DEPARTMENT OF THE ARMY
US ARMY COMMUNICATIONS-ELECTRONICS COMMAND
FORT MONMOUTH, NEW JERSEY 07703-5024

ENVIRONMENTAL ASSESSMENT

AND

FINDING OF NO SIGNIFICANT IMPACT

FOR THE

Am-241 VARIABLE X-RAY SOURCE

SECURITY VERIFICATION: THIS DOCUMENT HAS BEEN REVIEWED IN FULL CONSIDERATION OF THE REQUIREMENTS OF OPERATIONS SECURITY (OPSEC) AND HAS BEEN DETERMINED TO BE ACCEPTABLE FOR PUBLIC RELEASE (SEE SECTION I)

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ABBREVIATIONS

ALI	Annual Limit on Intake
AMCCOM	US Army Armament, Munitions and Chemical Command
Am-241	Americium-241
AR	Army Regulation
Bq	Becquerel
CECOM	US Army Communications-Electronics Command
CFR	Code of Federal Regulations
cm	centimeter
dy	day
DA	Department of the Army
DOD	Department of Defense
EA	Environmental Assessment
hr	hour
ICRP	International Commission on Radiological Protection
m	meter
mR	millirem
NICP	National Inventory Control Point
NRC	Nuclear Regulatory Commission
OPSEC	Operations Security
RPO	Radiation Protection Officer
sec	second
Sv	Sievert
TM	Technical Manual
yr	year

I. OPERATIONS SECURITY (OPSEC) REVIEW

A. Security Verification

1. The Environmental Assessment (EA) and Finding of No Significant Impact for the Am-241 Variable Energy X-ray Source supports a US Nuclear Regulatory Commission (NRC) license in accordance with requirements set forth in Army Regulation (AR) 200-2 and AR 385-11. The NRC license managed by the US Army Communications-Electronics Command (CECOM), Fort Monmouth, NJ is available for public review in the Public Documents Room, Washington, DC as required by Title 10, Code of Federal Regulations (CFR).

2. The information contained within this environmental documentation has been reviewed in accordance with OPSEC intentions/requirements presented in AR 530-1, and has been determined acceptable for public release.

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II. PUBLIC NOTIFICATION

A. Finding of No Significant Impact

1. CECOM has license management responsibilities for the Variable Energy X-ray Source as supplied by Amersham International Limited, Arlington Heights, IL. The Variable Energy X-ray Source utilizes Americium-241 (Am-241) as a sealed source and will be used solely for the calibration of the DT-590/PDR-56F X-ray Probe. The EA supports the NRC license application and complies with AR 200-2, Environmental Quality, Environmental Effects of Army Actions, which requires an evaluation of any radionuclide proposed for use within Army activities. The assessment demonstrates compliance with applicable regulatory requirements concerning radiation safety policies, control and specific disposal procedures for the Am-241 Variable Energy X-ray Source.

2. The assessment provides dosimetric analysis for internal exposure of individuals resulting from inhalation or ingestion of the radioactive material and the external dose presented to exposed individuals. For dose commitments resulting from inhalation or ingestion, 50 year (yr) dose commitment factors are utilized. The dosimetric evaluations identify air/water concentrations and exposure levels below Federal and Department of the Army (DA) regulatory requirements and demonstrate internal exposures below International Commission on Radiological Protection (ICRP) recommendations. Based upon this analysis and stringent military radiation safety policy, the EA concludes no discernable radiological health or environmental quality degradation, and therefore, does not require an Environmental Impact Statement. The EA is available for review upon request from Commander, US Army Communications-Electronics Command, ATTN: AMSEL-SF-MR, Fort Monmouth, New Jersey 07703-5024.

III. ENVIRONMENTAL ASSESSMENT

A. Summary and Conclusion

1. The following EA supporting a Finding of No Significant Impact and concurrent with an application for an NRC license to receive, possess, use and transfer radioactive material, has been prepared to maintain compliance with AR 200-2. The basic objective specified in this regulation is to perform all actions necessary in minimizing adverse effects on the quality of the human environment without impairment to the Army mission.

2. This document outlines:

a. The proposed use, need, and description of the Am-241 Variable Energy X-ray Source, inclusive of maximum safety design specifications and Army policies more restrictive than comparable governing Federal regulatory requirements.

b. Theoretical radiological/environmental impacts with resulting dose assessments from hypothetical accidents or misuse. The evaluation concludes and documents there is no potential degradation of environmental quality or significant radiological impact to occupational workers or to the health of the general public from the use/storage of the Am-241 Variable Energy X-ray Source.

