

**BY ORDER OF THE SECRETARY  
OF THE AIR FORCE**

**AIR FORCE INSTRUCTION 91-110**

**28 JUNE 2002**

**AIR FORCE MATERIEL COMMAND  
Supplement**

**21 JULY 2011**

**Safety**



**NUCLEAR SAFETY REVIEW AND LAUNCH  
APPROVAL FOR SPACE OR MISSILE USE  
OF RADIOACTIVE MATERIAL AND  
NUCLEAR SYSTEMS**

**COMPLIANCE WITH THIS PUBLICATION IS MANDATORY**

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This instruction implements AFD 91-1, *Nuclear Weapons and Systems Surety*. It defines the nuclear safety review and launch approval procedures for using radioactive materials in space or missiles. This instruction does not apply to the Air Force Reserve and Air National Guard. Send major command (MAJCOM) supplements to this instruction to the Air Force Safety Center (HQ AFSC/SEWE, 9700 Avenue G, Kirtland AFB NM 87117-5670) for coordination and to HQ USAF/SE, 1400 Air Force Pentagon, Washington DC 20330-1400, for approval before publication. **Attachment 1** lists abbreviations and acronyms used in this instruction.

(AFMC) This supplement implements and extends the guidance of Air Force Instruction (AFI) 91-110, *Nuclear Safety Review and Launch Approval for Space or Missile Use of Radioactive Material and Nuclear Systems*. This supplement describes AFMC procedures for use in conjunction with the basic AFI. This supplement applies to HQ AFMC, subordinate

organizations, and all Air Force associate units located on AFMC or non AFMC installations. This supplement does not apply to Air National Guard or Air Force Reserve units. Users of this supplement must notify Weapons Safety Division (HQ AFMC/SEW) of conflicts between this supplement and other directives, instructions, or technical orders. Forward unit supplement to HQ AFMC/SEW, Bldg 262, S154, 4375 Chidlaw Road, Wright-Patterson AFB OH 45433-5006. Send recommended changes and questions about this supplement to the Office of Primary Responsibility (OPR) using the AF IMT 847, Recommendation for Change of Publication. Route AF IMT 847s from the field through the appropriate functional’s chain of command.

(AFMC) Ensure that all records created as a result of processes prescribed in this supplement are maintained in accordance with Air Force Manual (AFMAN) 33-363, *Management of Records*, and disposed of in accordance with Air Force Records Information Management System (AFRIMS) Records Disposition Schedule located at <https://www.my.af.mil/gcss-af61a/afrims/afrims>. The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this supplement does not imply endorsement by the Air Force.

**SUMMARY OF CHANGES**

**This document is substantially revised and must be completely reviewed.**

Range Nuclear Safety Surveys are replaced by Range Nuclear Safety Inspections. The MAJCOM is assigned responsibility for performing these inspections. Range commanders are tasked with developing and exercising radiological safety and contingency plans for space and missile launches carrying radiological materials. They are also responsible for ensuring radiological issues have a more prominent place in launch readiness reviews. In addition, threshold quantities for radioactive materials have been increased to match threshold values for the safe transport of radioactive materials as outlined in the *International Atomic Energy Agency’s, Safety Series 6, Regulations for the Safe Transport of Radioactive Material, 1996 (Revised)*. These threshold values are now listed in Terabecquerels (TBQ) instead of Curies to conform with international standards.

(AFMC) This revision aligns the AFMC supplement with the AFI. Several paragraphs have been rewritten for clarification and improved readability. This revision updates organizational office symbols.

