permit documentation to the NRC Form 3 (per AFI 40-201).

1.1.3.6. Ensure compliance with directives and conditions of the Radioactive Materials Permit (RAMP).

1.1.3.7. Inform the AFTAC RSO of changes in equipment and/or procedures which could significantly alter approved radiation protection procedures and possibly lead to radiation accidents/incidents.

1.1.3.8. Report incidents/accidents involving RAM to the AFTAC RSO, who in turn, will notify the AF RIC Executive Secretaries.

1.1.3.9. Verify users are complying with the AFTAC Radiation Protection Program and practicing the ALARA philosophy.

1.1.3.10. As needed, prepare clarifying OIs which detail unique aspects of their program.

1.1.3.11. Ensure female radiation workers are familiar with NUREG 8.13, *Instructions Concerning Prenatal Radiation Exposure* (and its revisions).

1.1.3.12. Maintain a readily available and current inventory of RAM.

1.1.3.13. Ensure that monthly radiation surveys are performed in unrestricted areas adjacent to where RAM is used or stored. Documentation of the survey will be provided to the AFTAC RSO.

1.1.3.14. Ensure equipment used to process RAM is checked for residual radioactive contamination prior to transfer to an unrestricted area or removed from inventory.

1.1.3.15. Ensure all radioactive material is accounted for at all times. Use the sign in/out logs as necessary to ensure control of RAM.

1.1.4. Supervisors

1.1.4.1. Appoint in writing at least one RPT for each work center using RAM and/or as required by the RSO. Ensure radiation workers are briefed in accordance with this instruction.

1.1.4.2. Ensure RPTs under their supervision follow the conditions of this instruction.

1.1.4.3. Advise the AFTAC RSO and work center RPT of proposed uses of radioactive material and any matters affecting the radiation protection program.

1.1.4.4. Coordinate radiation survey or hazard evaluation activities with the AFTAC RSO.

1.1.4.5. Ensure timely reporting of accidents or incidents involving RAM to the AFTAC RSO or AFTAC Commander.

1.1.4.6. Assist in the investigation of incidents or accidents relating to the use of RAM.

1.1.4.7. Coordinate radiation safety training with the AFTAC RSO for newly assigned employees or airmen who may be exposed to ionizing radiation.

1.1.4.8. Document ALARA training on each individual's AF Form 55, *Employee Safety and Health Record*.

1.1.4.9. Coordinate with the AFTAC RSO before initiating any project including procurement, use, storage, and/or disposal of RAM or devices or any changes in working conditions or activities which could affect the radiation protection program. All coordination shall be accomplished prior to initiation of the project.

1.1.4.10. Submit operating instructions and procedures involving RAM to the AFTAC RSO prior to implementation.

1.1.4.11. Ensure all users are familiar with operating instructions and radiation safety procedures and the AFTAC ALARA program.

1.1.4.12. Ensure occupational workers are issued and wear dosimetry, as required by AFTAC RSO.

1.1.4.13. Advise the AFTAC RSO, in writing, of any proposed changes to the radioactive material inventory, any proposed acquisition of new radioactive material, or generation of radioactive waste.

1.1.4.14. Ensure periodic surveys and monitoring of work areas are conducted as directed by the RSO.

1.1.4.15. Ensure female radiation workers are briefed on prenatal radiation exposure (NUREG 8.13).

1.1.4.16. IAW AFMAN 48-125, *Personnel Ionizing Radiation Dosimetry*, promptly refer pregnant personnel to the AFTAC or Installation Radiation Protection Officer.

1.1.4.17. Designate work center RPTs in writing. (Must be approved by the AFTAC Commander).

1.1.5. Each individual using RAM

1.1.5.1. Understand and implement the rules of radiation safety as described in applicable local, state, and federal guidance.

1.1.5.2. Wear personnel monitoring devices [ex: thermoluminescent dosimeter (TLD)] when working with radioactive materials or as directed by supervisors, RPT's, and the AFTAC RSO.

1.1.5.3. Wear appropriate protective clothing and equipment as prescribed by supervisors and the AFTAC RSO.

1.1.5.4. Become familiar with the ALARA program which is dedicated to maintaining exposure to ionizing radiation ALARA.

1.1.5.5. Report incidents/accidents and hazardous conditions immediately to their supervisors or the AFTAC RSO if appropriate.

1.1.5.6. Assist the supervisor, RPT, or the AFTAC RSO, as directed, to control the site of an accident/incident.

1.1.5.7. Inform their supervisor of any changes to equipment, procedures, or other factors involving RAM which may alter the radiation safety practices or radiation levels in unrestricted areas.

1.1.5.8. Understand requirements of AFMAN 48-125, if they become pregnant.

1.2. Dosimetry

1.2.1. Individuals who routinely work with or in the vicinity of sources of ionizing radiation may be designated as radiation workers by the AFTAC RSO after an evaluation of the potential hazards. Note: The Installation Radiation Protection Officer manages the overall dosimetry program for each organization.

1.2.2. The AFTAC RSO will:

1.2.2.1. Work with the Installation Radiation Protection Officer to determine if radiation monitoring is required.

1.2.2.2. Issue and exchange radiation dosimeters.

1.2.3. Each individual to be monitored shall be provided with a radiation safety briefing to include an explanation concerning proper wear and storage of dosimeter, the right to periodically review the dosimetry results, and the potential hazards of radiation exposure to productive health. The Installation Radiation Protection Officer ensures each individual

monitored is provided with the summary results of dosimetry (internal and external) annually on AF Form 1527-1, *Annual Occupational Exposure History to Ionizing Radiation.*

1.2.3.1. Prior coordination with the AFTAC RSO concerning visitor access to restricted radiation areas is required.

1.2.4. Dosimeters will be worn while working in a designated radiation use area. The badges will be worn before beginning work and removed after leaving the radiation use area.

1.2.4.1 When not being worn, dosimeters must be stored in a low-radiation environment with the "control dosimeter." The control dosimeter always remains on the dosimeter storage board.

1.2.4.2. If a dosimeter is lost or damaged, the AFTAC RSO will request a memo from the wearer, coordinated through their supervisor, explaining the circumstances of the loss or damage and a brief description of work performed during the monitoring period. This information is provided to the Installation RSO who will determine if an administrative dose is assigned.

1.3. As Low As Reasonably Achievable (ALARA) Concept

1.3.1. AFTAC is committed to achieving an effective ALARA Program.

1.3.1.1. The AFTAC RSO shall ensure users, workers, and ancillary personnel are provided briefings describing the ALARA program at least annually.

1.3.1.2. The AFTAC RSO may require users to develop new procedures to implement the ALARA concept and shall review occupational radiation exposure records to ensure compliance with ALARA.

1.3.1.3 The AFTAC RSO shall encourage users to submit suggestions for improving health physics practices and increasing the effectiveness of the ALARA program.

1.3.1.4. The AFTAC RSO shall investigate all deviations from ALARA and direct changes when appropriate.

1.3.2. Personnel requiring training in radiation safety commensurate with their duties shall include:

1.3.2.1. Users.

1.3.2.2. Supervisors.

1.3.2.3. Radiation Protection Technicians.

1.3.2.4. Emergency response teams.

1.3.2.5. Ancillary personnel (such as housekeeping) who may perform duties in areas where RAM is used.

1.3.3. Training shall be provided by the AFTAC RSO to personnel.

1.3.3.1. Before personnel are permitted to assume duties with or in the vicinity of RAM.

1.3.3.2. Annually during a refresher training course.

1.3.3.3. When there is a significant change in duties or radiation safety requirements.

1.3.4. When training is accomplished, workplace supervisors shall ensure it is documented on each individual's AF Form 55.

1.4. Procurement, Receipt, Control, and Accountability of RAM

1.4.1. Procurement/Ordering

1.4.1.1. Under no circumstances will RAM be procured directly from a supplier or through a contract without prior coordination and approval from the AFTAC RSO.

1.4.1.2. The order must be forwarded and approved by the AFTAC RSO prior to submission for procurement.

1.4.1.3. The AFTAC RSO shall review the order to ensure it does not exceed authorization.

1.4.1.4. Each individual who intends to procure RAM must consult with the AFTAC RSO to determine if the material is authorized by the RAM Permit. The individual will request in writing to the RSO for approval to procure the needed materials.

1.4.1.5. If the material is not authorized by the permit, or the limit authorized by the permit may be exceeded, the AFTAC RSO will submit a written request to the AF RIC to have the permit amended. The user will be notified if the authorization is approved, but will not take action to procure the material until the permit is amended. Installation Radiation Protection Officers will be notified by the RSO prior to any RAM entering installation.

1.4.1.6. The purchase order shall specify that the AFTAC RSO shall be contacted during normal duty hours on receipt of the item at any AFTAC facility. If the package contains radioactive material and appears to be damaged or leaking, the AFTAC RSO shall be notified immediately through the AFTAC Alert Operations Center at DSN 854-4333 or commercially (321) 494-4333, irrespective of the day or time.

1.4.1.7. Upon notification that RAM has arrived at AFTAC, the AFTAC RSO shall send a member of the staff to inspect and monitor the package. Only the AFTAC RSO or a certified RPT shall open the package. The action taken shall depend on the hazard associated with the particular item and the condition of the package.

1.4.2. Receipt/Control of RAM

1.4.2.1. During duty hours, packages containing Type A quantities of RAM or greater shall be inspected and opened within 3 hours of receipt. If a Type A package is received after duty hours, it shall be inspected and opened within 3 hours after the beginning of the next duty day.

1.4.2.2. The AFTAC RSO will be notified upon the receipt of any RAM.

1.4.2.3. Upon receipt of RAM, an inspection will be conducted and documentation of receipt will be performed by the RSO or designated RPT.

1.4.2.4. For each package/source/material ordered, the following should be recorded, documented and/or complied with:

1.4.2.4.1. Isotope – If package is a sample to be processed, the isotope may not be available. In this case, record the primary activity of emission (i.e.; alpha, beta, gamma).

1.4.2.4.2. Activity (Curie or Becquerel) – If estimated, record instrument used and assumed efficiency for the instrument.

1.4.2.4.3. Physical form (solid, liquid, gas).

1.4.2.4.4. Volume or weight of material (if known).

1.4.2.4.5. When satisfied that all contents have been received notify the shipper.

1.4.2.5. Special precautions shall be taken when receiving and opening packages containing radioactive material:

1.4.2.5.1. Visually inspect the package and, if damaged, notify the AFTAC RSO immediately.

1.4.2.5.2. Measure the exposure rate at the package surface and, if greater than expected or 2 millirem per hour, contact the AFTAC RSO.

1.4.2.5.3. Verify the contents with the packaging slip.

1.4.2.5.4. Ensure ALARA practices are followed and proper personnel protective equipment is utilized (ex: disposable gloves).

1.4.2.5.5. After the package is opened and the contents examined, the AFTAC RSO shall be notified immediately if there is either a discrepancy, if the items appear damaged, or incorrect. All documentation including the shipping documents will be provided to the RSO.

1.4.2.5.6. Examine the integrity of the final source container.

1.4.2.6. Accountability

1.4.2.6.1. RAM that is exempt or permitted will be inventoried and accounted for within AFTAC.

1.4.2.6.2. Directorates, detachments, and operating locations in possession of RAM must keep an inventory; follow all laws for RAM disposal, transportation, and applicable portions of this instruction.

1.4.2.6.3. At a minimum, all RAM will be secured in a RAM approved, controlled, or restricted area to prevent unauthorized removal or access.

1.4.2.6.4. No RAM will be disposed of, transported, or shipped without notifying the AFTAC RSO.

1.4.2.7. Shipping

1.4.2.7.1. No RAM will be shipped without prior coordination with the AFTAC RSO.

1.4.2.7.2. If the material shipped is a sample for which isotopes are not yet identified, record all known data (ex: activity, dose exposure on contact).

1.4.2.7.3. RAM in excess of the exempt concentration levels and exempt consignment levels (Title 49 CFR Par 173), will be shipped per instruction of the AFTAC RSO or AFTAC Commander.

1.4.3. Storage

1.4.3.1. RAM will be stored IAW local, state, and federal guidance. Location of material must appear in the AFTAC RAM inventory.

1.4.3.2. Caustics, corrosives, acids, or explosives will not be stored in RAM storage areas.

1.4.3.3. RAM will not be stored in administrative areas.

1.4.4. Inventory

1.4.4.1. The AFTAC RSO maintains a master inventory for all RAM.

1.4.4.2. Each work center RPT will maintain an inventory of their exempt and permitted RAM. The accuracy of information on the inventory is the responsibility of the RPT and the AFTAC RSO.

1.4.4.3. An inventory will be conducted and documented quarterly.

1.4.4.4. The RPT will sign the inventory, noting any changes or updates, and forward to the AFTAC RSO for review.

1.4.4.5. Information on the inventory shall contain but is not limited to:

1.4.4.5.1. Building and room number (where the material/source is located).

1.4.4.5.2. Original Assay Date.

1.4.4.5.3. Medium (physical form).

1.4.4.5.4. Element –Isotope (radionuclide).

1.4.4.5.5. Section (office symbol of the organization in possession of the material/source).

1.4.4.5.6. Person responsible for the material (point-of-contact).

1.4.4.5.7. Source supplier (may be the manufacturer or another authorized user organization).

1.4.4.5.8. Remarks (e.g.; type of source, general or specific use/storage location, etc.).

1.5. Leak Testing of RAM

1.5.1. Sealed sources are leak tested at intervals specified in the AF radioactive material permits or as directed by the AFTAC RSO.

1.5.2. Leak testing shall be accomplished by the AFTAC RSO, qualified RPT, or as directed by the RSO.

1.5.2.1. Results shall be maintained by the AFTAC RSO.

1.5.2.2. If contamination is detected in excess of acceptable limits the source shall be secured in an isolated area and the AFTAC RSO contacted immediately.

1.6. Reporting Requirements

1.6.1. Mishaps, Incidents, and Accidents. Any abnormal occurrence involving radioactive material shall be reported immediately. Based on the severity of the occurrence, as specified in AFI 40-201, the AFTAC RSO shall make the proper notifications.

1.6.2. Notice of Violation or Hazard. Any worker or representative of workers who believe that a violation of NRC, AF instructions, or permit conditions has occurred, or that any defect in facilities or equipment exists which may pose a hazard to personnel or the environment, shall report such conditions to:

1.6.2.1 The immediate supervisor or their branch or division chief.

1.6.2.2 In absence of the AFTAC RSO, reports may be made to the AFTAC Commander.

1.7. Prescribed and/or Adopted Forms. All Air Force IMTs prescribed or adopted by this publication are available through the Air Force Publications Distribution system. Any other agency forms identified or required for use are available from AFTAC/RSO.

1.7.1. AF Form 55, *Employee Safety and Health Record.*

1.7.2. AF Form 847, *Recommendation for Change of Publication.*

1.7.3. AF Form 1527-1, *Annual Occupational Exposure History to Ionizing Radiation.*

MARK W. WESTERGREN, Colonel, USAF
Commander

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References

5 USC 552a, *(Public Law 93-579) – Privacy Act of 1974*

AFI 10-206, *Operational Instructions,* 4 October 2004

AFI 32-7020, *The Environmental Restoration Program,* 7 February 2001

AFI 32-7040, *Air Quality Compliance,* 9 May 1994

AFI 32-7042, *Solid and Hazardous Waste Compliance,* 12 May 1994

AFI 33-332, *Air Force Privacy Act Program,* 29 January 2004

AFI 40-201, *Managing Radioactive Materials in the US Air Force,* 13 April 2007

AFI 40-402, *Using Human Subjects in Research Development Test and Evaluation,* 5 May 2005

AFI 40-403, *Clinical Investigations in Medical Research Guidance and Procedures*

AFI 41-106, *Medical Readiness Planning and Training,* 2 December 2004

AFI 48-119, *Medical Environmental Quality Programs,* 25 July 1994

AFI 90-201, *Inspector General Activities,* 22 November 2004

AFI 91-101, *Air Force Nuclear Weapons Surety Program,* 19 December 2005

AFI 91-109, *Air Force Nuclear Reactor Program,* 1 January 1999

AFI 91-110, *Nuclear Safety Review and Launch Approval for Space or Missile Use of Radioactive Material and Nuclear Systems,* 28 June 2002

AFI 91-204, *Safety Investigations and Reports,* 14 February 2006

AFI 91-301, *Air Force Occupational and Environmental Safety, Fire Prevention, and Health (AFOSH)Program,* 1 June 1996

AFPD 24-2, *Preparation and Movement of Air Force Materiel,* 3 September 2003

AFPD 32-70, *Environmental Quality,* 20 July 1994

AFPD 40-2, *Radioactive Materials (Non-Nuclear Weapons),* 8 April 1993

AFPD 48-1, *Aerospace Medicine*, 3 October 2005

AFMAN 33-363, *Management of Records,* 1 March 2008

AFMAN 48-125, *Personnel Ionizing Radiation Dosimetry* 7 August 2006

AFJI 23-504, *Radioactive Items in the DoD Supply Systems,* 19 April 1985

DoD Directive 5400.11, *DoD Privacy Program,* 16 November 2004

DoDI 6055.8, *Occupational Radiation Protection Program,* 6 May 1996

Energy Reorganization Act of 1974 (Public Law 93-438)

MIL-STD-882B, *Systems Safety Program Requirements*

NUREG 8.13, *Instructions Concerning Prenatal Radiation Exposure*

NUREG 1575, *Multi-Agency Radiation Survey and Sight Investigation Manual*

Privacy Act of 1974

Resource Conservation and Recovery Act (RCRA)

Title II of the Energy Reorganization Act of 1974 (Public Law 93-438)

Title 10, Code of Federal Regulations (10 CFR), *Energy*

Part 2, Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders

Part 19, Notices, Instructions and Reports to Workers: Inspection and Investigations

Part 20, Standards for Protection Against Radiation

Part 21, Reporting of Defects and Noncompliance

Part 30, Rules of General Applicability to Domestic Licensing of Byproduct Material

Part 31, General Domestic Licenses for Byproduct Material

Part 33, Specific Domestic Licenses of Broad Scope for Byproduct Material

Part 34, Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations

Part 35, Medical Use of Byproduct Material

Part 36, Licenses and Radiation Safety for Irradiators

Part 40, Domestic Licensing of Source Material

Part 70, Domestic Licensing of Special Nuclear Material

Part 71, Packaging and Transportation of Radioactive Material

Part 74, Material Control and Accounting of Special Nuclear Material

Part 110, Export and Import of Nuclear Equipment and Material

Part 150, Exemptions and Continued Regulatory Authority in Agreement States

Title 29 Code of Federal Regulations (29 CFR), *Department of Labor*

Title 40 Code of Federal Regulation (40 CFR), *Protection Of Environment*

Title 49 Code of Federal Regulation (49 CFR), *Transportation*

Part 173, General Requirements For Shipments and Packaging

Uniform Code of Military Justice (UCMJ), *Article 92*

Abbreviations and Acronyms

AEA - Atomic Energy Act of 1954

AF RIC - Air Force Radioisotope Committee

ALARA - As Low As Reasonably Achievable

CFR - Code of Federal Regulations

DoE - Department of Energy

NUREG - US Nuclear Regulatory Commission Regulation

OI - Official Instructions

RAM - Radioactive Material

RAMP – Radioactive Materials Permit

RIC – Radioisotope Committee

RPT – Radiation Protection Technician

RSO - Radiation Safety Officer

TLD – Thermoluminescent Dosimeter

US NRC - Nuclear Regulatory Commission

Terms

Accelerator Produced Radioactive Material - Radioactive material produced as the result of operating a particle accelerator.