3. The Am-241 Variable Energy X-ray Source is used solely for the calibration of the DT-590/PDR-56F X-ray Probe. Unit description, user training, control, accountability and ultimate disposal are outlined in Part B.

4. Properly implemented safety procedures for actions involving the Am-241 Variable Energy X-ray Source preclude any unnecessary radiation exposure to occupational personnel or to the general public and exclude consideration of any potential release to the environment. In determining radiological hazards to occupational personnel or the general public, external dose assessments are presented. ICRP Publication 30 identifies recommended Annual Limits on Intake (ALI) for radionuclides. These recommendations are based upon mathematical and biological parameters of Standard Man for which exposure risk to the individual from the radionuclide is acceptable. The recommendations are derived from specified quantities which have been identified as not leading to the induction of significant biological effect and are expressed in terms of committed dose-equivalent rates. Complete derivation of the evaluations and identification of compliance to regulatory standards are provided for review in Part C. The EA outlines highly improbable modes of exposure and demonstrates minimal to non-existent environmental or radiological impact.

5. The Am-241 Variable Energy X-ray Source will be used by primary calibration laboratories/activities for reference calibration of the DT-590/PDR-56F X-ray Probe. Calibration checks of fielded DT-590/PDR-56F X-ray Probes will be made using the AN/UDM-7C Radiac Calibrator Set. The AN/UDM-7C utilizes plutonium-239 and is authorized for use under NRC Special Nuclear Material License Number SNM-1896 issued to CECOM. Presently no other means of performing the reference calibration exists within the Department of Defense (DOD) Supply System. The assessment does not consider the use of the Am-241 Variable Energy X-ray Source environmentally controversial, as it is neither capable of significantly affecting the quality of the human environment nor it is demonstrative of any radiological impact.

B. Description of the Am-241 Variable Energy X-ray Source and Proposed Action.

1. The Am-241 Variable Energy X-ray Source is a commercially available device containing a sealed ceramic primary source in a welded stainless steel capsule, which excites characteristic X-rays from six different targets. The 10 millicurie (mCi) annular primary source surrounds the X-ray emission aperture in the fixed part of the stainless steel assembly and the targets are mounted on a rotary holder. Each target can be presented to the primary source in turn with the characteristic X-rays from the target being emitted through the 4 millimeter diameter aperture. When not in use, the X-ray source is stored in a fitted wooded box with appropriate labeling.

2. The sealed sources are manufactured by Amersham International Limited in accordance with Amersham Radiochemical Centre (ARC) drawings 10040 and 10048 (Enclosures 1 and 2). The source has been subjected to and passed the American National Standards Institute (ANSI) C64344 Sealed Radioactive Source Classification tests for containment integrity (Enclosure 3). In addition, the source complies with International Atomic Energy Agency (IAEA) special form requirements (Enclosure 4). Leak test procedures, as identified at Enclosure 5, are performed on each production source prior to target assembly attachment. All sources are labeled with a serial number, activity and isotope.

3. The Am-241 Variable Energy X-ray Source will be possessed, maintained and utilized by DA calibration laboratories/activities at the following primary calibration locations: US Army Test, Measurement and Diagnostic Equipment (TMDE) Support Group, Redstone Arsenal, AL; Area Calibration and Repair Center (ACRC) - Lexington, KY; ACRC - Sacramento, CA;

524th Maintenance Company, Pirmasens, Germany; and the 2nd Maintenance Company, Camp Carroll, Korea. All calibration laboratories/activities will be supervised by the qualified local Radiation Protection Officer (RPO) who will have received a minimum of 40 hours (hr) formal training in radiation protection. Users of the Am-241 Variable Energy X-ray Source shall have a minimum of 8 hours training under the guidance of a qualified local RPO in the basic fundamentals of radiological operations, radiac instrumentation, theory and application, survey techniques and 8 hours on-the-job training in operation and care of the Am-241 Variable Energy X-ray Source. Instructions shall include safe working practices and potential hazards associated with the instrument.

4. Facilities for use and storage of the Am-241 Variable Energy X-ray Source will be designated radiation or radiation controlled areas for those purposes as approved by the local RPO and will be secured against unauthorized removal. Areas/buildings will be posted with appropriate radiation warning signs.