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### *Section A—General Information*

**1. Defining Scope and Requirements.** This instruction defines the nuclear safety review and launch approval process for using radioactive materials aboard a space or missile system. These requirements add to AFI 40-201, *Control of Radioactive Material* (formerly AFR 161-16), which allows Air Force installations to possess radioactive materials. This instruction implements Presidential Directive/National Security Council Memorandum-25, *Scientific or Technological Experiments with Possible Large-Scale Adverse Environmental Effects and Launch of Nuclear Systems Into Space*, December 14, 1977 (revised by letter, 8 May 1996), Department of Defense (DoD) Directive 3200.11, *Major Range and Test Facility Base*, January 26, 1998. and DoDD 3100.10, *DoD Space Policy*, September 14, 2000.

1.1. Nuclear safety review and launch approval procedures apply to:

1.1. (AFMC) AFMC develops, tests, or has operational responsibility for space or missile systems that use radioactive materials. Therefore, nuclear safety reviews and launch approval processes are required to prevent radiological mishaps and negative impacts to the environment.

1.1.1. Agencies that use any radioactive materials aboard a space or missile system (atmospheric, ballistic, orbital, or earth escape), including radioactive materials that the US Nuclear Regulatory Commission (NRC), Agreement States, or other Military Services exempt from licensing.

1.1.2. Any materials held under section 91b of the Atomic Energy Act of 1954, currently found in 42 USC 2121 (b).

1.1.3. Air Force agencies that develop, test, or have operational responsibility for radioactive materials in space.

1.1.4. Other agencies or organizations that plan to use an Air Force range to launch radioactive materials and have not completed a range-approved equivalent nuclear safety review.

1.2. These procedures do not apply to radioactive materials in gravity weapons or manned aircraft where they are used as structural material, instruments, or ballast.

**2. Reporting Radiological Mishaps.** Follow AFI 91-204, *Investigating and Reporting US Air Force Mishaps*, to report accidents involving radioactive material. If the radioactive material has

a permit from the US Air Force Radioisotope Committee or an NRC license, also follow AFI 40-201 and Title 10, Code of Federal Regulations, *Energy*.

**3. Obtaining Exemptions or Waivers.** The Air Force Chief of Safety (HQ USAF/SE) may approve requests for exemptions or waivers to this instruction. The Air Force Vice Chief of Staff or higher-level authority grants waivers for special access programs, which must be in writing. Send requests for exemptions and waivers to HQ AFSC/SEWE, 9700 Avenue G, Kirtland AFB NM 87117-5670.

**3. (AFMC)Requests for exemptions and waivers will be sent to HQ AFMC/SEW for review and submission to HQ AFSC/SEW.**

### *Section B—General Responsibilities*

#### **4. HQ Air Force Safety Center. HQ AFSC/SEW:**

4.1. Performs Nuclear Safety Analysis and Review by:

4.1.1. Evaluating safety analysis reports.

4.1.2. Providing the DoD coordinator for the Interagency Nuclear Safety Review Panel (INSRP).

4.1.3. Assigning members to the technical subpanels for INSRP.

4.1.4. Providing technical help to organizations developing systems that incorporate significant amounts of radioactive material.

4.2. Grants or obtains nuclear safety launch approval for launches, based on the threshold quantities defined in [Attachment 2](#). HQ AFSC establishes the nuclear safety position for Air Force launches that require higher approval. When the radioactive material exceeds threshold quantity, HQ AFSC requests nuclear safety launch approval from the Office of the Assistant to the Secretary of Defense (Nuclear, Chemical and Biological Defense Programs (OATSD (NCB))).

4.3. Performs launch forecast and notification by sending OATSD (NCB) a quarterly forecast of projected Air Force space or missile launches using radioactive material.

#### **5. Major Commands (MAJCOM) and Air Force Program Executive Offices (AFPEO):**

5.1. MAJCOMs and AFPEOs that develop, test, or operate any programs or systems involving radio-active material must:

5.1. (AFMC) Program executive offices (PEO), System program offices (SPO), designated acquisition commander (DAC) program offices, etc., must incorporate policy requirements into acquisition contracts where radioactive materials are used in commercial launch vehicles. Mishap investigating and reporting procedures must be defined in contracts and according to AFI 91-204.