Air Force Master Materials License - The single NRC license issued to the Department of the Air Force delegating to the Air Force regulatory authority over Byproduct, Source, and limited quantities of Special Nuclear Material used by the Air Force.

Alternate Radiation Safety Officer - A person, named as such on the US Air Force Radioactive Material Permit, who is qualified to act as RSO when the primary RSO is absent. Unless otherwise requested by the permittee, the alternate RSO becomes the primary RSO when the named primary RSO leaves the organization.

Assistant Radiation Safety Officer - A person in training for the position of RSO, who may only act under the supervision of the RSO.

As Low As Reasonably Achievable (ALARA) - The principle that personnel exposure must be maintained as low as possible consistent with existing technology, cost, and operational requirements.

Byproduct Material - Radioactive material (except Source and Special Nuclear Material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or using Source or Special Nuclear Material.

Low Level Radioactive Waste (LLRW) - Radioactive waste not classified as high level radioactive waste, transuranic waste, spent nuclear fuel, or Byproduct Material as defined in Section 11e(2) of the AEA (uranium or thorium tailings and waste).

Mixed Low Level Radioactive and Hazardous Wastes (Mixed Waste) - Low level radiological wastes that also contain chemical constituents that the Environmental Protection Agency defines as hazardous in 40 CFR 261, *Identification and Listing of Hazardous Waste.*

NUREG - Technical reports on various topics related to the regulation of nuclear energy published by the US Nuclear Regulatory Commission.

Naturally Occurring Radioactive Material - Radioactive material that occurs in nature; e.g.; radium-226

Permit - US Air Force or US Navy radioactive material permit issued to a unit within the respective service under the authority of a master materials license authorizing use of specific radioactive material for specific purposes or activities.

Permittee - The commander or senior functional manager of the Air Force organization identified in block 1 of a permit.

Radiation Safety Officer - An individual with specific education, military training, and professional experience in radiation protection practice appointed by a commander or the USAF Radioisotope Committee to manage radiation safety programs. The term "Radiation Safety Officer" (RSO) is a functional title and does not denote a commissioned status or specialty code. An RSO should be the most technically qualified person available. Take care when addressing RSO qualifications and duties to distinguish between installations and permit RSOs. Individuals appointed as the installation RSO may not always have the specific technical experience and training needed to qualify as the permit RSO.

Radioactive Item - A single unit or article constructed of or having radioactive materials as a component part.

Radioactive Material - Materials whose nuclei, because of their unstable nature, decay by emission of ionizing radiation. The radiation emitted may be alpha or beta particles, gamma or X-rays, or neutrons.

Restricted Area - For this instruction, a restricted area is an area having access limited to protect individuals against undue risks from exposure to radiation and radioactive material. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

Section Ninety-one b (91b) Material - Radioactive material exempted from NRC licensing controls under Section 91b of the Atomic Energy Act of 1954, as amended, in the interest of national defense.

Source Material - Uranium or thorium or any combination thereof in any physical or chemical form; or ores that have, by weight, one-twentieth of 1 percent (0.05 percent) or more of uranium, thorium, or any combination thereof. Source Material does not include Special Nuclear Material.

Special Nuclear Material - Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235; any other material that the NRC determines to be Special Nuclear Material and any material artificially enriched by the foregoing. Special Nuclear Material does not include Source Material.

Type A Package - A packaging that, together with its radioactive contents limited to A1 or A2 as appropriate, meets the requirements of 49 CFR 173.410 and 173.412 and is designed to retain the integrity of containment and shielding required by 49 CFR Part 173 under normal conditions of transport as demonstrated by the tests set forth in 49 CFR 173.465 or 173.466, as appropriate. A Type A package does not require Competent Authority Approval.

Unrestricted Area - For this instruction, an unrestricted area is any area access to which is not controlled by the permittee. Generally, it is an area that is accessible to a person who is not trained to work with radioactive materials or accessible to a member of the public.

US Nuclear Regulatory Commission - An agency established by Title II of the Energy Reorganization Act of 1974 (Public Law 93-438) to regulate Byproduct, Source, and Special Nuclear Material as provided for by the Atomic Energy Act of 1954, as amended. Within the NRC, final authority rests with the five member Commission acting as a body.

USAF Radioactive Material Permit - Written authorization from the USAF Radioisotope Committee for Air Force organizations to receive, possess, use, distribute, store, transport, transfer, and dispose of radioactive materials. Permits parallel NRC licenses in applications and scope. Unlike the NRC, a single permit may authorize Byproduct, Source, Special Nuclear Material, Accelerator Produced Radioactive Material, and Naturally Occurring Radioactive Material.

USAF Radioisotope Committee (RIC, Committee) - A committee set up according to the Air Force Master Materials License to coordinate the administrative and regulatory aspects of licensing, receiving, possessing, using, distributing, storing, transporting, transferring, and disposing of all radioactive materials in the Air Force except that transferred from the Department of Energy to the Department of Defense in nuclear weapon systems, certain radioactive parts of weapons systems and nuclear reactor systems, parts and fuel controlled under Section 91b of the AEA.

AFTAC Transportation Plan for RTG
Appendix K – Communications Plan

STRATEGIC COMMUNICATION PLAN and
PUBLIC AFFAIRS GUIDANCE
Air Force Technical Applications Center (AFTAC)
Office of Public Affairs
as *of 28 August 2014*

(U) SUBJECT: Burnt Mountain Radioisotope Thermoelectric Generator (RTG) Transportation Plan
(U) Attachment 1 - Questions and Answers

1. (U) PURPOSE: This Public Affairs Guidance provides background, information, questions and answers (Q&A), and key themes and messages regarding the Operational Transportation Plan that is scheduled to take place in July 2015.

2. (U//FOUO) BACKGROUND (NOT FOR RELEASE): For the protection of national security, sensitive details about the program or transfer of the RTGs will not be discussed or released due to Nuclear Regulatory Commission (NRC) restrictions. Areas that will not be discussed include specific operational information, seismic array architecture (to include geographic location and/or lat-long coordinates), physical protection details, or specific timelines of when and where the RTGs will be transferred. Additionally, the specific location of the RTGs and their association with Burnt Mountain are considered "FOR OFFICIAL USE ONLY" and should not be publicly disclosed based on NRC requirements.

(U//FOUO) AFTAC operates a seismic observatory on Burnt Mountain in Alaska to help verify compliance with nuclear test ban treaties. Data from the unattended station, located in a remote area about 60 miles within the Arctic Circle and approximately 50 miles south of the Arctic National Wildlife Refuge, are used to ascertain whether or not seismic activity has been caused by nuclear explosions . The data collection and communications equipment at the station use to be powered by 10 *radioisotope thermoelectric generators* (RTG). Each RTG is fueled with strontium-90 (Sr-90), a radioactive material. RTGs were used because of their high reliability and low maintenance requirements.

3. (U) BACKGROUND (RELEASEABLE): AFTAC globally operates multiple remote seismic arrays used in verification of compliance with nuclear test ban treaties. At one time, AFTAC utilized *radioisotope thermoelectric generators*, or RTGs, to power certain data collection and communications equipment. RTGs were used because of their high reliability and low maintenance requirements.

(U) In 1992, a tundra fire encroached on the Burnt Mountain site. It damaged some data cables, but did not impact the RTGs. The fire raised public concern among nearby inhabitants about the safety of using radioactive material as the power source at the station.

(U) The RTGs are no longer in use as a mission power source by the USAF. Although the RTGs remain an effective means of generating power, because of advances in technology, they have been replaced with a hybrid power system composed of batteries charged by solar panels and diesel generators. Our top priority continues to be safety of the public. Even though the RTGs are no longer used for power, they are still constantly monitored for both safety and security. The Air Force, in coordination with other agencies and mission partners, will remove the RTGs and transport them to an approved facility in the continental United States.

4. (U) OBJECTIVES:

a. (U) Provide an accurate, relevant flow of information to educate media/general public on about RTGs and the cooperative role AFTAC is playing during the relocation of the RTGs from their current location to a facility in the Continental U.S.

b. (U) Ensure any and all released information is in strict compliance with Operational Security (OPSEC) guidance.

c. (U) Highlight the "team effort" approach between the various interagencies involved the relocation, including (but not limited to) the Department of the Army ; Eielson AFB, AK; the State of Alaska ; the State of Nevada; Tribal authorities ; the Department of Energy; and the Nuclear Regulatory Commission.

5. (U) INTENDED AUDIENCES:

a. (U) DoD personnel and engaged interagencies

b. (U) U.S. government

c. (U) Media (Passive, RTQ)

d. (U) Citizens of the affected communities

6. (U) PA POSTURE: PA Posture is PASSIVE, RESPONSE TO QUERY (P/RTQ) when conducted in coordination with the involved agencies. Personnel and units tasked to deploy in support of this operation should direct media queries to the AFTAC Public Affairs Office. However, queries that are within the scope of this Comm Plan can be released by personnel on the ground in the interest of maximum disclosure/minimum delay. Subsequent to within-scope queries, responders must inform AFTAC/PA of the media engagement as soon as possible, but within 24 hours of release.

(U) Though each state has the right to speak freely about what is transpiring within its borders, state representatives are highly encouraged to refer their constituents' questions to AFTAC/PA. The Public Affairs Officer will be able to determine if what's being asked needs to be referred to another agency and will forward the query to the appropriate organization (i.e., if the question is, "What does the governor think about this plan?" then the question will be referred to the governor's office).

7. (U) VIEWS OF OTHERS: The U.S. Congressional Office of Technology Assessment issued a report in June 1994 entitled, "Power Sources for Remote Arctic Applications." Contained with the report was the following conclusion:

> *"Continued use of RTGs at Burnt Mountain bears low risk for the safety of maintenance workers and local populations and for the environment. In addition, it minimizes costs and further environmental disruption to the site. Each of the RTGs at Burnt Mountain contains between 1.2 and 3.9 pounds of Strontium-90 (Sr-90) fuel. Sr-90 produces the heat needed in the RTGs via radioactive decay, **not** through fission or fusion. It is manufactured as a byproduct of spent nuclear fuel reprocessing. Sr-90 has a half-life of 28 years. This makes it suitable for long-term power uses. RTGs do not require constant refueling."*

AFTAC Transportation Plan for RTG

8. **(U) KEY MESSAGES:** AFTAC has managed the RTGs since 1973. Through decades of deployment and utilization, there has never been a public health or environmental impact due to the RTGs. The radioactive material contained within the RTGs is managed in accordance with Nuclear Regulatory Commission requirements and governed by strict guidelines to ensure the safety of people and the environment. These AFTAC key messages focus on and display a responsive commitment to safety :

- *(U) AFTAC is a good steward to the environment and takes its environmental responsibilities very seriously.*
- *(U) AFTAC maintains a radioactive material license in accordance with NRG requirements to possess and safely operate the RTGs.*
- *(U) AFTAC continuously monitors the status of the RTGs for both safety and security concerns.*
- *(U) While the Air Force still maintains RTGs in the State of Alaska, they are no longer being used as a mission power source, and are in the process of being permanently relocated from their current location to a facility in the Continental United States.*
- *(U) In addition to its exemplary record of regulatory compliance, AFTAC has an exceptional safety record in its almost 40 years of managing the RTGs.*
- *(U) AFTAC has fully evaluated the process and requirements to safely remove the RTGs in a timely manner, while continuously keeping public health and environmental safety at the forefront of operational planning.*

9. **POCs:** AFTAC/PA point of contact is Ms. Susan A. Romano, (321) 494-7688 [DSN 854], susan.romano.2@us.af.mil; AFISRA/PA point of contact is Major Christian Hodge, (210) 977-2169 [DSN 969], christian.hodge@.us.af.mil.

Attachment 1

Questions and Answers

Q1. If they are still a viable power source, why aren't the RTGs being used anymore?
A1. The power output of the RTGs is no longer capable of meeting the requirements of the array. A hybrid power supply system was installed to replace the RTGs as the source of power.

Q2. When does the Air Force plan to remove/relocate the RTGs?
A2. Summer/Fall of 2015. For operational security reasons, we won't be releasing the specifics about the procedures of the relocation plan.

Q3. What installations/facilities are involved in the transportation plan?
A3. The RTGs are currently located in the State of Alaska. We are working with a number of DoD organizations and installations, as well as the DOE and state officials, to ensure the safe transport of the RTGs. For operational security reasons, we won't be releasing the specifics about the locations involved in the relocation.

Q4. What danger does transporting the RTGs pose to the general public?
A4. The Air Force, in consultation with numerous other federal agencies, designed a plan to mitigate any risks associated with the transport of the RTGs and has is executing the move during the summer to take advantage of the predictable and conducive weather. Detailed evaluations have not identified any significant risks to members of the public or the environment from the transport of the RTG's. In the very unlikely event of an incident or accident, emergency response personnel are on call and will receive immediate notification and appropriate instructions for ensuring public safety. A fully coordinated Emergency Response Plan is in place for this transport activity.

Q5. Why is the Army involved in the plan?
A5. The Army maintains and operates the aircraft needed to transport the RTGs.

Q6. Where will the RTGs be transported to?
A6. The plan is to transport the RTGs out of Alaska to a facility in the Continental United States.

Q7. What kind of container will the RTGs be in during transportation?
A7. The RTGs will be transported in a certified shipping container, approved by DoD, DOE and NRC.

Q8. If they pose no environmental threat, why not just keep them where they are?
A8. The RTGs are no longer in use or needed as a power source. Radioactive materials determined to be "excess" must be moved to a facility with a mission, capability and authorization to support long term storage or recycling of the material.

Q9. How do you know the RTGs have not impacted the environment or public health?
A9. The RTGs are compliant with all Nuclear Regulatory Commission requirements and are sealed radioactive sources. Periodic testing, with results verified by independent labs, provides confirmation of their integrity and verifies zero release of radioactive material.

Q10. You reported that you conducted a 'dry run' field assessment in 2013. How did that go?
A10. The purpose in the dry run was to assess the logistics associated with the transport of the RTGs and then use that assessment to develop detailed removal procedures required for transportation plan. The field assessment went very well and all objectives were met.

Q11. Has the EPA or OSHA been involved in this process?
A11. Numerous governmental agencies have been actively engaged in developing the transportation plan, including the state of Alaska, the Department of Energy, the Department of Transportation and the U.S. Nuclear Regulatory Commission.

Q12. How radioactive are the RTGs?
A12. The radioactive sources contained with the RTGs are stored in very robust containers designed to safely store the sources over long periods of time and to reduce any radiation exposures to personnel to very low levels. Radiation dose surveys are performed annually by AFTAC personnel. Radiation dose levels are measured on contact with the RTGs and at the closest accessible areas to the RTGs. The Nuclear Regulatory Commission has stringent requirements to ensure radiation levels are kept at appropriate levels to ensure the safety of people, property and the environment. All radiation emissions (dose levels) for these RTGs are well below the NRC allowances for workers and members of the public.

Q13. Do the aircrew and ground transportation crews require special training to transport radioactive materials?
A13. Personnel involved with the execution of the field assessment will receive radiation training from radiation safety officers.

Q14. How much is it going to cost to relocate them?
A14. Given the number of variables associated with relocation, the high cost of aircraft fuel, and the move's weather dependency, it is difficult to forecast a specific dollar amount. Estimates range from approximately $1M (most likely) to $2M (worst case).

Q15. What are the views of Alaska's elected officials with regard to the RTGs?
A15. You will have to direct that question to the specific elected officials for a response.

Q16. Who can I call to get more information about the RTGs or Det 460?
A16. Please call the Air Force Technical Applications Center Public Affairs office, which is located at Patrick AFB in Cocoa Beach, Florida, at (321) 494-7688, or via email at aftac.pa@us.af .mil.

APPENDIX L - Health and Safety Plan (HSP)

In Support of the Air Transportation of the USAF Radioisotope Thermoelectric Generators (RTG) from Burnt Mountain, Alaska to the National Nuclear Security Site Mercury, Nevada.

October 2014

AFTAC Transportation Plan for RTG

1. INTRODUCTION

This site-specific health and safety plan (HSP) describes the health and safety procedures when transporting 10 USAF Radioisotope Thermoelectric Generators (RTG) from Burnt Mountain, Alaska to the Nevada Nuclear Security Site (NNSS). All activities will be performed safely and in accordance with current Occupational Safety and Health Administration (OSHA) standards, Nuclear Regulatory Commission (NRC) standards, AF instruction, and this HSP.

Work activities will be planned to identify the safety, health, and radiation hazards associated with the work and to identify necessary controls to protect workers and members of the public. The Risk Assessment in Attachment 1 identifies the hazards associated with these activities. When necessary, additional documentation will be developed to incorporate the use of engineering controls, personal protective equipment (PPE) and other safeguards to ensure that appropriate measures are taken to control the risks and protect the well-being of personnel and the environment.

2. COMMITMENT TO HEALTH AND SAFETY

It is USAF policy to conduct operations in a way to ensure the safety and health of personnel and the environment. All activities will comply with applicable environmental safety and health regulations and requirements. Without exception, safety will take precedence over operations for the duration of this project. A risk management process will be used to assess all activities associated with this transport. In addition to meeting regulatory and other requirements, AFTAC is committed to minimizing the safety and health risks to personnel. This includes minimizing personnel exposures to hazardous substances and ensuring exposures to ionizing radiation are as low as reasonably achievable (ALARA).

3. APPLICABILITY

This HSP applies to all USAF personnel and contractors supporting the RTG transport. The HSP will be made available to all project personnel for review at any time and will be maintained by the project manager (PM) for the duration of the project. All USAF employees and contractors will review the HSP prior to any on-site work. The HSP will be made available on site during the transport.

4. GENERAL

4.1 Discussion

AFTAC will perform all assessments, surveys, and shipping activities for the RTG transport in accordance with this HSP and other federal/state requirements. This HSP identifies the potential hazards and establishes the proper controls to protect the workers, the public and the environment from potential harm.

AFTAC Transportation Plan for RTG

4.1.1 Project Information

The goal of this project is to transport 10 RTGs from Burnt Mountain, Alaska to NNSS and leave the RTG storage facilities in a condition such that a Final Status Survey (FSS) can be performed, with residual materials meeting the unrestricted release limits.

The supporting objectives include the following:

- Offload/load each RTG to awaiting aircraft for transport to next staging area.
- Ensure package and shipping requirements are met for transport.

4.2 Responsibilities and Organization

The AFTAC Commander is ultimately responsible for safety during the RTG transport. All participants must abide by this HSP. Several organizations will be supporting AFTAC during the transport including fixed and rotary wing units, Eielson AFB personnel, Creech AFB, DOE personnel and DoD contractors. Careful coordination with all supporting agencies must be accomplished ensuring they are aware of and comply with all health and safety requirements in this HSP. All participating organizations will be provided a copy of this HSP and all participating personnel will review and be familiar with this HSP.