5. Title 10, CFR, AR 385-11 and AR 700-64 are followed for disposal of radioactive waste. Initial requests for diposition are submitted to Headquarters, CECOM for review. After determination has been made for final disposition as radioactive waste, CECOM will authorize the user to dispose of the radioactive material in accordance with AR 385-11. Headquarters, US Army Armament, Munitions and Chemical Command (AMCCOM) has been delegated the responsibility of management coordination for radioactive waste disposal. AMCCOM assures that all radioactive waste is packaged and shipped in accordance with all applicable requirements for ultimate transfer of the radioactive waste to an authorized burial site.

C. Proposed Environmental/Radiological Impact for the Am-241 Variable Energy X-ray Source.

1. The following paragraphs will present hypothetical/actual information concerning the Am-241 Variable Energy X-ray Source in order to identify non-existent to insignificant environmental/radiological concern/impact. The evaluation presented will substantiate the conclusions presented in the Finding of No Significant Impact (Section II).

2. To determine any environmental/radiological impact associated with the Am-241 Variable Energy X-ray Source, the following evaluation is presented. The assessment is expressed in terms of committed dose equivalent rates determined for the organ(s) with the greatest potential of risk. It should be noted that no extensive data has been obtained on the distribution of Americium in man. Reliance must, therefore, be placed on the considerable data available on the metabolic behavior of Americium in experimental animals.

3. The assessment of internal exposure resulting from ingestion of Am-241 will take into consideration both the alpha and gamma emissions. However, because of the attenuation of the alpha particle from source encapsulation, only gamma radiation will be considered in determining external exposure. Furthermore, since only one Am-241 will be possessed at each user location, the assessment will evaluate exposure presented to individuals from a 3.70E+08 Becquerel (Bq) (10.00E+00 mCi) source.

4. Although the probability of internal exposure and significant external exposure due to the use of the Am-241 Variable Energy X-ray Source is minute, the assessment is presented to identify exposure limits below ICRP

recommendations and Federal and DA requirements. Additionally the assessment will unquestionably demonstrate there is no significant radiological/ environmental impact resulting from the use/storage of the Am-241 Variable Energy X-ray Source.

a. Assessment of External Radiation Exposure.

(1) A radiological survey of three Am-241 Variable Energy X-ray Sources, each with an activity of 3.70E+08 Bq (10.00E+00 mCi) was conducted by a member of the CECOM Safety Office health physics staff. The measurements were obtained utilizing standard Army beta-gamma radiation detection instruments, specifically the AN/PDR-27(J) Radiac Set and the newly developed AN/VDR-2( ) Radiac Set. Table C-1 provides the results of the exposure rate determinations. Since data provided by the manufacturer indicated the Terbium (Tb) target to provide the greatest photon flux, the Tb target was utilized in obtaining the exposure rate measurements. This information was physically verified through exposure rate determinations for each of the six targets available within the Am-241 Variable Energy X-ray Source. Use of the Am-241 Variable Energy X-ray Source is such that an operator need only come in surface contact with the device for the purpose of changing targets. This is accomplished through the simple rotation of a thumbwheel. Once target selection is complete and the source is positioned, no further contact with the Am-241 Variable Energy X-ray Source is necessary while the source is being used.

As indicated in Table C-1, an operator at a 5 centimeter (cm) distance would receive approximately 1.0 millirem per hour (mR/hr) in <u>direct</u> line with the "out beam" port with utilization of the Tb target. If one assumes a 40 hr work week and 52 weeks per year (yr), <u>constant</u> exposure to the Am-241 Variable Energy

X-ray Source, under the prescribed conditions, would present an annual whole body exposure of approximately 2.10 rem per year. The stipulated occupational amounts are 5.00 rem per year to the whole body, head and trunk, active blood forming organs, gonads or lens of the eye. The approximated annual exposure of 2.10 rem represents 42 percent of the occupational limit and again represents constant 40 hour per week, 52 weeks per year exposure to the Am-241 Variable X-ray Source.

In addition to the aforementioned exposure rate determinations, further measurements were obtained. These included direct constant surface measurements of the Am-241 Variable Energy X-ray Source utilizing the Tb and Copper (Cu) targets in addition to surface measurements obtained with the source stored within its fitted wooden box, both in the proper storage mode, i.e., with the Cu target in place, and in an improper storage mode, i.e., with the Tb target in place and the storage box inverted. Table C-2 and Table C-3 provide the results of these exposure rate determinations.