5.1.1. Notify HQ AFSC/SEW of the potential use of radioactive material as early as possible in the development or acquisition phase of the program.

5.1.1. (AFMC) PEO, SPOs, and DAC acquisition program managers will initially notify HQ AFSC/SEW, with courtesy copy to HQ AFMC/SEW, of potential use of radioactive material in tests/launches as early as possible in the acquisition process.

5.1.2. Prepare a safety analysis summary (SAS), if required. An SAS must be prepared for any planned launch of radioactive material when the total quantity of radioactive material exceeds the analysis threshold quantity listed in [Attachment 2](#). See [Attachment 3](#) for an SAS format.

5.1.2. (AFMC) The Safety Analysis Summary (SAS) is performed, prepared, and distributed by the PEO, SPO, or the DAC program office according to Table 1 and Attachment 3 of the basic instruction. Copies of the SAS must be sent through safety channels to HQ AFMC/SEW for review and submission to HQ AFSC/SEW.

5.1.2.1. If a Safety Evaluation Report (SER) is written by the INSRP, this report, along with its references Final Safety Analysis Report (FSAR) will be sufficient to meet this requirement.

5.1.3. Forecast and report all launches involving radioactive material to HQ AFSC/SEW. See [Attachment 4](#) for a report format.

5.1.3. (AFMC) PEO, SPO, or the DAC program office will forecast and report all launches involving radioactive material according to attachment 4 of the basic instruction. The forecast and report must be submitted to HQ AFMC/SEW for review, coordination, and submission to HQ AFSC/SEW.

5.1.4. Ensure coordination with higher authorities, per DoDI 3100.12, is accomplished.

5.2. The Air Force or INSRP reviews may require MAJCOMs to provide technical support.

5.3. Air Force Space Command (AFSPACECOM) must track systems with radioactive material throughout the system's life. AFSPACECOM can provide information on non-Air Force systems.

5.4. Perform Range Nuclear Safety Inspections that evaluate:

5.4.1. Safety procedures for launching radioactive material and contingency plans for responding to a radiological mishap.

5.4.2. Safety measures to prevent radiological mishaps.

5.4.3. These inspections may be performed in conjunction with other MAJCOM inspections.

5.4.4. MAJCOMS should report the results of these inspections to HQ AFSC/SEWE.

**6. Range Commanders.** Range commanders must ensure that all parties comply with [Table 1](#) notification, reporting, and launch approval requirements.

**6. (AFMC)PEO, SPO, or DAC program offices must include range safety personnel in launch/test planning so specific range requirements can be met.**

6.1. Develop and exercise radiological safety and contingency plans for launch-related radiological mishaps.

6.2. Review radiological issues at launch readiness reviews for launches containing radioactive material.

6.2.1. This review should include:

6.2.1.1. Types and quantities of radiological materials on board the launch vehicle and payload.

6.2.1.2. Review of radiological safety plans and procedures in place.

6.2.1.3. Review of plans and operations in place, to include coordination with external agencies (Department of Energy, NASA, US Navy, etc.), regarding contingency, clean up, or recovery plans.

**Table 1. Nuclear Safety Review, Approval, and Reporting Procedures.**

<b>S T E P</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
	<b>Who</b>	<b>What</b>	<b>To</b>	<b>When</b>
<b>1</b>	MAJCOM system program director, AFPEO, or project manager	initially notifies	HQ AFSC/SEW	as early as possible in the acquisition process.
<b>2</b>		prepares and sends a safety analysis (if required)		at least 180 calendar days before launch for HQ AFSC/SEW approval; as directed by HQ AFSC/SEW for
<b>3</b>	HQ AFSC/SEW	evaluates safety analysis. If program needs higher approval establishes Air Force safety position and sends nuclear safety	OATSD (NCB)	at least 150 calendar days before launch
<b>4</b>	Range commander	makes sure that the launch of radioactive materials or nuclear systems has required approvals. Provides type and quantity of radioactive	HQ AFSC/SEW	at least 5 calendar days before launch.
<b>5</b>		notifies of successful launch		within 5 calendar days after launch.