This section describes the responsibilities and authorities of project personnel with regard to the HSP. All personnel shall be cognizant of the potential hazards during the project and aware of the controls implemented to reduce the risk of exposure to radioactive or hazardous materials. All personnel shall comply with the rules and procedures set forth in this HSP. All operations will be conducted in accordance with federal and state regulations and USAF instruction.

4.2.1 Safety and Health Officer/ Radiation Safety Officer (RSO)

The AFTAC RSO will serve as the safety and health officer for the operation. The RSO is responsible for the development and implementation of the HSP. The RSO shall be knowledgeable in the applicable safety standards and the regulations and shall be trained and qualified in accordance with applicable regulations. The RSO will ensure the necessary radiation safety and health monitoring is performed and all required documentation is maintained. The RSO, or designee, has the authorization to stop work at any time the work conditions are dangerous to the health and safety of personnel or the environment. In addition, the RSO, or designee, is responsible for:

- Reviewing and approving the health and safety of operational plans
- Monitoring the operation for safety concerns
- Ensuring the proper performance of radiological surveys, sampling, and monitoring as required
- Implementing changes to this HSP based on changing work conditions
- Documenting any exposures to radioactive or hazardous materials
- Ensuring all training, medical, and exposure records are complete and available for review
- Conducting and documenting periodic health and safety meetings
- Ensuring proper PPE has been selected and used appropriately

- Ensuring all monitoring equipment and instrumentation meet calibration requirements
- Ensuring NISTe traceable documentation is maintained for all instrument calibrations
- Ensuring all personnel are properly trained for the tasks they are to perform
- Coordinating health and safety requirements for supporting organizations including Eielson AFB, Creech AFB and any other supporting agencies. Coordination will typically be through the Installation Radiation Safety Officer, Base Bioenvironmental Engineer and the base Ground Safety Office.
- Ensure proper ingress/egress procedures are followed

4.2.2 AF and Participating Contract Personnel

Personnel will:

- Be responsible for their own health and safety by following all health and safety requirements as defined by the RSO and this HSP
- Perform all activities in compliance with this HSP
- Notify the RSO of any radiological, safety, or operational conditions that change prior to continuing work
- Review this HSP and appropriate procedures for work
- Will have stop work authority for any safety, radiological, and operational concerns
- Will notify the RSO or on-site Commander immediately if they recognize a unidentified potential health or safety risk
- Contractor personnel are also required to comply with any additional health and safety requirements implemented by their organization or their contract with the USAF

4.2.4 On-site Commander

The on-site Commander will:

- Be responsible for RTG removal operations at all locations and will ensure all health and safety requirements of this HSP are implemented by all participating personnel
- Ensure the requirements of this HSP are communicated to support personnel
- Work with the RSO to ensure all potential hazards are identified and properly controlled
- Report all hazards to RSO and follow and implement all health and safety requirements identified by the RSO
- Coordinate HSP requirements with 354th Wing, Eielson AFB support personnel, 4-123d Aviation Regiment, and 99th ABW personnel.

4.2.5 AFTAC Commander/Permittee

The AFTAC Commander is responsible for the health and safety of all AFTAC personnel involved in this effort. The Commander will ensure the on-site Commander and the AFTAC RSO have all of the necessary resources and authority to ensure the health and safety of personnel. The Commander will ensure

health and safety requirements and any potential risks are properly communicated to all supporting organizations.

4.2.6. Aircraft Operations

The safe operation of all aircraft involved in this operation is the responsibility of the Aircraft commander. The aircraft commander will have final authority in the decisions regarding the safe operation of the fixed or rotary wing aircraft involved in the operation. The A/C Commander will be responsible for the Health and Safety of all passengers and crew during flight operations.

4.2.7. Supporting Personnel

A variety of support personnel from outside of AFTAC will participate in the RTG transport. The command authority for each unit will be responsible for ensuring their personnel comply with this HSP. This HSP will be provided to all participating units and the AFTAC RSO or designee will brief personnel on the contents of this HSP before work commences. Any changes or additions to the HSP will be communicated to all participating personnel and supporting units if appropriate.

5. TRAINING

Training requirements for this project include, but are not limited to:

- Training on this HSP will be provided to all participating personnel
- Radiation Protection training will be provided to all support personnel who will work in the vicinity of the RTG units. The RSO will determine who requires Radiation Protection training.
- The aircrew will be responsible for briefing passengers on safety requirements associated with aircraft operations
- Personnel will have the proper training and certification for any AF vehicles used including forklifts
- Personnel will be briefed on any changes to this HSP or any additional health and safety requirements implemented
- Personnel will receive site specific training as needed during the operation. Site specific training will include emergency contact information, location of fire extinguishers, evacuation routes and rally points, and any unique hazards present at the location. The on-site commander will be responsible for ensuring site specific training is provided.

All training will be documented and approved by the RSO.

6. HAZARDS AND CONTROLS

Anticipated hazards that may be encountered during the project include:

- Power equipment and power tool operations
- Slips/trips and fall hazards
- Working with heavy equipment (i.e., forklift)

- Fire
- Hazardous Noise
- Hazardous Materials
- Exposure to Radioactive Materials

This HSP will be used on this project to control the above hazards. In certain instances site specific procedures will be used provided they are at least as stringent as the controls listed in this HSP. Some specific controls are addressed as follows:

6.1 Power Equipment and Power Tool Operations

Power tools will only be used by properly trained personnel. Hearing protection will be worn with any power tools which produce hazardous noise. Power tools will only be used for their designed purpose and only will be used as described in the associated operator's manual. If appropriate, safety glasses or googles will be used with any power tools that present an eye hazard.

6.2 Slips, Trips, Falls, and Heavy items

RTG transport will include work in uneven and very soft terrain. All personnel will wear appropriate foot wear for the portion of the transport they will be participating in.

The RTG units are very dense and present a crushing hazard. Personnel directly involved in handling the RTG or who will work in the direct vicinity of the RTG will wear crush resistant footwear (i.e. steel toed boots or equivalent). Safety observers will be used when transporting the RTG by forklift. The RTG units will be secured by straps or chains to the fork lift when they are transported. All equipment used to transport the units will be certified to carry the weight of the RTG unit.

No personnel may be exposed to a fall over 6 feet without being tied off or having other fall protection as provided in 29 CFR 1926, Subpart M.

6.3 Fire Protection and Emergency Notification

Upon discovery of a fire, personnel must perform notification via the site notification system. See Attachment 2 for emergency contact numbers.

After notification, in the event of a small, manageable fire, which poses no immediate risk to workers, locate the nearest fire extinguisher to extinguish the fire. Fire extinguishers are located at:

Burnt Mountain: Each RTG shed contains a halon system. Additionally, inspected ABC fire extinguishers are located in each shed, at the power station, and at the living facility.

Fort Yukon: Fire services are approx 50 yards from the landing and refueling location. Full firefighting services are available.

Eielson AFB: Flight line firefighter support will be provided with minimal response time.

Creech AFB: Flight line firefighter support will be provided from either the North or South fire stations. Response time less than 90 seconds

Personnel may fight a fire if they can safely do so. Only trained personnel should attempt to extinguish the fire. Once the fire is extinguished, the incident must be reported to the RSO. The incident must be documented in accordance with USAF instruction. In all other situations, an emergency evacuation must take place following the guidance outlined in section 6.7.

When practical, emergency phone numbers including fire and ambulance services must be posted/provided at the work site prior to the start of work activities. Radios and cell phones will be used to contact emergency services. Unless otherwise directed, dial 911 to reach an emergency dispatcher. Other emergency contact information is provided in Attachment 2, Site Emergency Services Numbers for RTG Transport. Emergency contact information will be printed on cards and carried by all personnel.

6.5 Hazardous Noise

Hearing protection devices in the form of earplugs and/or earmuffs will be provided and worn by all personnel working in areas of hazardous noise. All personnel will wear hearing protection in the vicinity of operating aircraft.

6.6 Radioactive Materials

External exposure to radiation is the primary hazard from the RTG units. SR-90 and Y-90 are pure beta emitters which produce x-rays when interacting with the RTG packaging, thus, the RTG units produce continuous low intensity x-ray radiation on the exterior. The x-ray radiation does not present a short term hazard, but longer term exposures can increase long term health risks. For this reason, personnel must always practice ALARA when working with the units. Personnel will minimize time, maximize distance, and utilize shielding to limit exposures to radioactive materials.

To reduce potential exposures during RTG operations the following control measures are required:

- All personnel who will operate within 100 feet of the RTG units will either wear a whole body radiation dosimeter (TLD) or will be issued an Electronic Personal Dosimeter (EPD) by the RSO. Personnel who have the potential for exposures exceeding 2 mrem/hr will be identified in advance, receive Radiation Protection training commensurate with their duties, and be provided with a TLD. Any personnel who do not have a TLD but will be exposed to radiation exceeding 2 mrem/hr will receive an EPD from the RSO.
- Only essential personnel will be in the vicinity of the RTG units, non-essential personnel will be excluded from the area
- Members of the general public will be prevented from coming within 200 feet of the RTG units. If the units will place members of the public within 200 feet of the units, the RSO will perform radiation surveys and restrict areas as needed to maintain doses below public exposure limits

- The RSO will conduct routine monitoring throughout RTG transport operations to assess worker exposures and potential exposures to members of the public. The RSO will implement additional control measures when practical to further reduce exposures
- The RSO will conduct periodic swipe sampling to verify the integrity of the RTG units. At a minimum, swipe samples will be conducted at Eielson AFB and Creech AFB when the units are staged for shipment
- No smoking, drinking, or eating in the vicinity of the RTG units
- When the RTG are staged during transport at Eielson AFB and Creech AFB, any area with a dose rate greater than 2 mrem/hr will be clearly marked as a Radiation Area. Access to the area will be strictly controlled to essential personnel only
- Dosimetry will be coordinated by the AFTAC RSOs for all personnel. The AFTAC RSOs will coordinate with the following offices and request the appropriate number and type of dosimetry:
  - AFTAC Personnel assigned to Patrick AFB will wear their assigned TLD from Patrick AFB
  - AFTAC personnel assigned to Eielson AFB will wear their assigned TLD from Eielson AFB.
  - Army personnel will receive TLD's from USARMY HQDA ASO (Mr Greg Komp) through Ft Wainwright Safety Office (Mr Robert Tanner)
  - Eielson AFB personnel will wear their assigned TLD from Eielson AFB.
  - Creech AFB personnel wear their assigned TLD from Creech/Nellis AFB.
  - DOE personnel will bring their assigned TLD from DOE.
  - AFTAC RSOs will coordinate through TRANSCOM to the assigned Base for aircrew personnel supporting operations to determine if their host installation will provide TLD. If TLD's are unavailable from their host installation, AFTAC RSOs will coordinate with USAF School of Aerospace Medicine to determine who will provide TLD's for aircrew personnel.

6.7 Emergency Evacuation

In the event of an emergency evacuation as a result of fire or other emergency, personnel will follow the site specific procedures. The on-site commander will establish evacuation procedures for each site. All personnel will be briefed on the procedures at the start of operations at each site. Each site will establish evacuation routes and a rally point. In the event of emergency, personnel will proceed by the evacuation route to the rally point. The on-site commander will then account for all personnel and perform any appropriate notifications. Evacuation procedures for each site are:

Burnt Mountain: Evacuation routes follow the trails from the sites back to the living facility or power station, whichever is closer to the site of issue.

Fort Yukon: Emergency responders will direct civilian/military personnel in accordance with the local Fire Services evacuation procedures. Procedures will be pre-briefed to all participants.

Eielson AFB: Emergency responders will direct civilian/military personnel in accordance with the local evacuation procedures. Procedures will be pre-briefed to all participants.

Creech AFB: Emergency responders will direct civilian/military personnel in accordance with the local evacuation procedures. Procedures will be pre-briefed to all participants.

6.8 Health and Safety of Site Security Personnel

Site security will be provided at each location with the exception of Burnt Mountain, Alaska. Because of the remote location additional security will not be provided at Burnt Mountain. Participating Det 460 will provide any needed security for dangerous wild life (e.g. bears).

Security forces personnel will maximize their distance to the RTG units when possible. Local security personnel will consult with the RSO on patrols or posting locations. The RSO will assess the dose of posted security personnel and will ensure their doses are ALARA. Security personnel will be assigned TLD's and will receive Radiation Protection training before operations commence. Radiation Protection training will be provided by the AFTAC RSO or the Installation RSO. Security personnel will follow the security plan if any notifications are required. Security personnel will limit access to the RTG units to personnel approved by the AFTAC RSO.

6.9. Other Hazards

There are other hazards associated with this operation. These include but are not limited to wildlife, heavy lifting, electrical shock and others. Attachment 1 includes a list of all hazards identified and the control measures to be implemented. If additional hazards are identified before or during the operation proper control measures will be implemented and they will be briefed to effected personnel.

7. HAZARD COMMUNICATION

The purpose of the Hazard Communication (HAZCOM) Program is to ensure information concerning hazardous materials used during transport of the RTGs are communicated to personnel. The information concerning these hazards shall be communicated to employees and contractors during the initial safety briefing at each location. At this time, there are no hazardous chemicals associated with this operation.

In the event hazardous chemicals are used, the RSO will be responsible for maintaining material safety data sheets and conducting training of personnel. Hazardous chemicals will be approved by appropriate base organizations if needed.

8. PERSONAL PROTECTIVE EQUIPMENT

In addition to work practices, PPE will be used to protect personnel from harmful noise levels, and hazards associated with the use of power tools, heavy equipment and other workplace hazards.

The use of protective clothing and the establishment of proper area controls will be used to reduce the possibility of personnel injury.

The need for PPE will be established by the AFTAC ESOH Officer. At a minimum, all project personnel will wear appropriate clothing, which may include, but not be limited to:

- Personnel directly participating in transporting the RTG units will wear steel toed boots or equivalent.
- All personnel will be provided appropriate hearing protection and will wear the hearing protection when hazardous noise may be present.
- Safety glasses will be worn during operations that may pose a risk of eye injury, e.g. operating power tools
- Protective gloves will be worn by personnel assisting in RTG tie down operations. Gloves will also be worn by any personnel handling sharp objects or using tools that may result in skin lacerations
- PPE will be worn as required by other health and safety assessments

All PPE will be routinely inspected before use. Any damaged or worn PPE will be promptly replaced. All PPE used must be approved by the AFTAC RSO and must be in compliance with any applicable AF requirements.

9. RADIATION SAFETY

All radiation exposures on the project will be maintained As Low As Reasonably Achievable (ALARA). Except in an emergency incident no dose shall exceed those specified in AFI 48-148, Radiation Protection Program.

The RTGs at Burnt Mountain contain approximately 500 thousand curies of strontium-90 (Sr-90). The Sr-90 fuel capsule is shielded within the generator. The RTGs do emit x-rays but are safe to work around under normal conditions. If the RTG shielding is breached it is important to physically distance yourself from the contents and remain downwind as directed by the on-site radiation protection technician.

On the surface of the RTG, the exposure rate is less than 50 millirem per hour. In comparison, a person standing directly next to an RTG for 15 minutes would receive an exposure equivalent to a chest x-ray. The annual limit for radiation dose exposures for radiation workers is 5000 millirem. Personal radiation dosimeters are provided for all individuals working around the RTG units.

Personnel must adhere to the "As Low As Reasonably Achievable" (ALARA) principle. Because there is a small risk associated with even a small amount of radiation, radiation exposures must always be limited as much as practical. Only essential personnel should be in the vicinity of the units and members of the general public will be restricted from access to the RTG units. Additional controls are listed in section 6.6. In the event of a radioactive material accident see Appendix M of the transport plan for response procedures.

10. RISK MANAGEMENT ASSESSMENT

The overall risk for this effort is medium. This a non-routine task conducting at a remote location with very limited access. Risks from the operation include radiation exposure, work with heavy items and equipment, operations at a remote location, aircraft operations, and hazardous noise.

This HSP, and already established controls, implement procedures to reduce these risks as much as practical. The medium risk items include exposure to radioactive materials as a result of an accident and the heavy equipment operations. These risks are adequately addressed through administrative controls and training. While there is some risk associated with this effort, with properly implemented control measures, the risk is not significantly greater than other day-to-day operations. All reasonable risk controls/mitigation actions have been taken and will be enforced during execution of the effort.

AFTAC Transportation Plan for RTG

Attachment 1 – Risk Management Assessment

Risk Management Assessment

Task: All Activities

OVERALL RISK LEVEL AFTER CONTROLS ARE IMPLEMENTED: MEDIUM

Hazard	Initial Risk Level	Hazard Control	How to Implement/Who Will Implement	Residual Risk Level
Fire	Med	Flammable liquids will be stored in flammable safety containers. Properly rated fire extinguishers will be placed within 50 ft of fuel storage areas, within sight of heavy equipment, personnel will be trained in the proper use of fire extinguishers. All personnel will be briefed on evacuation routes and rally points. Personnel will be trained on proper fire extinguisher use.	Briefing will be provided by the on scene commander or designee.	Med
Operating Hand tools: Manual and Power	Low	Tools will be inspected before use. Damaged tools will be tagged out-of –service until repair can be performed by qualified personnel. Tools will be used for their intended purpose only	On scene commander and AFTAC RSO will ensure proper PPE is utilized and personnel are properly trained/certified for the work being performed.	Low
Traffic	Low	Work areas will be clearly marked with appropriate signs displayed. Traffic will be routed as necessary. Persons working around heavy equipment will wear high visibility vests.	On scene commander will ensure areas are properly marked and personnel are trained of hazard.	Low
Strains and sprains from manually lifting and moving.	Low	Proper lifting techniques will be used: Keeping back straight and lifting with legs. Personnel will avoid twisting back. Get help from others; use mechanical equipment; no lifting over 50 lb.	Personnel will ensure proper lifting techniques while working with heavy equipment.	Low
Slips, trips, falls, terrain, vegetation,	Low	Work area will be visibly inspected. Slip, trip and fall hazards will be removed or	Administrative controls, direct supervision and training to prevent slips, trips, and falls	Low

Risk Management Assessment Task: All Activities OVERALL RISK LEVEL AFTER CONTROLS ARE IMPLEMENTED: MEDIUM				
Hazard	Initial Risk Level	Hazard Control	How to Implement/Who Will Implement	Residual Risk Level
uneven surfaces		marked and barricaded.	while loading and unloading the RTGs.	
Abrasions and lacerations, hands or fingers caught between objects	Low	Workers will be made aware of the hazard in handling and placement of heavy objects. Materials being handled will be inspected for sharp or rough edges and take appropriate precautions to avoid contact. Workers will wear work gloves (per PPE requirements) and avoid placing hands between objects.	Briefing will be provided by the on scene commander or designee.	Low
Striking and being struck by operating equipment, loads, falling objects and pinch points	Low	Workers will stay out of the swing area of all equipment and from under loads. All personnel will wear PPE including full length pants, long sleeved shirts, work gloves, steel toed and steel shank boots, safety glasses, and hearing protection (during noise-generating activities). The workers will be advised to be aware of the potential of being struck in loading areas when the forklift is in operation. Workers exposed to traffic hazards will wear traffic/reflector vests.	Briefing of hazards will be provided by the on scene commander or designee.	Low
Inclement weather including rain, lighting, heat and cold stress, sunburn, poor visibility	Low	Workers will have appropriate PPE for working in rain or cold. Fluids will be provided to all workers. Work rest periods will be established with ACGIH and NIOSH guidelines. Engineering controls (early morning work	Briefing of weather conditions will be provided by the on-site commander or designee prior to and during operations.	Low