TABLE C-1
Am-241 Variable Energy X-ray Source
Exposure Rate Determinations

Instrument utilized	Distance from "Beam out" port (cm)	Exposure Rate (mR/hr) Source 1	Source 2	Source 3	Average Exposure Rate (mR/hr)
	5	1.1	1.0	1.0	1.03
AN/PDR-27(J)	10	0.4	0.3	0.3	0.33
	30	0.1	0.05	0.07	0.07
	5	1.69	1.66	1.71	1.68
AN/VDR-2	10	0.512	0.656	0.676	0.614
	30	0.127	0.105	0.115	0.115

TABLE C-2

Am-241 Variable Energy X-ray Source
Surface Contact
Exposure Rate Determinations*

Target Selection	Surface Exposure Rate (mR/hr) Top	Bottom**	Outside diameter
Tb	0.814	8.00	0.448
Cu	0.925	1.02	0.593

*utilizing the AN/VDR-2
**at "beam out" port

TABLE C-3

Am-241 Variable Energy X-ray Source
Storage Case Exposure Rate Determinations*

Target Selection	Surface Exposure Rate (mR/hr) Top	Bottom**	Sides
Tb	0.540	2.82	0.082
Cu	0.712	0.382	0.097

*utilizing the AN/VDR-2
**with storage case placed upside down on table

As indicated at Table C-2, an exposure rate of 8.00 mR/hr was obtained while utilizing the Tb target. It is noteworthy to mention that this is in constant, direct surface contact with the "beam out" port. Proper use of the Am-241 Variable Energy X-ray Source dictates handling the source by the outside rim where the exposure rate was determined to be 0.448 mR/hr. Even if one assumes the Am-241 Variable Energy X-ray Source were improperly handled, i.e., by direct surface contact with the "beam out" port, the operator could conceivably hold the source in the manner prescribed for 12 hours per week, 52 weeks per year, before achieving the 5.00 rem occupational limit.

If proper handling of the Am-241 Variable Energy X-ray Source is assumed, i.e., by the outside rim, constant surface contact would afford the user an annual exposure of only 0.93 rem or 18 percent of the stipulated 5.00 rem per year occupational limit.

It should be noted that the use factor identified, i.e., 40 hours per week, 52 weeks per year, is a gross overestimation of actual using time elements. Use of the Am-241 Variable Energy X-ray Source will be on an "as required" basis, with each calibration procedure being approximately 15 minutes in duration. Present procurement plans indicate the purchase of approximately one thousand DT-590/PDR-56F X-ray Probes. Calibration of all the probes could theoretically be accomplished within 250 hrs. Assuming a 5 cm operator distance and one individual performing all the calibrations, this presents a total external exposure of approximately 0.257 rem to the individual or 5 percent of the stipulated 5 rem per year occupational exposure limit. Even in this extreme case, i.e., one individual calibrating one thousand DT-590/PDR-56F X-ray Probes over a 250 hr period of time, would receive only 5 percent of the permissible 5

rem per year occupational exposure limit. More realistically, the calibrations would be performed on an "as required" basis by a number of qualified individuals located at each of the five indicated primary calibration sites.

A review of Table C-3 indicates that improper storage of the Am-241 Variable Energy X-ray Source in its fitted wooden box presents an exposure rate of 2.82 mR/hr. Personnel in direct surface contact with the storage container could receive an annual exposure, based upon 40 hrs/wk, 52 wks/yr, of approximately 17 percent above the 5.00 rem occupational limit based upon a constant exposure.

However, proper storage of the Am-241 Variable Energy X-ray Source presents a maximum exposure rate of 0.712 mR/hr, or based on the same exposure criteria, 1.48 rem per year or approximately 30 percent of the occupational yearly limit. Again this reflects exposure through constant direct surface contact with the storage box and does not take into account factors such as placement of the storage box into the designated storage cabinet, and time and distance factors. Accountability of any of the aforementioned parameters would undoubtedly reduce storage exposure rates to negligible levels.

(2) Based upon actual radiological survey data obtained and analysis of the data, it is evident that proper use/storage of the Am-241 Variable Energy X-ray Source presents no external radiation hazard to operator personnel or to individuals frequenting an area where the Am-241 Variable Energy X-ray Source is either used or stored.

b. Source Leakage/Damage Leading to Ingestion.

(1) Assume a 3.70E+08 Bq (10.00 E+00 mCi) Am-241 Variable Energy X-ray Source has leaked without detection resulting in the ingestion of radioactive

material with the following assumptions:

(a) One percent of the total activity, 3.70E+06 Bq (1.00E-01 mCi), is distributed within the assembly.