GREG ALSTON, Colonel, USAF  
Acting Chief of Safety

(AFMC)

STEVE HILDENBRANDT, GS14  
Director of Safety (Acting)

**Attachment 1****GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION*****References***

DoDD 3200.11, *Major Range and Test Facility Base*

DoDD 3100.10, *DoD Space Policy*, September 14, 2000

AFI 40-201, *Control of Radioactive Material*

AFPD 91-1, *Nuclear Weapons and Systems Surety*

AFI 91-204, *Investigating and Reporting US Air Force Mishaps*

Presidential Directive/National Security Council Memorandum-25, *Scientific or Technological Experiments with Possible Large-Scale Adverse Environmental Effects and Launch of Nuclear Systems Into Space*

*International Atomic Energy Agency's, Safety Series 6, Regulations for the Safe Transport of Radioactive Material, 1996 (Revised)*

***Abbreviations and Acronyms***

**AFI**—Air Force Instruction

**AFPEO**—Air Force Program Executive Office

**AFR**—Air Force Regulation

**AFSC**—Air Force Safety Center

**AFSC/SEW**—AFSC, Weapons, Space and Nuclear Safety Division

**AFSC/SEWE**—AFSC/SEW, Space and Engineering Branch

**AFSPACECOM**—Air Force Space Command

**OATSD (NCB)**—Office of the Assistant to the Secretary of Defense (Nuclear, Chemical and Biological Defense Programs)

**DoD**—Department of Defense

**HQ AFSC**—Headquarters, Air Force Safety Center

**INSRP**—Interagency Nuclear Safety Review Panel

**MAJCOM**—Major Command

**NRC**—Nuclear Regulatory Commission

**OPR**—Office of Primary Responsibility

**SAS**—Safety Analysis Summary

## Attachment 2

## ANALYSIS THRESHOLD QUANTITIES FOR RADIOACTIVE MATERIALS

**A2.1.** The threshold quantity determines the level of launch approval and depth of analysis. Local range requirements guide launch approval of radioactive materials below the threshold quantity.

**CAUTION:** *Threshold quantities do not apply to reactors or other devices when a potential for criticality is present.* The end of this attachment shows the analysis threshold quantities for mixed fission or unlisted radionuclides and mixtures of radionuclides. HQ AFSC/SEW determines the necessary level of safety review and approval for quantities that exceed the threshold and for reactors or other devices where the potential for criticality exists. **NOTE:** 1 TBq ~ 27.03 Ci