Risk Management Assessment

Task: All Activities

OVERALL RISK LEVEL AFTER CONTROLS ARE IMPLEMENTED: MEDIUM

Hazard	Initial Risk Level	Hazard Control	How to Implement/Who Will Implement	Residual Risk Level
		schedules) will be implemented if heat stress is a problem. Work will cease during rain or lighting. Sun block will be used as appropriate.		
Radiation Hazard	Med	Personnel will be assigned a TLD and radiation monitoring will be conducted by the RSO. Additional control measure, described in the HSP, will be implemented.	Workers will be made aware of the potential external exposure by proximity to radioactive materials. The potential risk of handling or working with the RTGs is low. Workers will maintain external exposure ALARA by minimizing time spent in close proximity to the RTGs and maximize their distance from the RTGs.	Low
Heavy Lifting	Low	Workers will be trained in proper lifting techniques.	On-site commander or designee will ensure personnel are properly trained for the work being performed.	Low
Exposure to hazardous material	Med	Workers will be trained in proper use of PPE and proper fit of PPE Daily inspections will be performed on all safety equipment	On-site commander or designee will ensure proper PPE is worn.	Low
Personal Injury	Low	Daily inspections will be performed on all equipment.	Workers will be trained on the HSP and the associated hazards including physical hazards. Initial site-specific training will be conducted. Safe work practices and good housekeeping will be followed. Workers will be informed of the contaminants and chemicals at each site and availability of Safety Data Sheets.	Low

AFTAC Transportation Plan for RTG

Risk Management Assessment Task: All Activities OVERALL RISK LEVEL AFTER CONTROLS ARE IMPLEMENTED: MEDIUM				
Hazard	Initial Risk Level	Hazard Control	How to Implement/Who Will Implement	Residual Risk Level
			A first aid kit will be provided and maintained in a designated area during the project.	
Wildlife	Low	Many areas include unimproved wildlife habitat. Bears, snakes, spiders, insects and other hazardous wildlife are native to the area.	On-site commander or designee will brief personnel of wildlife in the local area prior to operations beginning.	Low

AFTAC Transportation Plan for RTG

Attachment 2 – On Site Emergency Services Numbers

Burnt Mountain Alaska	Telephone/Radio
Emergency	Radios provided by Det 460
Emergency Services	Eielson AFB Command Post 907-377-1500

Fort Yukon Alaska	Telephone/Radio
Emergency – On Site	Radios provided by Det 460
Ambulance Service/Fire Department	911

Eielson AFB Alaska	Telephone/Radio
Emergency – On & Off Base	911
Ambulance Service/Fire Department	911

Creech AFB Nevada	Telephone/Radio
Emergency – On & Off Base	911
Ambulance Service/Fire Department	911

NNSS	Telephone/Radio
Emergency – On & Off Base	911
Ambulance Service/Fire Department	911

Other contact numbers for non-critical situations

Organization	Telephone/Radio
Eielson AFB Radiation Safety Officer	Lt Robyn Pack: 907-377-6687/6602 (On Call Cell: (b)(6)
Eielson AFB Ground Safety Office	907-377-8735
Eielson AFB Public Health (Insect Bites and hazardous wildlife information)	907-377-6678
Eielson AFB Clinic	907-377-1847
Eielson AFB Fire Department (non-emergency)	907-377-2178
Eielson AFB Security Forces	907- 377-5130
Creech AFB Radiation Safety Officer	Maj Richard Kice: 702-653-3316 (On Call Cell: (b)(6) (b)(6)
Creech AFB Ground Safety Office	702-404-3786
Creech AFB Clinic	702-404-1142
Creech AFB Fire Department (non-emergency)	702-404-0864
Creech AFB Security Forces	702-652-2311
Poison Control	702-404-0911 (Emergency Response)
AFTAC Command Post	321-494-4333
AFTAC Radiation Safety Officer	Mark Talbert: 321-446-5408 Joy Morris: 321-604-5074

AFTAC Transportation Plan for RTG

Maps/Routes to nearest medical treatment facilities:

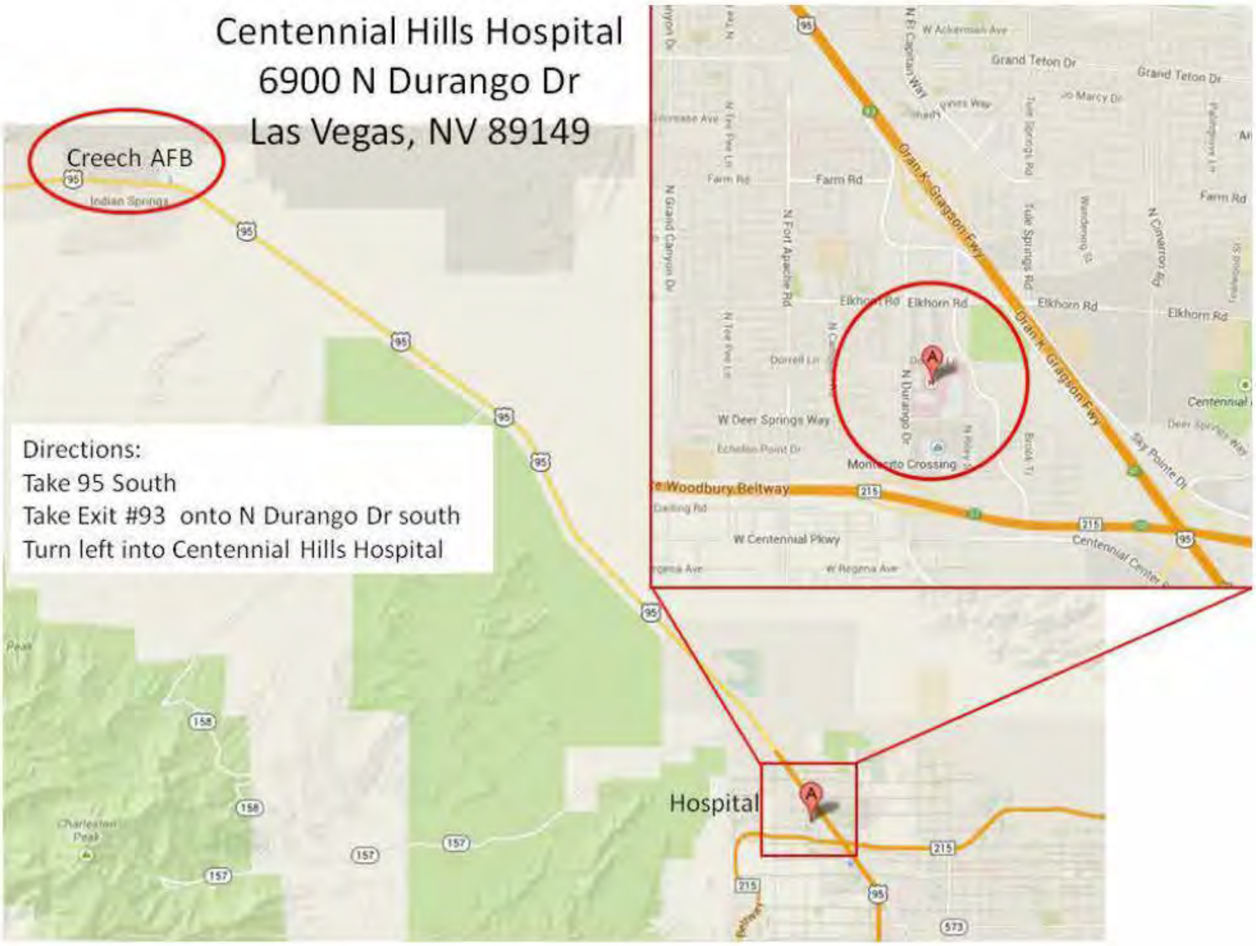
Ft Yukon

AFTAC Transportation Plan for RTG

Eielson AFB

AFTAC Transportation Plan for RTG

Creech AFB



APPENDIX M – EMERGENCY MANAGEMENT PLAN

1) Purpose and Scope

This plan describes the actions to be taken and the procedures to be followed in the event of an emergency involving the transport of 10 Radioisotope Thermoelectric Generators (RTGs). Reporting of radioactive material mishaps and incidents associated with RTG transportation is governed by AFI 40-201 paragraph 3.12 and attachments 11 and 12 as well as portions of 10 CFR 20 as referenced in the AFI. Emergency Response Summary Information is provided at the end of this appendix. This information will accompany the RTG s throughout transport.

2) General

A. Emergency Contact Information:

LOCATION	COMMAND POST	POLICE DEPT	FIRE DEPT	RAD SAFETY OFFICER
AFTAC	321-494-4333	N/A	N/A	Mark Talbert: 321-494-4851 (cell (b)(6)) Joy Morris: 321-604-5074
Ft Yukon	N/A	907-662-2311	907-662-2379	N/A
Eielson AFB	907-377-1500	907- 377-5130	907-377-2178	Maj Scott Boyd: 907-377-6690 Lt Robyn Pack: 907-377-6687/6602 (On Call Cell: (b)(6) (b)(6)
Creech AFB	702-652-2446	702-652-2311	702-404-0864	Maj Richard Kice: 702-653-3316 (On Call Cell: (b)(6)
Indian Springs	N/A	702-879-3333	702-879-3330	N/A
NNSS	702-295-0311	Operations Coordination Center		

B. An emergency involving a RTG is defined as any event which potentially constitutes a radiological accident such as fire, collision, or dropping of the RTG so as to do visible external damage, or an event which can be interpreted to be a loss of control over the RTG, such as theft or vandalism. Emergency determination will be made by consult between the On-site Commander and the Radiation Safety Officer (RSO)

C. Mishaps and incidents are broadly defined as:
1. Loss of control of radioactive material that could cause a hazard to life or health
2. Individual exposure above thresholds defined in 10 CFR 20.2202
3. The release of radioactive material, inside or outside of a restricted area
4. Any event, such as fire, explosion, or toxic gas release, involving radioactive material that requires immediate protective actions to avoid exposures to radiation or radioactive material, or to avoid releases of licensed or permitted material, above regulatory limits

5. Any spill or unplanned release of radioactive material resulting in exposure to unprotected or inadequately protected individuals

D. An emergency begins with any event involving the RTG which potentially constitutes a radiological accident or which can be interpreted as loss of control over the RTG. An emergency is considered resolved when:
1. It has been determined by positive action that radioactive materials have not been released
2. If radioactive materials have been released, surveys and cordons have been established where control of the area is complete and radiation dose rates are within acceptable limits
3. If control of the RTG has been lost, control has subsequently been regained

E. All radiological mishaps and incidents will be immediately reported to the Wing Command Post (CP) with current operational control; Eielson or Creech AFB. The Wing CP will initiate notifications IAW established procedures such as:
1. (AFI) 10-2501, Air Force Emergency Management Program Planning and Operations
2. National Incident Management System (NIMS)
3. National Response Framework (NRF)
4. Wing Comprehensive Emergency Management Plans

F. Agencies potentially involved in incident notification and emergency response:

Mission Support Group Commander (Chair)	Logistics Readiness Squadron
*Emergency Management (facilitator)	Air Force Office of Special Investigations
*Security Forces	Operations Group
*Medical Representative	Senior Installation Chaplain
*Bioenvironmental Engineer Officer	Mental Health
*Public Health Emergency Officer	Tenant Units
*Safety	Public Affairs
*Fire Emergency Services	Maintenance Group
* Communications	Air Traffic Control
*Civil Engineer	Judge Advocate
*Explosive Ordnance Disposal	Wing Inspector General
*Installation Antiterrorism Officer	Installation Deployment Officer
*Weather	Wing Plans and Programs
*Contracting	Installation Exercise Evaluation Team Chief
*Force Support (Services & Personnel Readiness)	Wing Critical Asset Risk Management/Critical Infrastructure Protection Program Manager
Aircrew Flight Equipment	Intelligence

Note: Recommended members of the All Hazards Response Planning Team are asterisked (*)

G. The incident will be reported to the Operations Commander and the AFTAC or Installation Radiation Safety Officer (RSO) identified in paragraph 2.A. The RSO will in turn notify the appropriate organizations as governed by AFI 40-201. Notifications made to report an emergency shall be made

by voice insofar as possible unless precluded by security requirements. Organizations to be notified by the RSO are:

1. Radio Isotope Committee (RIC): DSN 425-6308, Comm (703) 588-6308
2. RIC Secretariat: DSN 761-6946, Comm (703) 681-6946
3. Andrews Regional Command Post (after duty hours): DSN 858-5058, Comm (301) 981-5058
4. Bolling AFB Command Post: DSN 297-4011, Comm (202) 767-4011
5. AK state official: Mr. John Madden, (907) 782-8287
6. NV state official: Ms. Karen Beckley, (775) 687-7540

H. Release of Information: Special care will be taken when reporting a mishap or incident to ensure reports do not contain sensitive unclassified information. All reports involving RTGs will be handled as sensitive information and transmitted as required by NRC Sensitive Unclassified Non-Safeguards Information (SUNSI). All information will be properly marked and secured from unauthorized access.

3) General Aspects and Common Procedures for All Emergencies

A. Emergency Protection Phase

1. Objective. The objective of the emergency protection phase is to save human lives and to minimize potential or actual radiation exposures.
2. Duration. The emergency protection phase begins with the discovery of the event which started the emergency and ends when the evacuation of humans from the emergency area is completed.
3. Observe Radiation Precaution. When in doubt if the radioactive material is still confined to its container, assume that the immediate accident area is radioactively contaminated and that anyone and anything in the area MAY BE contaminated. Take special care to minimize personal contact with the outer clothing of individuals, the surface of the ground, vegetation, and the surfaces of other material within the accident area or material that has been removed from the accident area.
4. Rescue Humans. Make every effort possible to rescue injured or trapped persons and remove them from the accident area.
5. Evacuate Humans. Evacuate all persons from the emergency operations area to an assembly area where the radiation exposure under the circumstances could reasonably be expected to be zero or very nearly zero.
   a. If any radioactive material has been released, and
   b. If such material has been released, the extent of the contamination area, or
   c. If such material has not been released, if there has been and loss of shielding

B. Situation Determination Phase

1. Objective. The objective of the situation determination phase is to determine whether a radiation release has occurred and establish the severity of the release.
2. Duration. The situation determination phase begins as early as possible because information that radioactive materials have not been released will facilitate execution of the emergency

protection and damage control phases and simplify some of the requirements in the preventive control phase.

3. Conduct Radiological Surveys. All monitors conducting the surveys will be equipped with dosimeters. If abnormal radiation levels are encountered personnel will move to safe distances as directed by the RSO.
4. Notifications. Wing Command Posts must be notified immediately if an emergency situation is declared.
5. Personnel will remain at safe distances and the area secured until a hazardous response team arrives to evaluate the situation.

C. Report Phase. (Applicable only to radiological accidents.)

1. Objective. The objective of the report phase is to provide a final official record of each radiological accident as required. Reports will contain all available essential elements of information providing a chronological history of the accident, information on what happened, what actions were taken in response thereto, the consequences of those actions, and the names and organizations of appropriate individuals involved.
2. Submit Final Report

4) Actions and Procedures for Handling an Impact Accident

A. Occurrence. An impact accident could occur due to a mishap during handling of the RTG (loading, unloading) or during transport of the RTG.

B. Response to an impact accident will be as follows, in accordance with subparagraphs in paragraph 3) above:

1. Execute emergency protection of human life
   a. Observe radiation precautions
   b. Rescue humans
   c. Evacuate humans
2. Execute damage control measures
   a. Shut down equipment
   b. Contain damage
3. Establish preventive control measures
   a. Establish control of human movement
   b. Establish control of equipment
   c. Establish control of area
4. Determine actual hazard situation.
   a. Conduct a radiological survey of the incident area
      i. Execute notification
      ii. Perform radiation dose rate measurements
      iii. Position personnel in safe area
      iv. Control access RTGs
      v. Provide detailed information to emergency responders

5) Actions and Procedures for Handling a Fire Accident

A. Occurrence. A fire accident could occur during transport of the RTG by any vehicle or while the RTG is in storage.

B. Response to a fire accident will be as follows:
   1. Execute emergency protection of human life
      a. Sound the alarm and inform the fire department that there is a fire involving an RTG.
      b. Observe radiation precautions
      c. Rescue humans
      d. Evacuate humans
   2. Execute damage control measures
      a. Shut down equipment
      b. Fight fire. Fight the fire as though toxic chemicals are involved. To the extent possible keep upwind from the fire and avoid smoke, fumes, and dust. Segregate clothing and tools used at the fire until they can be checked for radioactive contamination before being returned to normal use. (This monitoring will not be necessary if radiological safety personnel determine that there has been no compromise of the RTG fuel containment.) Personnel involved in fire fighting operations shall wear pocket dosimeters or film badges/TLDs.
      c. Evacuate RTG and removable equipment. If the fire is in the vicinity of the RTG, but does not involve the RTG, a reasonable effort shall be made to remove the RTG from the fire area at the earliest possible time without endangering personnel. If the fire has caused an increase in the ambient temperature in the vicinity of the RTG and the RTG has not suffered any visible external damage, the RTG should be kept cool with water spray, if possible. Evacuate other valuable equipment if fire conditions permit this action without endangering personnel.
      d. Contain damage
   3. Establish preventive control measures
      a. Establish control of human movement
      b. Establish control of equipment movement
      c. Establish control area
   4. Determine actual hazard situation
      a. Conduct a radiological survey of the accident area
      b. If radioactive materials have not been released, and if there has been no loss of shielding

6) Actions and Procedures for Handling Loss of Control of an RTG (RTG Damaged)

A. Occurrence. Loss of control resulting in a damaged RTG could occur due to vandalism and /or attempted theft at any time.
   1. Notify Wing Command Post immediately

B. Response to loss of control resulting in a missing RTG will be as follows:
   1. Determine present location of RTG. This may be accomplished by determining the last known geographical location of the RTG as accurately as possible, together with any information that may be helpful in predicting or determining the present location.
      a. If necessary request assistance from law enforcement
      b. Release preliminary information if necessary

EMERGENCY RESPONSE SUMMARY INFORMATION

EMERGENCY RESPONSE TELEPHONE NUMBER:

Eielson Emergency Response: 907-377-2178; Radiation Safety Officer: 907-388-6477
Nellis/Creech Emergency Response: 702-404-0864; Radiation Safety Officer: 702-289-3486

Basic description and technical name: Strontium-90. The RTGs consist of the Sr-90 heat source encased in fuel cladding consisting of a stainless steel liner and a Hastelloy C fuel capsule. The Sr-90 is in the form of strontium titanate ($SrTiO_3$).