(b) Ten percent 3.70E+05 Bq (1.00E-02 mCi), is accessible for contamination of the individual.

(c) Ten percent of the accessible contamination, 3.70E+04 Bq (1.00 E-03 mCi), is transferred to the individual.

(d) One percent, 3.70E+02 Bq (1.00E-05 mCi), is ingested.

(2) ICRP Publication 30 identifies the Gonads, Red Marrow, Bone Surface and Liver as the primary organs of concern following oral ingestion of Am-241.

(3) The tabulated committed dose equilvalents, based on ICRP 30 data, are indicated at Table C-4. The maximum committed dose equivalent resultant from ingestion is identified as being 4.07 E+03 Sievert (Sv) (4.07 E-01 rem) to bone. The total ingested activity of 3.7 E+02 Bq (1.00 E-05 mCi) is 7.4 E-01 percent of the Annual Limit on Intake (ALI) (5.00 E+04 Bq) given for oral ingestion.

TABLE C-4

Committed Dose Equivalents to Various Organs Following Oral Ingestion of Am-241

Activity Ingested	Gonads	R. Marrow	Bone Surface	Liver
3.70 E+02 Bq (1.00 E-05 mCi)	5.18 E-05 Sv (5.18 E-03 rem)	3.11 E-04 Sv (3.11 E-02 rem)	4.07 E-03 Sv (4.07 E-01 rem)	8.51 E-04 Sv (8.51 E-02 rem)

(4) It is noteworthy to mention that in addition to passing ANSI Classification C64344 tests for containment integrity, the sealed source complies with IAEA special form requirements. In addition, leak testing

procedures as described at Enclosure 5, are performed by the manufacturer on each production source prior to target assembly attachment. Furthermore, source construction, i.e., the fact that the Am-241, as oxide, is a chemical constituent of a ceramic enamel bonded to stainless steel, essentially eliminates loss of sealed source integrity and unintentional ingestion of radioactive material. Therefore, the occurrence of this or any scenario involving source leakage/damage leading to ingestion of radioactive material is highly improbable in its consideration.

c. Calibration Laboratory/Activity Fire:

(1) The proposed incident involves a calibration laboratory/activity fire involving an Am-241 Variable Energy X-ray Source resulting in a release of Am-241 to the air. The hypothetical incident evaluates internal radiation exposure to firefighting personnel through the inhalation of Am-241 with the following assumptions:

(a) One Am-241 Variable Energy Source with an initial activity of 3.70 E+08 Bq (10.00 E+00 mCi) is involved in the fire.

(b) The fire envelops the storage case causing 1.00 E-01 percent of the source activity to be released, with one percent of the released activity escaping to the storage case, i.e., 3.70 E+03 Bq (1.00 E-04 mCi).

(c) Fifty percent of the activity escapes the storage case and is released into the 9.34 E+01 cubic meter (m^3) calibration laboratory yielding a concentration of 1.98 E+01 Bq/m^3 (5.35 E-07 mCi/m^3).

(d) The breathing rate of firefighting personnel is 1.20 m^3/hr. A firefighter, failing to implement protective respiratory apparatus, would in a five minute period of time, inhale a total activity of 1.98 E+00 Bq (5.35 E-08 mCi).

(2) The committed dose equivalents based on ICRP 30 data are summarized in Table C-5. The total inhaled activity is identified as being approximately one percent of the recommended ALI for inhalation (2.00 E+02 Bq). The air concentration limit, as specified in 10 CFR 20, is 2.22 E-01 Bq/m^3 (6.00 E-12 uCi/cm^3) for soluble forms and 3.70 E+00 Bq/m^3 (1.00 E-10 uCi/cm^3) for insoluble forms. The calculated air concentration of 1.98 E+01 Bq/m^3, averaged over one year, is equal to 5.42 E-02 Bq/m^3 (1.46 E-12 uCi/cm^3) or 24 percent of the air concentration limit for soluble forms and approximately 1.5 percent of the insoluble limit.

TABLE C-5

Committed Dose Equilavents to Various Organs
Following Inhalation of Am-241

Activity Inhaled	Gonads	R. Marrow	Bone Surface	Liver
1.98 E+00 Bq (5.35 E-08 mCi)	6.34 E-05 Sv (6.34 E-03 rem)	3.96 E-04 Sv (3.96 E-02 rem)	4.95 E-03 Sv (4.95 E-01 rem)	1.09 E-03 Sv (1.09 E-01 rem