**Table A2.1. Allowable Limits for Radioisotopes.**

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY</u></b> <b><u>TBq</u></b>
<b>Actinium (89)</b>	Ac-225 (a)	$6 \times 10^{-3}$
	Ac-227 (a)	$9 \times 10^{-5}$
	Ac-228	$5 \times 10^{-1}$
<b>Silver (47)</b>	Ag-105	$2 \times 10^0$
	Ag-108m (a)	$7 \times 10^{-1}$
	Ag-110m (a)	$4 \times 10^{-1}$
	Ag-111	$6 \times 10^{-1}$
<b>Aluminium (13)</b>	Al-26	$1 \times 10^{-1}$
<b>Americium (95)</b>	Am-241	$1 \times 10^{-3}$
	Am-242m (a)	$1 \times 10^{-3}$
	Am-243 (a)	$1 \times 10^{-3}$
<b>Argon (18)</b>	Ar-37	$4 \times 10^1$
	Ar-39	$2 \times 10^1$
	Ar-41	$3 \times 10^{-1}$
<b>Arsenic (33)</b>	As-72	$3 \times 10^{-1}$
	As-73	$4 \times 10^1$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY</u></b> <b><u>TBq</u></b>
	As-74	$9 \times 10^{-1}$
	As-76	$3 \times 10^{-1}$
	As-77	$7 \times 10^{-1}$
<b>Astatine (85)</b>	At-211 (a)	$5 \times 10^{-1}$
<b>Gold (79)</b>	Au-193	$2 \times 10^0$
	Au-195	$6 \times 10^0$
	Au-198	$6 \times 10^{-1}$
	Au-199	$6 \times 10^{-1}$
<b>Barium (56)</b>	Ba-131 (a)	$2 \times 10^0$
	Ba-133	$3 \times 10^0$
	Ba-133m	$6 \times 10^{-1}$
	Ba-140 (a)	$3 \times 10^{-1}$
<b>Beryllium (4)</b>	Be-7	$2 \times 10^1$
	Be-10	$6 \times 10^{-1}$
<b>Bismuth (83)</b>	Bi-205	$7 \times 10^{-1}$
	Bi-206	$3 \times 10^{-1}$
	Bi-207	$7 \times 10^{-1}$
	Bi-210	$6 \times 10^{-1}$
	Bi-210m (a)	$2 \times 10^{-2}$
	Bi-212 (a)	$6 \times 10^{-1}$
<b>Berkelium (97)</b>		
	Bk-247	$8 \times 10^{-4}$
	Bk-249 (a)	$3 \times 10^{-1}$
<b>Bromine (35)</b>	Br-76	$4 \times 10^{-1}$
	Br-77	$3 \times 10^0$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY</u></b> <b><u>TBq</u></b>
	Br-82	$4 \times 10^{-1}$
<b>Carbon (6)</b>	C-11	$6 \times 10^{-1}$
	C-14	$3 \times 10^0$
<b>Calcium (20)</b>	Ca-41	Unlimited
	Ca-45	$1 \times 10^0$
	Ca-47 (a)	$3 \times 10^{-1}$
<b>Cadmium (48)</b>	Cd-109	$2 \times 10^0$
	Cd-113m	$5 \times 10^{-1}$
	Cd-115 (a)	$4 \times 10^{-1}$
	Cd-115m	$5 \times 10^{-1}$
<b>Cerium (58)</b>	Ce-139	$2 \times 10^0$
	Ce-141	$6 \times 10^{-1}$
	Ce-143	$6 \times 10^{-1}$
	Ce-144 (a)	$2 \times 10^{-1}$
<b>Californium (98)</b>	Cf-248	$6 \times 10^{-3}$
	Cf-249	$8 \times 10^{-4}$
	Cf-250	$2 \times 10^{-3}$
	Cf-251	$7 \times 10^{-4}$
	Cf-252	$3 \times 10^{-3}$
	Cf-253 (a)	$4 \times 10^{-2}$
	Cf-254	$1 \times 10^{-3}$
<b>Chlorine (17)</b>	Cl-36	$6 \times 10^{-1}$
	Cl-38	$2 \times 10^{-1}$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY</u></b> <b><u>TBq</u></b>