1. POTENTIAL HAZARDS
   a. HEALTH
      - Radiation presents minimal risk to transport workers, emergency response personnel and the public during transportation accidents.
      - Undamaged packages are safe; however, due to the presence of radiation personnel should limit their time around the units if possible. Contents of damaged packages may cause higher external radiation exposure, or both external and internal radiation exposure if contents are released.
      - The RTGs are contained in a Type B package. Life threatening conditions may exist only if contents are released or package shielding fails. Because of design, evaluation and testing of packages, these conditions would be expected only for accidents of utmost severity.
      - Radiation levels will be measured by qualified radiation safety individuals.

   b. FIRE OR EXPLOSION
      - These materials will not burn, but will melt
      - Radioactivity does not change flammability or other properties of materials.
      - Type B packages are designed and evaluated to withstand total engulfment in flames at temperatures of 800°C (1475°F) for a period of 30 minutes.

2. PUBLIC SAFETY
   - **CALL Emergency Response telephone numbers listed above**
   - **Dose rates are expected to only present acute hazards only in the immediate vicinity of the units. Contamination risks should not take precedence over priorities for rescue, life-saving, first aid, fire control.**
   - Stay upwind.
   - Keep unauthorized personnel away.
   - Detain or isolate uninjured persons or equipment suspected to be contaminated; delay decontamination and cleanup until instructions are received from Radiation Authority.

   a. PROTECTIVE CLOTHING
      - Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection against internal radiation exposure, but not external radiation exposure.

   b. EVACUATION
      - Fire: Consider an initial evacuation distance of 300 meters (1000 feet) in all directions.

3. EMERGENCY RESPONSE

a. FIRE

- Presence of radioactive material will not influence the fire control processes and should not influence selection of techniques.
- Move containers from fire area if you can do it without risk.
- Do not move damaged packages; move undamaged packages out of fire zone.
- Small Fire: Dry chemical, CO2, water spray or regular foam.
- Large Fire:
  - Water spray, fog (flooding amounts).
  - Dike fire-control water for later disposal.

b. Abnormal Radiation Dose Rates

- Move personnel to safe distances as directed by the RSO
- Notify Wing CP
- Create a cordon for any dose above 2 mrem/hr using security personnel
- Control Access and notify the Operations Commander

c. FIRST AID

- Call 911 or emergency medical service.
- Medical problems take priority over radiological concerns.
- Use first aid treatment according to the nature of the injury.
- Do not delay care and transport of a seriously injured person.
- Give artificial respiration if victim is not breathing.
- Administer oxygen if breathing is difficult.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- Injured persons contaminated by contact with released material are not a serious hazard to health care personnel, equipment or facilities.
- Ensure that medical personnel are aware of the material(s) involved, take precautions to protect themselves and prevent spread of contamination.

AFTAC Transportation Plan for RTG

APPENDIX N – Security Plan

1. **PURPOSE**: This security plan is implemented and maintained to comply with Nuclear Regulatory Commission (NRC) requirements in Title 10 CFR Part 37 and Title 49 of Code of Federal Regulations (49 CFR) Part 172. The purpose of the plan is to establish the security strategy for the transport of ten USAF Radioisotope Thermoelectric Generators (RTGs) licensed to the Air Force Technical Applications Center (AFTAC) from their current operational location (Burnt Mountain, AK) to the Nevada National Security Site (NNSS).

2. **APPLICABILITY:** 10 CFR Part 37 Subpart C has specific requirements. The goal is to establish, implement, and maintain a security program for physical protection of the RTGs. Information pertaining to this project is deemed Sensitive Unclassified Non-Safeguards Information (SUNSI) and will be protected in accordance with NRC and USAF requirements. AFTAC On-site Commander and the Radiation Safety Officers (RSO) are responsible for implementing the security plan. On-site Commander is Col Johnathan VanNoord (321-494-2468) and the RSOs are Mr. Mark Talbert (321-494-4851) and Ms. Joy Morris (321-494-3870). This plan applies to all personnel participating in the preparation for and execution of transport of the RTGs.

3. **DEFINITIONS:** The following terms for the purpose of this document are defined below.

A. ***Access control:*** a system for allowing only approved individuals to have unescorted access to the security zone and for ensuring all other individuals are subject to escorted access.

B. ***Approved individual***: an individual whom the licensee has determined to be trustworthy and reliable for unescorted access in accordance with 10 CFR Subpart B, has completed the required training, and is designated in writing.

C. ***Escorted access:*** accompaniment while in a security zone by an approved individual who maintains continuous direct visual surveillance over an individual who is not approved for unescorted access.

D. ***Movement control center:*** an operations center remote from transport activity that maintains position information on the movement of radioactive material, receives reports of attempted attacks or thefts, provides a means for reporting these and other problems to appropriate agencies, and can request and coordinate appropriate aid. AFTAC Alert Operation Center (AOC) will serve this function.

E. ***Security zone:*** any temporary or permanent area determined and established by the licensee for the physical protection of radioactive material.

F. ***Trustworthiness and reliability:*** characteristics of an individual considered dependable in judgment, character, and performance, such that unescorted access to category 1 or category 2 quantities of radioactive material by that individual does not constitute an unreasonable risk to the public health and safety or security. A determination of trustworthiness and reliability for this purpose is based upon the results from a background investigation.

G. ***Unescorted access:*** solitary access to an aggregated category 1 or category 2 quantity of radioactive material or the devices that contains the material.

4. **PROCEDURES:**

A. This regulation governs public inspections, exemptions, and requests for withholding information. It authorizes disclosure of NRC records and documents, except for matters that are "specifically authorized under criteria established by an Executive order to be kept secret in the interest of national defense or foreign policy". This exemption from disclosure applies to the RTGs due to the specific quantities of radioactive material employed in their operation.

i. The presence of non-nuclear reactor, radioactive material also classifies certain RTG information as sensitive unclassified non-safeguards information (SUNSI).

ii. NRC Regulatory Issue Summary (RIS) 2005-31 discusses SUNSI restrictions and provides guidance on handling security related documents and information pertaining to special nuclear material.

a. This SUNSI designation covers a range of information for which *"the loss, misuse, modification, or unauthorized access can reasonably be foreseen to harm the public interest"*

b. SUNSI communications are considered For Official Use Only (FOUO)

iii. The NRC further clarifies its guidance in Attachment 2 to RIS 2005-31.

a. Attachment 2 contains document threshold criteria for withholding and examples of information protected from public disclosure.

b. Public release of information pertaining to the RTGs is restricted under NRC regulation 10 CFR 2.390

c. This includes information on the exact location of radioactive material, certain detailed design drawings, information on nearby facilities, emergency planning information, and certain assessments of vulnerability and safety analyses

iv. Additional NRC guidance restricts release of detailed information generated by the licensee that describes the physical protection of radioactive material quantities of concern. This level of information is also considered sensitive and protected from unauthorized disclosure.

v. The licensee is required to control access to its physical protection information to those persons who have an established need-to-know the information, and are considered to be trustworthy and reliable (T&R). Trustworthy and reliable is defined as an individual who is considered consistently dependable in judgment, character, performance, and does not constitute an unreasonable risk to the public health and safety.

AFTAC Transportation Plan for RTG

Criteria	Details
Locations and quantities of radioactive material	• Withhold information identifying the exact locations of radioactive material • Withhold information on possession limits or actual inventories of radionuclides • Withhold manufacturers and model numbers of sealed sources and devices
Design of structures/ equipment (site specific)	Withhold information related to security requirements, information from analyses which could reveal vulnerabilities, reports or specific or predicted failures, and any other information which could reasonably be expected to be useful to potential adversaries
Nearby Facilities	Withhold information related to nearby facilities if the information might reasonably be helpful to those planning an attack
Design Information (non-site specific)	Examples include, but are not limited to spent fuel casks, transportation packages, sealed sources and device registry (SSDR) and files • Withhold drawings showing detailed design information • Withhold design/performance information that indicates vulnerabilities that could reasonably be expected to be useful to potential adversaries
Emergency Planning/ Fire Protection Information	• Withhold information related to emergency planning, emergency response, and fire protection. Review any considerations and/or requests for release on a case-by-case basis • Withhold information describing permittee or government responses to malevolent attacks • Withhold information and drawings identifying locations or radioactive material, and onsite routes and pathways to or from the locations of radioactive material • Withhold information which State or local government agencies have designated as sensitive
Vulnerability/ Security Assessments/ Accident Analyses/ Safety Analyses/ Risk Assessments	• Release typical accident analyses that involve conservative models to demonstrate a facility's ability to respond to design basis events (i.e., non-security related events), unless the analysis could reasonably be expected to be useful to an adversary • Withhold assessments that use a malevolent event as an initial condition (e.g., vulnerability/security analysis) • Withhold descriptions of structural features related to potential malevolent attacks • Withhold detailed information and drawings describing the specific locations of equipment relied upon by safety or security • Withhold discussions of safety features or mitigation strategies within vulnerability/security assessments • Withhold any analysis that identifies those events that do have significant consequences and those that do not • Withhold information related to security events and any information that could be useful to an adversary due to identification of vulnerabilities

B. All personnel involved with RTG transport will be government personnel, government contractors, state representatives and law enforcement official who have had background checks. This requirement is satisfied for DoD, and DOE personnel who have had a favorably adjudicated U.S. Government criminal history records check within the last 5 years. State and local law enforcement personnel will be approved access to SUNSI IAW 10 CFR part 37. AFTAC RSOs are the designated Trustworthy and Reliability Officials for approving unescorted access to the RTGs (see attachment). AFTAC RSOs will provide an access list to security forces personnel. Contact the AFTAC RSOs to request unescorted access to the RTGs. Security personnel and emergency response personnel are authorized unescorted access to the RTGs when required due to an incident or accident.

C. Physical protection and access control to the RTGs will be accomplished IAW 10 CFR part 37. Any deviations from these requirements will be brought to the attention of the On-Site Commander and/or RSOs.

D. When staged and awaiting the next mode of conveyance, the RTGs will be secured in an approved enclosed facility with controlled entry points. On-site security personnel will be required if the facility is not monitored by a system capable of 24/7 surveillance and response. Permit Radiation Safety Officers (RSO) will coordinate with the AF Radioisotope Committee and the Installation RSO (IRSO) to approve secure staging areas. The secure facility for the RTGs will be:

   i. Minimum area (security zone) of 40' x 50' with controlled access limited to personnel approved for unescorted access only (see attached). (Note: The 10 RTGs will have a physical foot print of 30' x 30' being on 463L pallets.)
   ii. External radiation exposure rates will be maintained below 2 millirem/hr outside of the controlled access area as required by 10 CFR 20. Exposure rates will be measured by AFTAC personnel once RTGs are placed in the facility to ensure this requirement is met.
   iii. IAW 10 CFR the applicable signs will be posted in the RTG storage area. For example: "CAUTION RADIOACTIVE MATERIALS" or "CAUTION RADIATION AREA"
   iv. If the facility is not monitored through a monitored alarm system, SFS must maintain visual surveillance of the facility/security zone from the time the RTGs are off loaded to the time they are reloaded for transport.
   v. Monitoring the exterior of the facility can be conducted visually by SFS personnel in lieu of an alarm system. SFS personnel are not required to be positioned within the facility unless the size of the facility requires to control access. SFS does not have to maintain direct vision on the RTGs. At all times SFS personnel will be positioned outside of the controlled access area to minimize radiation exposures to personnel. Additionally, RSOs will ensure personnel exposures to radiation are maintained "As Low As Reasonably Achievable" (ALARA) IAW 10 CFR.
   vi. Security zone will be inside of an enclosed structure, deviation from this will require coordination of the On-site Commander, AFTAC RSO, IRSO and coordinated through the AF Radioisotope Committee.
   vii. Individuals not approved for unescorted access must be escorted by an approved individual when in a security zone. The AFTAC RSO will provide an unescorted access letter for SFS to create an EAL.
   viii. Emergency personnel (e.g. fire and police) are approved for unescorted access and may access the controlled area (security zone) as required when responding to an emergency without prior approval.

E. Eielson AFB and Creech AFB SFS function as the local law enforcement agency (LLEA) and monitor the security zone by patrol and have the capability to immediately assess and respond, as needed. The RSO shall coordinate with law enforcement personnel who will act as LLEA during the off-base transport of the RTGs from Creech AFB to NNSS. LLEA will need to be present at the time of offloading/loading, transition to temporary storage (as required), and during temporary storage.

  i. Eielson AFB and Creech AFB SFS are armed and have arrest authority on their respective base. SFS personnel will use standard law enforcement procedures.
  ii. The security plan provides for Eielson AFB and Creech AFB SFS to function as the LLEA. The Radiation Safety Officer (RSO) coordinates with the Eielson AFB and Creech AFB SFS OIC, to ensure coordination is completed per 10 CFR Part 37.45.
  iii. Eielson AFB and Creech AFB SFS will use standard law enforcement procedures. The standard law enforcement procedures are not addressed in this implementing procedure.

F. A response will be executed to an actual or attempted theft, sabotage, or diversion of such radioactive material or of the devices which is consistent in scope and timing with a realistic potential vulnerability of the sources containing such radioactive material. Monitoring and detection must be performed by:

  i. A monitored intrusion detection system that is linked to an onsite or offsite central monitoring facility; or
  ii. Electronic devices for intrusion detection alarms that will alert nearby facility personnel; or
  iii. A monitored video surveillance system; or
  iv. Direct visual surveillance by RSO approved individuals or LLEA located within the security zone; or
  v. Direct visual surveillance by RSO approved individuals or LLEA located outside the security zone.

G. The dependable methods to communicate between and among individuals who might detect and identify an unauthorized access or suspicious activity include, but are not limited to, the following:

  i. Land telephones to report unauthorized access or suspicious activity.
  ii. Public announcement systems at Eielson and Creech AFB to make general announcements about security circumstances and to summon persons not otherwise contacted by land telephones or other communication methods.
  iii. Cell telephone numbers to contact or summon individual responders or key staff.
  iv. Hand-held radios for the Security Forces to use for communication with and among responding officers.

H. All significant security breaches will immediately be reported to SFS. Significant security breaches include:

  i. Any incident involving actual or attempted hijacking of shipments.
  ii. Any deliberate act aimed at stopping the transportation conveyance or to cause an accident.
  iii. Any incident involving the use, or threatened use, of weapons of any kind.
  iv. Any discovery of sabotage or attempted sabotage of RTGs, equipment, or security system.
  v. Unauthorized personnel found in or attempting to enter areas involving RTG operations.
  vi. Any loss, theft, or compromise of RTGs.

vii. Observations of apparent or suspected terrorist acts.

I. The RTGs will be transported via DOD owned/operated ground transportation from Creech AFB to NNSS. Ground travel distance to NNSS is approximately 20 miles. No stops or Safe Havens are required. The route, after departing Creech AFB and leaving the Indian Springs area, will include approximately 18 miles of the Veterans Memorial Highway and does not pass any other populated areas. AFTAC RSOs will coordinate with LLEA for off-base transport. Escort vehicles will accompany the truck in case of emergency. The truck and escort vehicles will carry radios (supplied by Creech AFB) as well as personal cell phones for crisis communication and all personnel will have law enforcement and emergency response phone numbers in their possession.

J. Personnel Roles and Responsibilities

i. On-site Commander and AFTAC RSOs are responsible for implementing the security plan and training participating personnel.
ii. Eielson AFB and Creech AFB security forces are responsible for safeguarding the RTGs during staging and providing a response force if a security breach occurs.
iii. Aircraft pilots and crew, along with an approved individual, are responsible for safeguarding the RTGs during air transport.
iv. Truck drivers, along with an approved individual, are responsible for safeguarding the RTGs during ground transport.
v. All participants are responsible for controlling access to the RTGs during the transport activities and making the appropriate notification should a security breach occur.

K. Training Personnel: Personnel will be trained on security plans and procedures associated with this activity. Training, provided approximately a week prior to the transport, will include security objectives, site-specific security procedures, personnel responsibilities, organizational security structure, security risks associated with hazardous materials transportation, and how to recognize and respond to possible security threats.

5. Incident Response

Assessing and responding to alarms or suspicious activity noted in or around the security zone and an individual not approved for unescorted access is observed.

A. Personnel monitoring alarms and note an abnormal condition or personnel who observe suspicious activity will initiate a response / perform the following:

i. Offer to provide assistance and request explanation of apparent unauthorized access or suspicious activity.
ii. Ask the unauthorized individual to identify themselves and state their purpose of being in the area.
iii. Request the unauthorized individual to move away from the security zone.
iv. Contact Eielson AFB or Creech AFB Security Forces (SFS) and/or Radiation Safety Officer for assistance.
v. Do not attempt to restrain or use physical force to detain the unauthorized individual.
vi. Avoid confrontation with the unauthorized individual and immediately leave the security zone or proximity if the individual makes threats or appears to have the potential for violence.

vii. Comply with any demands by the unauthorized individual for access to the security zone, if the individual uses coercion or threats of violence.
viii. Note identifying information such as height, weight, sex, and clothing about the unauthorized individual for later report to the SFS.
ix. Maintain constant visual surveillance of the unauthorized individual, if the individual remains in the security zone or proximity.
x. Do not follow the unauthorized individual, if the individual leaves the area.
xi. Use the radiation protection principles of time, distance, and shielding, as needed, to maintain potential radiation exposure to ALARA.
xii. Provide assistance to SFS, and/or Radiation Safety Officer who respond.

B. The SFS who receive an alarm, observe suspicious activity, or respond for assistance will respond immediately and do the following:

i. Use standard law enforcement procedures in their capacity as federal law enforcement officers to assess the circumstances and determine if an unescorted access has occurred and whether an actual or attempted theft, sabotage, or diversion of the RTGs occurred.
ii. Take mitigating actions to secure or recover the RTGs/security zone, if needed.
iii. Coordinate with AFTAC RSO to use the radiation protection principles of time, distance, and shielding, as needed, to maintain potential radiation exposure to ALARA.
iv. Request assistance from federal and/or state law enforcement agencies, if needed.
v. Assist AFTAC RSO and On Site Commander in reviewing the circumstances, identifying basic causes, and establishing corrective actions to preclude recurrence.

C. The On-site Commander, who hears an alarm, observes suspicious activity, or responds for assistance will respond immediately and do the following:

i. Provide oversight for efforts to assess the circumstances and determine if an unescorted access has occurred and whether an actual or attempted theft, sabotage, or diversion of the RTGs occurred.
ii. Direct and coordinate mitigating actions to secure or recover the RTGs or security zone, if needed.
iii. Coordinate with the AFTAC RSO to use the radiation protection principles of time, distance, and shielding, as needed, to maintain potential radiation exposure to ALARA.
iv. Ensure the Wing Command Post has been notified if damage or theft of an RTG is confirmed.
v. Assist SFS and AFTAC RSO in reviewing the circumstances, identifying basic causes, and establishing corrective actions to preclude recurrence.
vi. Direct and coordinate implementing corrective actions to preclude recurrence.