<b>Curium (96)</b>	Cm-240	$2 \times 10^{-2}$
	Cm-241	$1 \times 10^0$
	Cm-242	$1 \times 10^{-2}$
	Cm-243	$1 \times 10^{-3}$
	Cm-244	$2 \times 10^{-3}$
	Cm-245	$9 \times 10^{-4}$
	Cm-246	$9 \times 10^{-4}$
	Cm-247 (a)	$1 \times 10^{-3}$
	Cm-248	$3 \times 10^{-4}$
<b>Cobalt (27)</b>	Co-55	$5 \times 10^{-1}$
	Co-56	$3 \times 10^{-1}$
	Co-57	$1 \times 10^1$
	Co-58	$1 \times 10^0$
	Co-58m	$4 \times 10^1$
	Co-60	$4 \times 10^{-1}$
<b>Chromium (24)</b>	Cr-51	$3 \times 10^1$
<b>Caesium (55)</b>	Cs-129	$4 \times 10^0$
	Cs-131	$3 \times 10^1$
	Cs-132	$1 \times 10^0$
	Cs-134	$7 \times 10^{-1}$
	Cs-134m	$6 \times 10^{-1}$
	Cs-135	$1 \times 10^0$
	Cs-136	$5 \times 10^{-1}$
	Cs-137 (a)	$6 \times 10^{-1}$
<b>Copper (29)</b>	Cu-64	$1 \times 10^0$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY</u></b> <b><u>TBq</u></b>
	Cu-67	$7 \times 10^{-1}$
<b>Dysprosium (66)</b>	Dy-159	$2 \times 10^1$
	Dy-165	$6 \times 10^{-1}$
	Dy-166 (a)	$3 \times 10^{-1}$
<b>Erbium (68)</b>	Er-169	$1 \times 10^0$
	Er-171	$5 \times 10^{-1}$
<b>Europium (63)</b>	Eu-147	$2 \times 10^0$
	Eu-148	$5 \times 10^{-1}$
	Eu-149	$2 \times 10^1$
	Eu-150 (short lived)	$7 \times 10^{-1}$
	Eu-150 (long lived)	$7 \times 10^{-1}$
	Eu-152	$1 \times 10^0$
	Eu-152m	$8 \times 10^{-1}$
	Eu-154	$6 \times 10^{-1}$
	Eu-155	$3 \times 10^0$
	Eu-156	$7 \times 10^{-1}$
	<b>Fluorine (9)</b>	F-18
<b>Iron (26)</b>	Fe-52 (a)	$3 \times 10^{-1}$
	Fe-55	$4 \times 10^1$
	Fe-59	$9 \times 10^{-1}$
	Fe-60 (a)	$2 \times 10^{-1}$
<b>Gallium (31)</b>	Ga-67	$3 \times 10^0$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY TBq</u></b>
	Ga-68	$5 \times 10^{-1}$
	Ga-72	$4 \times 10^{-1}$
<b>Gadolinium (64)</b>	Gd-146 (a)	$5 \times 10^{-1}$
	Gd-148	$2 \times 10^{-3}$
	Gd-153	$9 \times 10^0$
	Gd-159	$6 \times 10^{-1}$
<b>Germanium (32)</b>	Ge-68 (a)	$5 \times 10^{-1}$
	Ge-71	$4 \times 10^1$
	Ge-77	$3 \times 10^{-1}$
<b>Hafnium (72)</b>	Hf-172 (a)	$6 \times 10^{-1}$
	Hf-175	$3 \times 10^0$
	Hf-181	$5 \times 10^{-1}$
	Hf-182	Unlimited
<b>Mercury (80)</b>	Hg-194 (a)	$1 \times 10^0$
	Hg-195m (a)	$7 \times 10^{-1}$
	Hg-197	$1 \times 10^1$
	Hg-197m	$4 \times 10^{-1}$
	Hg-203	$1 \times 10^0$
<b>Holmium (67)</b>	Ho-166	$4 \times 10^{-1}$
	Ho-166m	$5 \times 10^{-1}$
<b>Iodine (53)</b>	I-123	$3 \times 10^0$
	I-124	$1 \times 10^0$
	I-125	$3 \times 10^0$
	I-126	$1 \times 10^0$
	I-129	Unlimited
	I-131	$7 \times 10^{-1}$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY</u></b> <b><u>TBq</u></b>