D. The RSO who hears an alarm, observes suspicious activity, or responds for assistance will respond immediately and do the following:

i. Provide radiation safety and health physics support for efforts to assess the circumstances and determine if an unescorted access has occurred and whether an actual or attempted theft, sabotage, or diversion of the RTGs occurred.
ii. Provide radiation safety and health physics support for mitigating actions to secure or recover the RTGs or security zone, if needed.

iii. Coordinate with individuals approved for unescorted access, the On-site Commander, and SFS to use radiation protection principles of time, distance, and shielding, as needed, to maintain potential radiation exposure to ALARA.
iv. Notify AF Radioisotope Committee is notified IAW AFI 40-201
v. Assist the On-site Commander and SFS in reviewing circumstances, identifying basic causes, and establishing corrective actions to preclude recurrence.
vi. Prepare a summary report of any unauthorized access for review and evaluation by the Radiation Safety Committee.
vii. Evaluate and audit implementation of corrective actions to preclude recurrence.

Assessing and responding for circumstances where the security zone is found to be left open and unattended and unauthorized or suspicious individuals are not observed in the area.

A. The individual approved for unescorted access who finds the security zone left open and unattended will respond immediately and do the following:

i. Secure the security zone, if possible.
ii. Establish and maintain constant visual surveillance of the security zone, if the room cannot be secured, move away as far as possible.
iii. Contact SFS, On-site Commander, and/or AFTAC RSO for assistance.
iv. Note identifying information about the circumstances of finding the security zone left open and unattended for later report to SFS.
v. Use the radiation protection principles of time, distance, and shielding, as needed, to maintain potential radiation exposure to ALARA.
vi. Provide assistance to the SFS, On-site Commander, and/or AFTAC RSO who respond.

B. SFS will respond immediately for assistance and do the following:

i. Use standard law enforcement procedures in their capacity as federal law enforcement officers to assess the circumstances and determine if an unescorted access has occurred and whether an actual or attempted theft, sabotage, or diversion of the RTGs occurred.
ii. Take mitigating actions to secure or recover the RTGs and/or security zone, if needed.
iii. Coordinate with the AFTAC RSO to use the radiation protection principles of time, distance, and shielding, as needed, to maintain potential radiation exposure to ALARA.
iv. Request assistance from federal and/or state law enforcement agencies, if needed.
v. Assist the AFTAC RSO in reviewing the circumstances, identifying basic causes, and establishing corrective actions to preclude recurrence.

C. On-site Commander, will respond immediately for assistance and do the following:

i. Provide oversight for efforts to assess the circumstances and determine if an unescorted access has occurred and whether an actual or attempted theft, sabotage, or diversion of the RTGs occurred.
ii. Direct and coordinate mitigating actions to secure or recover the RTGs or security zone, if needed.
iii. Coordinate with the AFTAC RSO to use the radiation protection principles of time, distance, and shielding, as needed, to maintain potential radiation exposure to ALARA.
iv. Request assistance from RIC and/or Air Force oversight groups, if needed.

v. Assist SFS and AFTAC RSO in reviewing the circumstances, identifying basic causes, and establishing corrective actions to preclude recurrence.
vi. Direct and coordinate implementing corrective actions to preclude recurrence.

D. AFTAC RSO will respond immediately for assistance and do the following:

i. Provide radiation safety and health physics support for efforts to assess the circumstances and determine if an unescorted access has occurred and whether an actual or attempted theft, sabotage, or diversion of the RTGs occurred.
ii. Provide radiation safety and health physics support for mitigating actions to secure or recover the RTGs or security zone, if needed.
iii. Coordinate with individuals approved for unescorted access, the On-site Commander, and SFS to use radiation protection principles of time, distance, and shielding, as needed, to maintain potential radiation exposure to ALARA.
iv. Request assistance from RIC, if needed.
v. Provide required regulatory notifications or reports to RIC, if needed.
vi. Assist the On-site Commander, and SFS in reviewing circumstances, identifying basic causes, and establishing corrective actions to preclude recurrence.
vii. Prepare a summary report of any unauthorized access for review and evaluation by the Radiation Safety Committee.
viii. Evaluate and audit implementation of corrective actions to preclude recurrence.

Assessing and responding for circumstances where a fire, flooding, or natural disaster occurs which might impact the RTGs or security zone.

A. The individual approved for unescorted access who is informed of fire, flooding, or an actual or pending natural disaster will respond immediately and do the following:

i. Secure the RTGs and security zone, if possible.
ii. Evacuate the area, if directed by emergency response staff.
iii. Inform SFS, On-site Commander, and/or AFTAC RSO about whether the RTGs and security zone was secured, when feasible.

B. The individual approved for unescorted access who returns to the security zone area after a fire, flooding, or natural disaster which might have impacted the RTGs or security zone will do the following, when emergency response persons approve return to the area:

i. Assess the scene; if there appears to be damage to the RTGs do not proceed without AFTAC RSO or Radiation Protection Staff present to survey for contamination.
ii. Secure the RTGs or security zone, if needed.
iii. Establish and maintain constant visual surveillance of the security zone, if the room cannot be secured move away as far as possible.
iv. Contact SFS, On-site Commander, and/or AFTAC RSO for assistance.
v. Note identifying information about the circumstances of returning to the security zone area for later report to the SFS.
vi. Use the radiation protection principles of time, distance, and shielding, as needed, to maintain potential radiation exposure to ALARA.
vii. Provide assistance to the SFS, On-site Commander, and/or AFTAC RSO who respond.

C. The SFS member who responds for assistance when emergency response staff approves return to the area will do the following:

   i. Use standard law enforcement procedures in their capacity as federal law enforcement officers to assess the circumstances and determine if an unescorted access has occurred and whether an actual or attempted theft, sabotage, or diversion of the RTGs occurred.
   ii. Take mitigating actions to secure or recover the RTGs or security zone, if needed.
   iii. Coordinate with the AFTAC RSO to use radiation protection principles of time, distance, and shielding, as needed, to maintain potential radiation exposure to ALARA.
   iv. Request assistance from federal and/or state law enforcement agencies, if needed.

D. On-site Commander, who responds for assistance when emergency response persons approve return to the area will do the following:

   i. Provide oversight for efforts to assess the circumstances and determine if any damage, unescorted access, any actual or attempted theft, sabotage, or diversion of the RTGs has occurred.
   ii. Direct and coordinate mitigating actions to secure or recover the RTGs or security zone, if needed.
   iii. Coordinate with the AFTAC RSO to use the radiation protection principles of time, distance, and shielding, as needed, to maintain potential radiation exposure to ALARA.
   iv. Request assistance from RIC and/or Air Force oversight groups, if needed.
   v. Assist SFS and AFTAC RSO in reviewing the circumstances, identifying basic causes, and establishing corrective actions to preclude recurrence.
   vi. Direct and coordinate implementing corrective actions to preclude recurrence.

E. The Radiation Safety Officer who responds for assistance when emergency response persons approve return to the area will do the following:

   i. Ensure proper precaution is used in surveying the site for radiological contamination.
   ii. Brief responding personnel on risk avoidance and safety measures to take into consideration.
   iii. Provide radiation safety and health physics support for efforts to assess the circumstances and determine if any damage, unescorted access, any actual or attempted theft, sabotage, or diversion of the RTGs has occurred.
   iv. Provide radiation safety and health physics support for mitigating actions to secure or recover the RTGs or security zone, if needed.
   v. Coordinate with individuals approved for unescorted access, the On-site Commander, and SFS to use radiation protection principles of time, distance, and shielding, as needed, to maintain potential radiation exposure to ALARA.
   vi. Request assistance from RIC, if needed.
   vii. Provide required regulatory notifications or reports to RIC, if needed.
   viii. Assist the On-site Commander and SFS in reviewing circumstances, identifying basic causes, and establishing corrective actions to preclude recurrence.
   ix. Prepare a summary report of any unauthorized access for review and evaluation by the Radiation Safety Committee.
   x. Evaluate and audit implementation of corrective actions to preclude recurrence.

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE OHIO

30 January 2015

Certificate of Equivalency
AF14-19

1. This Certificate of Equivalency (COE) is issued pursuant to Title 49 CFR 173.7(a) of the Department of Transportation (DOT) hazardous materials regulations, and under the authority established in AFI 24-210_IP (DLAD 4145.41, AR 700-143), Packaging of Hazardous Material.

2. **COMMODITY**: The authorized items are ten (10) Sentinel Radioisotope Thermoelectric Generators (RTG). The heat source of each generator is Strontium-90 titanate doubly encapsulated in a stainless steel liner and Hastelloy or Uniloy HC capsule which meets the requirements of special form radioactive material. The tungsten inner shield and cast iron housing reduce radiation levels to less than 10 mR/hr at one meter from the generator's surface. The RTGs are identified as follows:

Model	Serial Number	Isotope	Beginning of life (BOL)	Initial Activity (Ci)	Current Activity TBq	Transport Index (TBD)	Label Category
100F	RTG1	Sr-90 (Y-90)	Mar 1972	328,400	4,281		Yellow III
25A	RTG4	Sr-90 (Y-90)	Apr 1968	94,000	1,115		Yellow III
25E	RTG8	Sr-90 (Y-90)	Feb 1969	105,200	1,273		Yellow III
25E	RTG9	Sr-90 (Y-90)	Feb 1969	108,300	1,311		Yellow III
25E	RTG10	Sr-90 (Y-90)	Feb 1969	105,900	1,282		Yellow III
25F	RTG14	Sr-90 (Y-90)	Dec 1970	107,800	1,364		Yellow III
25E	RTG17	Sr-90 (Y-90)	Apr 1971	109,300	1,394		Yellow III
25E	RTG18	Sr-90 (Y-90)	Apr 1971	106,500	1,357		Yellow III
25E	RTG19	Sr-90 (Y-90)	Apr 1971	105,700	1,357		Yellow III
25E	RTG20	Sr-90 (Y-90)	Apr 1971	105,600	1,346		Yellow III

Proper Shipping Name:	**Radioactive Material, Type B (M) package**
Hazard Class:	Class 7
UN Identification Number:	UN2917
Activity:	Varies with specific unit TBD at time of shipment
Form	Solid, Oxide (Normal Form)
Transport Index	T.I.-Varies with specific unit TBD at time of shipment
Packing Group:	N/A
Label:	Radioactive Yellow III-Meets the definition of Highway Route Controlled Quantity which requires the Yellow III label
Placard:	Radioactive placard on square background §172.507(a)

3. **PRESCRIBED PACKAGING:** The RTGs are designed as the packaging for the Strontium-90 heat source. The heat source of each generator is doubly encapsulated in a stainless steel liner and Hastelloy or Uniloy HC capsule. There is a tungsten inner shield and cast iron housing to reduce radiation levels. The top cover, or shield plug, that encloses the fuel capsule assembly is fastened to the fuel capsule body with CRES-A-286 (corrosion resistant enhanced steel) plated bolts. The shield, coupled with the inherent material and spacing within the generator, combine to provide nominal radiation dose rates no greater than 10 mRem/hr at a distance of three feet.

4. **BASIS:** The NRC previously certified (NRC certificate numbers 4888 and 5862) the 10 RTGs as Type B containers. Each of the Sentinel RTGs were designed, and licensed, to act as their own shipping container. Due to regulatory changes, the original NRC Type B packaging certificates have expired and can no longer be renewed necessitating this DOD COE. The RTG's packaging has been evaluated by the DOE and was found to meet the requirements of 10 CFR Part 71 with respect to containment, shielding, and criticality. The AF Medical Support Agency, Radioisotope Committee Secretariat (RICS) has reviewed the package design and transport plan and concurs with the DOE Safety Evaluation Report. The RTG packaging and transportation controls provide a level of safety equivalent to compliant packaging (i.e. Type B(M)-96)

5. **MODES OF TRANSPORTATION:** Transportation authorized by military cargo aircraft and military transport vehicle.

6. **REGULATIONS AFFECTED:** AFMAN 24-204 Paragraph A11.9 and 49 CFR §173.416

7. **SPECIAL PROVISIONS:**

    a. A copy of this COE must accompany the shipment.

    b. Each RTG will be marked with "COE AF14-19."

    c. Shipping papers shall contain the statement "Packaged in accordance with 49 CFR 173.7(a) by authority of COE AF14-19," and the words "Highway route controlled quantity" or "HRCQ". §172.203(d)(10), §173.403

    d. All packages will be Radioactive Yellow III. This is due to the activities in each RTG exceeding 3000 times the A1/A2 values or 27,000 Ci (whichever is less). Therefore, each package is to be labelled YIII since they are Highway Route Controlled Quantities (HRCQ). §172.403

    e. Placarding for ground transport of HRCQ requires ground transport vehicles are placarded with a Class 7 Placard placed on top of a White Square Placard. §172.507, §172.527

f. Shipper must comply with all other requirements of 49 CFR and AFMAN 24-204 as applicable. Any incidents involving the use of this COE must be reported immediately to AFMC A4RT, 4375 Chidlaw Rd, Wright-Patterson AFB, OH, 45433. Telephone: Commercial 937-257-1984, DSN 787-1984.

8. **POINT OF CONTACT:** Jim Frank at DSN 787-1984, email james.frank.2@us.af.mil or Bill Heineman at DSN 787-4503, email william.heineman@us.af.mil.

9. **DATE OF CERTIFICATION:** 30 January 2015

10. **EXPIRATION DATE:** 31 August 2016

MARK P. FERGUSON
Chief, Transportation and Packaging Policy Branch

cc: LOGSA/PSCC
HQ AMC/A4TC

U.S. AIR FORCE

TRANSPORTATION PLAN

For

Ten (10)

Radioisotope Thermoelectric Generators

6 January 2015

I approve this Transportation Plan and authorize the commencement of the activities described therein.

CHRISTOPHER A. WORLEY, Colonel, USAF
AFTAC Commander

REVIEWER SIGNATURES:

JOY MORRIS, GG-13, USAF
AFTAC Radiation Safety Officer

MARK W. TALBERT, GG-12, USAF
AFTAC Radioactive Materials Shipper

SCOTT C. LATTIMER, GG-13, USAF
AFTAC RTG Project Manager

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Appendices

A. PURPOSE

This transportation plan addresses the removal of 10 radioisotope thermoelectric generators (RTGs) from Burnt Mountain, Alaska and their subsequent transfer to the U.S. Department of Energy (DOE). Elements of this plan include security, safety, communication, transportation routes, equipment requirements, procedures, etc., and are designed to ensure successful RTG removal while minimizing potential health, safety, and environmental risks. The transport is planned for approximately 10 days in July 2015; however, contingency planning allows for increased time due to weather, mechanical, or logistical delays.

B. BACKGROUND

The U.S. Air Force operates a seismic observatory at Burnt Mountain, Alaska to assist in nuclear treaty verification. This unattended station, consisting of five sites clustered within a 1.5-mile radius, is located in a remote area north of the Arctic Circle, approximately 50 miles from the nearest village. The seismic monitoring and data communications equipment at the station require low, but very reliable, power. 10 RTGs, each containing between 1.2 and 3.9 pounds of strontium 90, a radioactive material, were used to supply power because of their high reliability and low maintenance. The RTGs no longer provide sufficient power to support the equipment on-site. To effectively maintain mission support equipment, the USAF replaced the RTGs with an alternative source of power. The RTGs will be removed from Burnt Mountain and transferred to the DOE.

C. PARTICIPATING ORGANIZATIONS

Air Force Technical Applications Center

HQ AFTAC
10989 S. Patrick Dr
Patrick AFB, FL 32925
321-494-3870

Detachment 460
2681 Flightline Ave
Eielson AFB, AK 99702
907-377-2428

United States Army, Alaska (USARAK)

HQ USARAK
Fort Wainwright
Box 35455
Fort Wainwright, AK 99703
907-460-6209

4-123d Aviation Regiment
BLDG 3010 Montgomery Road
Fort Wainwright, Alaska 99703
907-353-6195

11th Air Force

611th Air Support Group
Elmendorf AFB, AK
907-552-7282

611th Air Support Squadron
Elmendorf AFB, AK
907-552-5107

354th Fighter Wing, Eielson AFB
354th FW/CC
354 Broadway St Unit 19A
Eielson AFB AK 99702-1899
907-377-6101

Nellis /Creech AFB

799th Air Base Group	432d Wing	99th Logistics Readiness Squadron
Creech AFB, NV	Creech AFB, NV	Nellis AFB, NV
702-404-3947	702-404-1368	702-404-0949

Department of Energy
National Nuclear Security Administration
Sandia National Lab
Box 5400
Albuquerque, NM 87185

Air Force Radioactive Recycle and Disposal Office (AFRRAD)
88 ABW/CEIEC
1450 Littrell Road
Wright-Patterson AFB, OH 45433

D. ORGANIZATIONAL ROLES AND RESPONSIBILITIES

RTG transport to the Nevada National Security Site (NNSS) for disposition is under the direction of Headquarters AFTAC, Patrick AFB FL. AFTAC will provide administrative direction and guidance to all organizations involved to ensure safe, efficient, and cost-effective execution of the project.

1. HQ AFTAC is responsible for developing and coordinating all required documentation, obtaining or providing necessary funding, and notifying all appropriate organizations or agencies of the transport and its status. HQ AFTAC is also directly accountable for all radiation safety aspects of the project and has overall responsibility for project security, to includes training of personnel.

2. The AFTAC Director of Operations (AFTAC/DO), acting as the on-site Commander, is responsible for the execution of the transport operation. He/she will ensure all requirements and restrictions are adhered to, enforce all safety standards, and have final go/no go authority on all aspects of the operation.

3. The AFTAC Radiation Safety Officers (RSOs) are responsible for providing subject matter expertise regarding activities in support of the transport of the RTGs from Alaska to NNSS. RSOs have authority to suspend operations that pose a significant health risk to personnel or the

public, or can cause contamination of the environment or noncompliance with the assigned radioactive materials permit or AFI 40-201.

4. The AFTAC NEPA Compliance Officer is responsible for ensuring all requirements of the National Environmental Protection Act are adhered to.

5. AFTAC Detachment 460 is responsible for supporting the development and execution of site-specific procedures in Alaska, coordinating with local military organizations to include Fort Wainwright and Eielson AFB, and coordinating with Alaskan entities involved in or affected by the project.

6. The Air Force Liaison to NNSA is responsible for coordinating with NNSS, Creech AFB, and NNSA.

7. The 1-52d Aviation Regiment is responsible for CH-47 operations. This includes provision of helicopters and crews along with standard support equipment and direction of actual operations and loading/unloading.

8. TRANSCOM will provide aircraft, crews, and standard support equipment to transport the RTGs from Eielson AFB to Creech AFB. Based upon current aircraft basing, a C-17 is the most likely aircraft for this mission.

9. Eielson AFB will be used as a transshipment point for the RTGs. Eielson is responsible for providing a secure staging area for overnight staging, security forces, support equipment and operators necessary for unloading/loading of RTGs, and emergency response should the need arise. The 354LRS will provide ten 463L pallets in support of the operation.

10. Creech AFB will be used as a transshipment point for the RTGs. Creech, via the 799ABG, is responsible for providing security, support equipment and operators necessary for unloading/loading of RTGs, and emergency response should the need arise. The 432d Wing will provide a secure staging area for overnight staging. 99LRS will provide the tractor trailers and HAZMAT certified drivers to move the RTGs from Creech AFB to NNSS. The Comm Squadron will provide radios for Nevada operations.

11. Sandia National Labs (SNL) is responsible for developing and submitting documentation needed to maintain approvals for RTG acceptance at NNSS, inspecting the RTGs prior to each shipment to ensure final acceptance at NNSS is not compromised, and accepting ownership at NNSS.

12. DOE HQ is responsible for issuing Certificates of Compliance for non-transport and an Exemption to specific transportation requirements.

13. NNSS is responsible for completing the draft “Environmental Assessment for the Non-routine Transportation of Radioisotope Thermoelectric Generators”, coordinating courses of action that impact the site prior to and during acceptance of the RTGs at NNSS. Additionally, responsibilities include on-site transportation management, handling on-site emergency actions, and accepting ownership and providing long-term stewardship of the assets.

14. AFRRAD is responsible for assisting with transportation and is the packaging/shipment certifying agency (performing dose rate measurements, marking, labeling, completing bill of ladings, etc.)

15. HQ AMC/A4TC is supporting this operation by evaluating the RTG packaging and providing a DOD Certificate of Equivalency under the authority established in AFI 24-210_IP (DLAD 4145.41, AR 700-143), Packaging of Hazardous Material

E. ENVIRONMENTAL ASSESSMENT

The National Environmental Policy Act (NEPA) of 1969 requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. Regulations provide for the preparation of an Environmental Assessment (EA) to determine whether the proposed action fits within the definition of actions that require an Environmental Impact Statement (EIS). An EA considers the impacts of the proposed action and alternatives and may conclude with either a recommendation to prepare an EIS or a recommendation to prepare a Finding of No Significant Impact (FONSI). An EA must generally include the same contents, but may be briefer. The specific content of an EA is dictated by the specific section of the Code of Federal Regulations relating to the involved federal agency.

The Air Force’s process for compliance with NEPA is codified in Title 32 Code of Federal Regulations (CFR) 989. NEPA, and thus 32 CFR 989.13, specifies categories of actions that do not individually or cumulatively have potential for significant effect on the environment and do not require further environmental analysis in an EA or EIS may be categorically excluded. The Air Force provides a list of such categorical exclusions (CATEXs) in Appendix B of 32 CFR 989.

The CATEX with the most similar action of transporting the RTGs is found in A2.3.28, which states “Routine transporting of hazardous materials and waste in accordance with applicable Federal, state, interstate, and local laws.” The airlift portions of the movement of the RTGs from their current location are not considered “routine”, thus an EA is being prepared under a separate cover.

F. TRANSPORTATION MODES

RTG movement will utilize air and ground transportation. All transportation vehicles will be government owned and operated by qualified government personnel. The RTGs were designed and certified as Type B shipping containers through the Nuclear Regulatory Commission (NRC). Certification of the containers for use as Type B expired and was not renewable. Subsequently, DOE and DoD evaluated the RTG packaging and determined their construction and condition to be equivalent (suitable) for transport as Type B packages. To support DoD transport, a DoD Certificate of Equivalency was issued under the authority established in AFI 24-210_IP (DLAD 4145.41, AR 700-143), *Packaging of Hazardous Material* . Additionally, DOE issued a non-transport Certificate of Compliance for future storage at a DOE location and an Exemption from specific requirements within the code of federal regulations. Certificates and Exemption are presented as Appendices to this document and all transportation elements will be handled accordingly.

The following is a description of each of the modes of transport.

1. Air
   a. The first leg of the transportation will be accomplished using Chinook CH-47 helicopters. The CH-47F is a twin-engine, tandem rotor heavy-lift helicopter with a top speed of 196 mph, a cruising speed of 149 mph, and a range of 450 miles. It has a wide loading ramp at the rear of the fuselage and three external-cargo hooks. The CH-47 is crewed by three personnel and has a capacity of 33-35 troops or 28,000 lb of cargo. Two turbo shaft engines power the CH-47 and provide the ability for a single engine to drive both rotors should one engine fail.

   b. The second leg will utilize fixed wing aircraft provided by TRANSCOM. C-17 aircraft is the most likely choice given the basing proximity of Joint Base Elmendorf-Richards (JBER). The C-17 Globemaster III is the most likely variant for this mission. This aircraft is powered by four Pratt & Whitney F117-PW-100 turbofans and has a cruising speed of 515 mph with a ceiling of 45,000 feet carrying 170,900 lb of cargo. Payload size determines aircraft range and ranges from 2,785 miles to 6,456 miles. The aircraft is crewed by three personnel and its maximum load can be comprised of a maximum of 18 pallets or a mix of personnel, palletized cargo, and vehicles.

2. Ground
   Two tractors and flatbeds provided by 99LRS will make the final leg of the journey. The tractors are Freightliner Business Class M2's. They have 100 gallon tanks and a range of approximately 600 miles without having to stop to refuel. The trailers are "40 ft 20 ton" trailers and as such are 623 inches long x 96 inches wide x 73 inches high.

G. ROUTE PLAN

The transportation route consists of three legs beginning at Burnt Mountain, AK and concluding at the NNSS. Route selection involved a detailed analysis of several factors to include travel distance, fuel consumption/cost, accident risk, personnel safety, and environmental concerns. The following paragraphs provide details for the selected legs.

1. Burnt Mountain to Eielson AFB via military conveyance (i.e., Chinook CH-47 helicopter)

   

   The USAF will use a minimum of two CH-47 Chinook helicopters and an all-terrain vehicle forklift to accomplish the move from Burnt Mountain to Eielson AFB, AK. Helicopters are needed because of uneven terrain and lack of aircraft runways. The forklift weighs approximately 10,000 pounds, will be transported by helicopter, and will be used to maneuver the RTGs from their storage shelters into a CH-47 helicopter for transport. The CH-47 can accommodate two RTGs at a time due to size and weight restrictions, thus five helicopter trips are required. The distance to Eielson AFB is 202 miles south and the flying time is 1 hour 45 minutes. Over five trips, this amounts to a total of about 2020 miles; the RTGs will be on board a helicopter for a total of 1010 miles. The CH-47s will land at Eielson AFB where staging of the RTGs may last five to six days, unless delayed by weather or other unforeseen circumstance. The RTGS will be staged in an enclosed facility, leak tested to ensure no damage has occurred during helicopter transport, and transferred to a fixed wing aircraft. Reference Appendix N - Security Plan for appropriate security measures while the RTGs are staged at Eielson AFB.

2. Eielson AFB to Creech AFB via military conveyance (i.e., C-17 aircraft)

   

   The USAF will move the RTGs on fixed wing aircraft from Eielson AFB, AK to Creech AFB, NV with an approximate flight distance of 2030 miles. This aircraft can accommodate all 10 RTGs so only one trip is required. Creech AFB is the closest available/

approved runway to NNSS. The RTGs will be staged over night in a hanger, leak tested to ensure no damage has occurred during C-17 transport, and then transferred to a tractor-trailer.

3. Creech AFB to DOE storage site via truck.

   The USAF will then transfer the RTGs onto two flatbed tractor-trailers for transport to the NNSS. The distance traveled will be approximately 40 miles. The flatbeds will each carry five RTGs, so only one trip is required. The distance from Creech AFB to the entrance of NNSS is approximately 18 miles. DOE will take possession of the RTGs at the gate of the NNSS.

An alternative to the selected route, in the case of emergency or unforeseen circumstance, is to land at Ft Yukon, AK for Ch-47 refueling. Alaska conducts fire-fighting operations from this location and the Alaska Fire Service has granted the U.S. Air Force permission to utilize their landing location and fuel tanks if necessary.

H. EQUIPMENT REQUIREMENTS

1. All-terrain Forklift: An all-terrain forklift is required to remove the RTGs from the storage shelters for loading on to the helicopter due to the permafrost. The forklift will have a safe working load sufficiently greater than the weight of the RTG/pallet combination and will have been weight-tested within the prescribed period. The forklift will be transferred from site to site via helicopter. The weight of the forklift is approximately 10,000 pounds.

2. 10,000 lb forklifts and K-loaders are required at both Eielson AFB and Creech AFB. Each AFB will provide this equipment and certified operators.

3. Temporary Roadway Material: Due to the permafrost, and soft swampy ground at Burnt Mountain sites 1 and 4, roadway material is required to prevent the forklift from getting stuck and damage of the site. The material selected, I-Trac by Macroplastics, "is a state-of-the-art modular infrastructure system that enables vehicular traffic over inhospitable or unsafe ground [and]… creates a contiguous surface capable of carrying extreme loads over virtually all ground conditions" It "is manually deployable… requiring no special skills or equipment." One piece is 47.5in x 36.3in x 2.1in, covers 8.6 square feet, and weighs 38 lbs. The required I-Trac material was purchased and is forward deployed and stored at the sites.

4. Plywood Sheets: To assist with the loading of the RTGs onto the helicopter, several plywood sheets are needed. Plywood is forward deployed and stored at the sites.

5. Cargo Load Coasters: Cargo load coasters will be used to assist with the loading of the RTGs onto the helicopter.

6. Helicopter Winch: The helicopter winch will need to be in working order to accomplish the loading of the RTGs.

7. Standard Tool Kit: Standard tools will be required to perform minor changes to the current notification system configuration once the RTGs have been removed.

8. Torque wrench and socket set to verify bolts are secured properly.

9. Communications Equipment: Portable radios for the deployment team to keep in contact with team members at different locations. Det 460 will furnish Iridium phones and radios for Alaska operations (additional phones/radios are available from the 354LRS) and Creech AFB will provide radio for operations in Nevada.

10. 463L Pallets: Pallets will be provided by Eielson AFB (354LRS) and accepted by Creech AFB (99LRS)

11. Tie-down chains and tensioners: 10,000 lb chains and appropriate tensioners will be purchased by Det 460 to secure the RTGs to the 463L pallets and flatbed trailer. Refer to Appendix G – Transport and Handling for equipment specifications.

I. HEALTH AND SAFETY

Safety has been considered in accordance with AFI 91-202 The US Air Force Mishap Prevention Program; AFI 91-207 The US Air Force Traffic Safety Program; AFI 91-103 The Air Force Occupational and Environmental Safety, Fire Protection and (AFOSH) Health Program; and Occupational Safety and Health Administration (OSHA) standards. Personnel tasked with implementing this plan will adhere to these standards, including but not limited to: general safety, electrical safety, lifting heavy objects, blood borne pathogens, and proper use of personal protective equipment.

Minimizing the time personnel spend near an RTG and maximizing the distance between personnel and an RTG will insure doses are maintained as low as reasonably achievable. These precautions are reflected in the transport and handling procedure in Appendix G. Prior to execution of this transportation plan or exposure to potential hazards, all personnel will be briefed on specific safety instructions contained in Appendix L – Health & Safety Plan.

J. EMERGENCY RESPONSE

Reporting of radioactive material mishaps and incidents associated with RTG transportation is governed by AFI 40-201 paragraph 3.12 and attachments 11 and 12 as well as portions of 10 CFR 20 as referenced in the AFI. Appendix M – Emergency Management Plan provides procedures for notification and handling of an emergency.

In the unlikely event of an incident, to include an in-flight emergency or an in-route accident or breakdown, State and local government agencies have the primary responsibility for response. All mishaps and incidents will be reported immediately by notifying the Operations Commander and the AFTAC or Installation Radiation Safety Officer (RSO) identified in paragraph 2.A of Appendix M. The RSO will in turn notify the appropriate organizations as governed by AFI 40-201. Notifications made to report an emergency shall be made by voice insofar as possible unless precluded by security requirements. Organizations to be notified by the RSO are:

- Radio Isotope Committee (RIC): DSN 425-6308, Comm (703) 588-6308
- RIC Secretariat: DSN 761-6946, Comm (703) 681-6946
- Andrews Regional Command Post (after duty hours): DSN 858-5058, Comm (301) 981-5058
- Bolling AFB Command Post: DSN 297-4011, Comm (202) 767-4011

Special care will be taken when reporting a mishap or incident to ensure reports do not contain classified or sensitive unclassified information. All reports involving RAM exceeding NRC quantities of concern will be handled as sensitive information and transmitted as directed by the RIC. All information will be properly marked and secured from unauthorized access.

If an event should occur, in addition to making appropriate notifications, on site personnel will initiate emergency response procedures in accordance with Appendix M. If any situation arises requiring an emergency landing, the aircraft commander will determine the safest landing location based upon a variety of factors to include proximity to an Air Force base, current weather, and runway conditions. NNSS is a designated safe haven should an in route emergency arise during the Nevada ground portion of the RTG transport. If travel to NNSS is obstructed, shipment will return to Creech AFB.

Personnel involved in the transport of the RTGs will carry communication equipment and a copy of Appendix M - Emergency Management Plan. In addition, the Emergency Response Summary information (extracts from the Emergency Response Guide 163) contained at the end of Appendix M will accompany the RTG throughout transport.

K. SECURITY

Appendix N to this document contains the security plan associated with this transportation effort. The plan is implemented and maintained to comply with NRC requirements in 49 CFR Part 172 and 10 CFR Part 37. The purpose of the plan is to establish the security strategy to be used during the transport of the RTGs from Burnt Mountain to the NNSS. AFTAC RSOs are responsible for implementing the security plan. RSOs are Mr. Mark Talbert (321-494-4851) and Ms. Joy Morris (321-494-3870). Refer to Appendix N for an assessment of the security risk for this transport effort and a complete description of the security plan.

RTG TRANSFER SITREP
20 JULY 2015

1. OPERATIONS:

A. SIGNIFICANT EVENTS: THE RTG EXTRACTION TEAM CANCELLED EXTRACTION ACTIVITIES ON 20 JULY 2015 DUE TO WEATHER AT BURNT MOUNTAIN.

FT WAINWRIGHT DEPARTURE:	1600Z
BURNT MOUNTAIN ARRIVAL:	N/A
BURNT MOUNTAIN DEPARTURE:	N/A
EIELSON AFB ARRIVAL:	N/A
FT WAINWRIGHT ARRIVAL:	1641Z

B. MAJOR EVENTS NEXT 24-48 HOURS: ON 21 JULY 2015, THE RTG EXTRACTION TEAM WILL CONTINUE WITH EXTRACTION OF RTGs #7/#8 FROM BURNT MOUNTAIN SITE #4.

C. MISSION IMPACT: NO IMPACT ON NEW BASELINE SCHEDULE. C-17 DEPARTURE STILL PLANNED FOR 24 JULY 2015.

2. WEATHER:

A. NEXT 24-48 HOURS: PARTLY CLOUDY / 0% PRECIP
B. LONG RANGE: LOW CHANCE OF RAIN AND MOSTLY SUNNY FOR 21-24 JULY 2015.

3. LOGISTICS:

A. CH-47 #1: FMC
B. CH-47 #2: FMC
C. CH-47 #3: FMC
D. FIELD FORKLIFT: FMC
E. EIELSON GSE: FMC
F. C-17: FMC
G. CREECH GSE: N/A

4. PERSONNEL DATA:

A. TDY PERSONNEL: 6 ACTIVE DUTY AIR FORCE / 8 CIVILIANS / 1 CONTRACTORS
B. AFTAC PERSONNEL (TDY & DET 460): 18 EIELSON AFB / 0 CREECH AFB / 4 BURNT MOUNTAIN / 1 FT YUKON / 1 FAIRBANKS MEMORIAL HOSPITAL

5. RTG LOCATION: 4/10 BURNT MOUNTAIN / 6/10 EIELSON AFB / 0/10 CREECH AFB

6. COMMUNICATIONS STATUS:

A. LMR: PMC
B. CELL PHONE: FMC
C. DSN: FMC
D. SAT PHONE: FMC
E. SIPR/NIPR E-MAIL: FMC
F. COMMENTS: RADIO TO BURNT MOUNTAIN LIVING FACILITY IS FMC. SITES 1/2/4 RADIO REPEATER INSTALLATION IS ONGOING. ETIC UNKNOWN – NO MISSION IMPACT; SAT PHONES WITH TEAM.

7. MEDICAL STATUS: MEMBER INJURED ON 17 JULY STILL IN FAIRBANKS HOSPITAL. HE IS DOING WELL AND IN VERY GOOD SPIRITS. MEDICAL STAFF IS EVALUATING AND WILL MAKE DECISION TO SEND HIM HOME DAY BY DAY. CONSIDERATIONS ARE HIS TODDLER AT HOME, HIS MOBILITY, AND ABILITY TO CHANGE HIS OWN DRESSING.

8. CONTACT INFO:

A. RTG COMM CENTER: DSN: 317-377-7689 / Commercial: 907-377-7689
B. EIELSON COMMAND POST: DSN: 317-377-1500 / Commercial: 907-377-1500
C. RTG ON SITE COMMANDER: Cell: (b)(6)
D. RTG OPERATIONS MANAGER: Cell: (b)(6)

9. ON SITE COMMANDER COMMENTS: HELOS DEPARTED TODAY BUT WERE UNABLE TO MAKE IT OVER THE MOUNTAINS TO THE NORTH DUE TO LOW CLOUDS AND VISIBILITY. THE LOW CEILING AND RAIN IN THE FAIRBANKS AREA SATURDAY AND SUNDAY LIFTED, BUT STILL REMAIN OVER THE MOUNTAINS. WE DEPARTED FORT WAINWRIGHT AND TRIED TWO DIFFERENT VALLEYS BUT WERE UNABLE TO MAKE IT THROUGH. DUE TO THE LOW ALTITUDE OF THE ICING LEVEL, WE WERE UNABLE TO PROCEED IFR. WE WILL RE-ATTACK TOMORROW.

RTG TRANSFER SITREP
21 JULY 2015

1. OPERATIONS:

A. SIGNIFICANT EVENTS: ON 21 JULY 2015, THE RTG EXTRACTION TEAM SUCCESSFULLY TRANSFERRED RTGs #7/#8 FROM BURNT MOUNTAIN SITE #4 TO THE EIELSON AFB STAGING AREA.

FT WAINWRIGHT DEPARTURE:	1548Z
BURNT MOUNTAIN ARRIVAL:	1716Z
BURNT MOUNTAIN DEPARTURE:	2000Z
EIELSON AFB ARRIVAL:	2124Z

B. MAJOR EVENTS NEXT 24-48 HOURS: ON 22 JULY 2015, THE RTG EXTRACTION TEAM WILL CONCLUDE MOUNTAIN OPERATIONS WITH EXTRACTION OF RTGs #9/#10 FROM BURNT MOUNTAIN SITE #5.

C. MISSION IMPACT: C-17 DEPARTURE STILL PLANNED FOR 24 JULY 2015.

2. WEATHER:

A. NEXT 24-48 HOURS: MOSTLY SUNNY / 10% PRECIP
B. LONG RANGE: LOW CHANCE OF RAIN AND MOSTLY SUNNY FOR 22-24 JULY 2015.

3. LOGISTICS:

A. CH-47 #1: FMC
B. CH-47 #2: FMC
C. CH-47 #3: FMC
D. FIELD FORKLIFT: FMC
E. EIELSON GSE: FMC
F. C-17: FMC
G. CREECH GSE: N/A

4. PERSONNEL DATA:

A. TDY PERSONNEL: 6 ACTIVE DUTY AIR FORCE / 8 CIVILIANS / 1 CONTRACTORS
B. AFTAC PERSONNEL (TDY & DET 460): 19 EIELSON AFB / 0 CREECH AFB / 4 BURNT MOUNTAIN / 1 FT YUKON

5. RTG LOCATION: 2/10 BURNT MOUNTAIN / 8/10 EIELSON AFB / 0/10 CREECH AFB

6. COMMUNICATIONS STATUS:

A. LMR: PMC
B. CELL PHONE: FMC
C. DSN: FMC
D. SAT PHONE: FMC
E. SIPR/NIPR E-MAIL: FMC

F. COMMENTS: RADIO TO BURNT MOUNTAIN LIVING FACILITY IS FMC. SITES 1/2/4 RADIO REPEATER INSTALLATION IS ONGOING. ETIC UNKNOWN – NO MISSION IMPACT; SAT PHONES WITH TEAM.

7. MEDICAL STATUS: MEMBER INJURED ON 17 JULY RELEASED FROM FAIRBANKS HOSPITAL. HE IS DOING WELL AND RECOVERING AT HIS LOCAL RESIDENCE.

8. CONTACT INFO:

A. RTG COMM CENTER: DSN: 317-377-7689 / Commercial: 907-377-7689
B. EIELSON COMMAND POST: DSN: 317-377-1500 / Commercial: 907-377-1500
C. RTG ON SITE COMMANDER: Cell: (b)(6)
D. RTG OPERATIONS MANAGER: Cell: (b)(6)

9. ON SITE COMMANDER COMMENTS: SUCCESSFUL DAY WITH MOVING 2 MORE RTGs TO EIELSON. WEATHER ENROUTE CONTINUES TO BE A CHALLENGE AS WE HAD TO CLIMB ABOVE THE CLOUD DECK TODAY TO STAY CLEAR OF ICING. WEATHER IN FAIRBANKS TOMORROW LOOKS GOOD. AS WE HAVE LEARNED THROUGHOUT THIS OPERATION, FORECASTING WEATHER OVER THE MOUNTAINS IS VERY DIFFICULT. EXPECT TO FLY A 3-SHIP TOMORROW TO BRING THE LAST RTGs BACK AS WELL AS THE FORKLIFT. THURSDAY WILL BE DEDICATED TO FINAL PREPPING OF RTGs FOR MOVEMENT AS WELL AS SURVEYING THE C-17 WHEN IT LANDS. PLANNED FLIGHT TO CREECH WILL BE ON FRIDAY THE 24TH.

FINAL DISPOSITION INSPECTIONS AND SURVEYS MUST BE COMPLETED AT CREECH. DUE TO THE INSPECTORS FROM SANDIA NOT ARRIVING UNTIL SUNDAY NIGHT, THE FINAL INSPECTIONS WILL BE ACCOMPLISHED ON MONDAY THE 27TH AND THE FINAL LEG OF THE JOURNEY WILL OCCUR ON TUESDAY THE 28TH.

RTG TRANSFER SITREP
22 JULY 2015

1. OPERATIONS:

A. SIGNIFICANT EVENTS: ON 22 JULY 2015, THE RTG EXTRACTION TEAM SUCCESSFULLY TRANSFERRED RTGs #9/#10 FROM BURNT MOUNTAIN SITE #5 TO THE EIELSON AFB STAGING AREA.

FT WAINWRIGHT DEPARTURE:	1603Z
BURNT MOUNTAIN ARRIVAL:	1750Z
BURNT MOUNTAIN DEPARTURE:	2014Z
EIELSON AFB ARRIVAL:	2136Z

B. MAJOR EVENTS NEXT 24-48 HOURS: ON 23 JULY 2015, THE RTG EXTRACTION TEAM WILL PERFORM RADIATION SURVEYS OF ALL 10 RTGS, PREPARE THE RTGS FOR THE C-17 FLIGHT, PERFORM RADIATION SURVEYS OF THE C-17, AND CONDUCT REQUIRED ACTIVITIES TO CLEAR ALL EQUIPMENT AND FACILITIES USED AT EIELSON AFB.

C. MISSION IMPACT: C-17 DEPARTURE STILL PLANNED FOR 24 JULY 2015.

2. WEATHER:

A. NEXT 24-48 HOURS: CLEAR
B. LONG RANGE: PARTLY CLOUDY WITH A CHANCE OF RAIN FOR 23-24 JULY 2015.

3. LOGISTICS:

A. CH-47 #1: FMC
B. CH-47 #2: FMC
C. CH-47 #3: FMC
D. FIELD FORKLIFT: FMC
E. EIELSON GSE: FMC
F. C-17: FMC
G. CREECH GSE: N/A

4. PERSONNEL DATA:

A. TDY PERSONNEL: 6 ACTIVE DUTY AIR FORCE / 8 CIVILIANS / 1 CONTRACTORS
B. AFTAC PERSONNEL (TDY & DET 460): 19 EIELSON AFB / 0 CREECH AFB / 5 BURNT MOUNTAIN / 1 FT YUKON

5. RTG LOCATION: 0/10 BURNT MOUNTAIN / 10/10 EIELSON AFB / 0/10 CREECH AFB

6. COMMUNICATIONS STATUS:

A. LMR: PMC
B. CELL PHONE: FMC
C. DSN: FMC
D. SAT PHONE: FMC
E. SIPR/NIPR E-MAIL: FMC

F. COMMENTS: RADIO TO BURNT MOUNTAIN LIVING FACILITY IS FMC. SITES 1/2/4 RADIO REPEATER INSTALLATION IS ONGOING. ETIC UNKNOWN – NO MISSION IMPACT; SAT PHONES WITH TEAM.

7. MEDICAL STATUS: NSTR

8. CONTACT INFO:

A. RTG COMM CENTER: DSN: 317-377-7689 / Commercial: 907-377-7689
B. EIELSON COMMAND POST: DSN: 317-377-1500 / Commercial: 907-377-1500
C. RTG ON SITE COMMANDER: Cell: (b)(6)
D. RTG OPERATIONS MANAGER: Cell: (b)(6)

9. ON SITE COMMANDER COMMENTS: SUCCESSFUL DAY WITH MOVING LAST 2 RTGs TO EIELSON. WEATHER FOR THE FINAL DAY WAS PICTURE PERFECT AND ALL OPS WENT SMOOTHLY. WE ALSO WERE ABLE TO BRING THE FORKLIFT BACK ON A THIRD HELO.

EXCELLENT JOB BY THE WHOLE TEAM. THE SUPPORT FROM THE 354WG HAS BEEN SIMPLY OUTSTANDING. THEY HAVE LEANED FORWARD, BEEN WITH US EVERY STEP, AND PROVIDED EVERYTHING WE HAVE NEEDED. ARMY AVIATION PRESSED HARD EVERYDAY YET KEPT US SAFE AND MADE THE HARD ABORT CALLS ONLY WHEN NECESSARY.

WHILE A HUGE SUCCESS THUS FAR, WE STILL THE HAVE THE SECOND HALF OF THE MISSION AHEAD. OUR AIRLIFT ARRIVES TOMORROW NIGHT. WE MUST SURVEY AND LOAD THE AIRCRAFT WHICH COULD DELAY CREW REST A BIT TOMORROW NIGHT BUT TACC IS AWARE AND I WILL COORDINATE WITH THE CREW. PLANNED DEPARTURE IS FOR MID DAY FRIDAY WITH ARRIVAL AT CREECH EARLY EVENING. DUE TO SANDIA REPRESENTATIVES ARRIVING SUNDAY, WE WILL PREP AND LOAD FOR THE FINAL LEG ON MONDAY THE 27TH AND DELIVER TUESDAY 28TH.

RTG TRANSFER SITREP
23 JULY 2015

1. OPERATIONS:

A. SIGNIFICANT EVENTS: ON 23 JULY 2015, THE TEAM SUCCESSFULLY LOADED THE C-17 WITH ALL RTGs AND COMPLETED RADIATION SURVEYS.

B. MAJOR EVENTS NEXT 24-48 HOURS: ON 24 JULY 2015, THE RTG EXTRACTION TEAM WILL TRAVEL ABOARD THE C-17 TO CREECH AFB, NEVADA. RTGs WILL REMAIN AT CREECH AFB UNTIL SANDIA NATIONAL LABORATORY INSPECTION ON 27 JULY AND DELIVERY TO NNSS ON 28 JULY.

C. MISSION IMPACT: NSTR

2. WEATHER:

A. NEXT 24-48 HOURS: NSTR
B. LONG RANGE: NSTR

3. LOGISTICS:

A. CH-47 #1: N/A
B. CH-47 #2: N/A
C. CH-47 #3: N/A
D. FIELD FORKLIFT: N/A
E. EIELSON GSE: FMC
F. C-17: FMC
G. CREECH GSE: FMC

4. PERSONNEL DATA:

A. TDY PERSONNEL: 6 ACTIVE DUTY AIR FORCE / 8 CIVILIANS / 1 CONTRACTOR
B. AFTAC PERSONNEL (TDY & DET 460): 17 EIELSON AFB / 3 CREECH AFB

5. RTG LOCATION: 0/10 BURNT MOUNTAIN / 10/10 EIELSON AFB / 0/10 CREECH AFB

6. COMMUNICATIONS STATUS:

A. LMR: PMC
B. CELL PHONE: FMC
C. DSN: FMC
D. SAT PHONE: FMC
E. SIPR/NIPR E-MAIL: FMC
F. COMMENTS:

7. MEDICAL STATUS: NSTR

8. CONTACT INFO:

A. RTG COMM CENTER: DSN: N/A
B. EIELSON COMMAND POST: DSN: 317-377-1500 / Commercial: 907-377-1500
C. RTG ON SITE COMMANDER: Cell (b)(6)
D. RTG OPERATIONS MANAGER: Cell: (b)(6)

9. ON SITE COMMANDER COMMENTS: C-17 ARRIVED THIS EVENING AND IS LOADED FOR TOMORROW'S MISSION. AFTER THE C-17 LANDED AND OFFLODAED ITS CARGO, WE COMPLETED AIRCREW TRAINING AND SURVEYED THE EMPTY AIRCRAFT. WE WERE ALSO ABLE TO UPLOAD ALL THE RTGS AS WELL AS DO CLEARING SURVEYS ON THE BUILDING THEY HAVE BEEN HOUSED IN AND THE GROUND EQUIPMENT MOVING THEM. I ANTICIPATE AN ON TIME DEPARTURE TOMORROW AT 1955Z. FINAL PREPARATION WILL OCCUR ON MONDAY THE 27TH WITH DISPOSITION ON TUESDAY THE 28TH.

THREE AFTAC ADVANCE MEMBERS HAVE ARRIVED AT CREECH AND ARE PREPPING FOR OUR ARRIVAL. THERE ARE STILL AFTAC (DET460) PERSONNEL ON BURNT MOUNTAIN ACCOMPLISHING THEIR NORMAL SUMMER DUTIES, HOWEVER SINCE THE RTG PORTION OF THEIR MISSION IS OVER, WE WILL NOT BE COUNTING THEM FOR SITREP PURPOSES ANYMORE. SIDE NOTE; OUR INJURED MEMBER WAS PRESENT ON BASE YESTERDAY TO WITNESS THE FINAL RTGS ARRIVAL AND IS DOING WELL.

RTG TRANSFER SITREP
24 JULY 2015

1. OPERATIONS:

A. SIGNIFICANT EVENTS: ON 24 JULY 2015, THE TEAM SUCCESSFULLY TRANSPORTED ALL RTGs TO THE CREECH AFB STAGING AREA.

EIELSON AFB DEPARTURE:	1935Z
CREECH AFB ARRIVAL:	0030Z

B. MAJOR EVENTS NEXT 24-48 HOURS: RTGs WILL REMAIN AT CREECH AFB UNTIL SANDIA NATIONAL LABORATORY INSPECTION ON 27 JULY AND DELIVERY TO NNSS ON 28 JULY.

C. MISSION IMPACT: NSTR

2. WEATHER:

A. NEXT 24-48 HOURS: NSTR
B. LONG RANGE: NSTR

3. LOGISTICS:

A. CH-47 #1: N/A
B. CH-47 #2: N/A
C. CH-47 #3: N/A
D. FIELD FORKLIFT: N/A
E. EIELSON GSE: FMC
F. C-17: FMC
G. CREECH GSE: FMC

4. PERSONNEL DATA:

A. TDY PERSONNEL: 4 ACTIVE DUTY AIR FORCE / 7 CIVILIANS / 1 CONTRACTOR
B. AFTAC PERSONNEL (TDY): 8 CREECH AFB

5. RTG LOCATION: 0/10 BURNT MOUNTAIN / 0/10 EIELSON AFB / 10/10 CREECH AFB

6. COMMUNICATIONS STATUS:

A. LMR: N/A
B. CELL PHONE: FMC
C. DSN: FMC
D. SAT PHONE: FMC
E. SIPR/NIPR E-MAIL: FMC
F. COMMENTS:

7. MEDICAL STATUS: NSTR

8. CONTACT INFO:

A. RTG COMM CENTER: DSN: N/A
B. EIELSON COMMAND POST: DSN: 317-377-1500 / Commercial: 907-377-1500
C. RTG ON SITE COMMANDER: Cell: (b)(6)

D. RTG OPERATIONS MANAGER: Cell: (b)(6)

9. ON SITE COMMANDER COMMENTS: C-17 FLIGHT FROM EIELSON TO CREECH PROCEEDED WITHOUT ISSUE. THE RTGs ARE SECURED INSIDE A HANGAR FOR THE WEEKEND. SANDIA PERSONNEL WILL ARRIVE ON SUNDAY AND WE WILL PREPTHE RTGs FOR MOVEMENT ON MONDAY. ACTUAL DELIVERY IS STILL ON TRACK FOR TUESDAY. SINCE THERE WILL BE NO OPERATIONS THIS WEEKEND, THE NEXT SITREP WILL BE MONDAY NIGHT THE 27TH.

RTG TRANSFER SITREP
27 JULY 2015

1. OPERATIONS:

A. SIGNIFICANT EVENTS: ON 27 JULY 2015, SANDIA NATIONAL LABORATORY REPRESENTATIVES COMPLETED SURVEYS OF ALL RTGs WITH NO SIGNIFICANT FINDINGS. THE AFTAC TEAM LOADED ALL RTGs ONTO THREE FLATBED TRUCKS AND COMPLETED ALL TRANSFER PAPERWORK.

B. MAJOR EVENTS NEXT 24-48 HOURS: RTGs WILL REMAIN ON FLATBED TRUCKS AT CREECH AFB OVERNIGHT. 28 JULY 2015 ACTIVITIES WILL CONSIST OF FINAL TRANSFER PAPERWORK VERIFICATION AND TRANSPORT TO NNSS. EXPECTED TIME OF DEPARTURE FROM CREECH AFB IS 1500Z. EXPECTED ARRIVAL AT NNSS SITE 5 1615Z.

C. MISSION IMPACT: NSTR

2. WEATHER:

A. NEXT 24-48 HOURS: NSTR
B. LONG RANGE: NSTR

3. LOGISTICS:

A. CH-47 #1: N/A
B. CH-47 #2: N/A
C. CH-47 #3: N/A
D. FIELD FORKLIFT: N/A
E. EIELSON GSE: N/A
F. C-17: N/A
G. CREECH GSE: FMC

4. PERSONNEL DATA:

A. TDY PERSONNEL: 4 ACTIVE DUTY AIR FORCE / 7 CIVILIANS / 4 CONTRACTORS
B. AFTAC PERSONNEL (TDY): 7 CREECH AFB

5. RTG LOCATION: 0/10 BURNT MOUNTAIN / 0/10 EIELSON AFB / 10/10 CREECH AFB

6. COMMUNICATIONS STATUS:

A. LMR: N/A
B. CELL PHONE: FMC
C. DSN: FMC
D. SAT PHONE: FMC
E. SIPR/NIPR E-MAIL: FMC
F. COMMENTS:

7. MEDICAL STATUS: NSTR

8. CONTACT INFO:

A. RTG COMM CENTER: DSN: N/A
B. CREECH AFB CRT: DSN: 312-384-0511 / Commercial: 702-404-0511

C. RTG ON SITE COMMANDER: Cell: (b)(6)
D. RTG OPERATIONS MANAGER: Cell: (b)(6)

9. ON SITE COMMANDER COMMENTS: LOADING OF THE RTGs ONTO FLATBEDS WENT NORMALLY TODAY WITH NO ISSUES. THE TRUCKS/RTGs ARE INSIDE OF BUILDING 120 FOR THE EVENING. WE ANTICIPATE ARRIVING AT NNSS AROUND 0900L. THERE ARE NO KNOWN ISSUES AT THIS TIME TO PRECLUDE A NORMAL TRANSFER TOMORROW.

RTG TRANSFER SITREP
28 JULY 2015

1. OPERATIONS:

A. SIGNIFICANT EVENTS: ON 28 JULY 2015, THE RTG EXTRACTION TEAM SUCCESSFULLY DELIVERED ALL 10 RTGs TO NNSS FOR DISPOSAL AT 2030Z. MISSION COMPLETE.

B. MAJOR EVENTS NEXT 24-48 HOURS: FOUR AFTAC RADIATION SAFETY PERSONNEL WILL REMAIN IN NEVADA FOR FINAL EQUIPMENT SURVEYS AND SURVEY EQUIPMENT SHIPPING. ALL OTHER PERSONNEL WILL RTB ON 29 JULY 2015.

C. MISSION IMPACT: NSTR

2. WEATHER:

A. NEXT 24-48 HOURS: NSTR
B. LONG RANGE: NSTR

3. LOGISTICS:

A. CH-47 #1: N/A
B. CH-47 #2: N/A
C. CH-47 #3: N/A
D. FIELD FORKLIFT: N/A
E. EIELSON GSE: N/A
F. C-17: N/A
G. CREECH GSE: FMC

4. PERSONNEL DATA:

A. TDY PERSONNEL: 4 ACTIVE DUTY AIR FORCE / 7 CIVILIANS / 4 CONTRACTORS
B. AFTAC PERSONNEL (TDY): 7 CREECH AFB

5. RTG LOCATION: 10/10 NEVADA NATIONAL SECURITY SITE

6. COMMUNICATIONS STATUS:

A. LMR: N/A
B. CELL PHONE: FMC
C. DSN: FMC
D. SAT PHONE: FMC
E. SIPR/NIPR E-MAIL: FMC
F. COMMENTS:

7. MEDICAL STATUS: NSTR

8. CONTACT INFO:

A. RTG COMM CENTER: DSN: N/A
B. CREECH AFB CRT: DSN: 312-384-0511 / Commercial: 702-404-0511
C. RTG ON SITE COMMANDER: Cell: (b)(6)
D. RTG OPERATIONS MANAGER: Cell: (b)(6)

9. ON SITE COMMANDER COMMENTS: MISSION COMPLETE! OPERATIONS TODAY WENT VERY SMOOTH AND WE SUCCESSFULLY TRANSFERRED 10 RTGs TO NNSS. THANKS TO ALL THAT HAD A HAND IN THIS OPERATION. FROM NORTH OF THE ARCTIC CIRCLE TO THE DESERTS OF NEVADA THIS COULD NOT HAVE BEEN ACCOMPLISHED WITHOUT THE TEAM WORK OF MULTIPLE AGENCIES ACROSS DOD, DOE, STATES AND COUNTY. GREAT SUPPORT AND PROFESSIONALISM BY ALL.

THIS IS THE FINAL RTG SITREP.