	I-132	$4 \times 10^{-1}$
	I-133	$6 \times 10^{-1}$
	I-134	$3 \times 10^{-1}$
	I-135 (a)	$6 \times 10^{-1}$
<b>Indium (49)</b>	In-111	$3 \times 10^0$
	In-113m	$2 \times 10^0$
	In-114m (a)	$5 \times 10^{-1}$
	In-115m	$1 \times 10^0$
<b>Iridium (77)</b>	Ir-189 (a)	$1 \times 10^1$
	Ir-190	$7 \times 10^{-1}$
	Ir-192	$6 \times 10^{-1}$
	Ir-194	$3 \times 10^{-1}$
<b>Potassium (19)</b>	K-40	$9 \times 10^{-1}$
	K-42	$2 \times 10^{-1}$
	K-43	$6 \times 10^{-1}$
<b>Krypton (36)</b>	Kr-81	$4 \times 10^1$
	Kr-85	$1 \times 10^1$
	Kr-85m	$3 \times 10^0$
	Kr-87	$2 \times 10^{-1}$
<b>Lanthanum (57)</b>	La-137	$6 \times 10^0$
	La-140	$4 \times 10^{-1}$
<b>Lutetium (71)</b>	Lu-172	$6 \times 10^{-1}$
	Lu-173	$8 \times 10^0$
	Lu-174	$9 \times 10^0$
	Lu-174m	$1 \times 10^1$
	Lu-177	$7 \times 10^{-1}$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY TBq</u></b>
<b>Magnesium (12)</b>	Mg-28 (a)	$3 \times 10^{-1}$
<b>Manganese (25)</b>	Mn-52	$3 \times 10^{-1}$
	Mn-53	Unlimited
	Mn-54	$1 \times 10^0$
	Mn-56	$3 \times 10^{-1}$
<b>Molybdenum (42)</b>	Mo-93	$2 \times 10^1$
	Mo-99 (a)	$6 \times 10^{-1}$
<b>Nitrogen (7)</b>	N-13	$6 \times 10^{-1}$
<b>Sodium (11)</b>	Na-22	$5 \times 10^{-1}$
	Na-24	$2 \times 10^{-1}$
<b>Niobium (41)</b>	Nb-93m	$3 \times 10^1$
	Nb-94	$7 \times 10^{-1}$
	Nb-95	$1 \times 10^0$
	Nb-97	$6 \times 10^{-1}$
<b>Neodymium (60)</b>	Nd-147	$6 \times 10^{-1}$
	Nd-149	$5 \times 10^{-1}$
<b>Nickel (28)</b>	Ni-59	Unlimited
	Ni-63	$3 \times 10^1$
	Ni-65	$4 \times 10^{-1}$
<b>Neptunium (93)</b>	Np-235	$4 \times 10^1$
	Np-236 (short lived)	$2 \times 10^0$
	Np-236 (long lived)	$2 \times 10^{-2}$
	Np-237	$2 \times 10^{-3}$
	Np-239	$4 \times 10^{-1}$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY TBq</u></b>
<b>Osmium (76)</b>	Os-185	$1 \times 10^0$
	Os-191	$2 \times 10^0$
	Os-191m	$3 \times 10^1$
	Os-193	$6 \times 10^{-1}$
	Os-194 (a)	$3 \times 10^{-1}$
<b>Phosphorus (15)</b>	P-32	$5 \times 10^{-1}$
	P-33	$1 \times 10^0$
<b>Protactinium (91)</b>	Pa-230 (a)	$7 \times 10^{-2}$
	Pa-231	$4 \times 10^{-4}$
	Pa-233	$7 \times 10^{-1}$
<b>Lead (82)</b>	Pb-201	$1 \times 10^0$
	Pb-202	$2 \times 10^1$
	Pb-203	$3 \times 10^0$
	Pb-205	Unlimited
	Pb-210 (a)	$5 \times 10^{-2}$
	Pb-212 (a)	$2 \times 10^{-1}$
<b>Palladium (46)</b>	Pd-103 (a)	$4 \times 10^1$
	Pd-107	Unlimited
	Pd-109	$5 \times 10^{-1}$
<b>Promethium (61)</b>	Pm-143	$3 \times 10^0$
	Pm-144	$7 \times 10^{-1}$
	Pm-145	$1 \times 10^1$
	Pm-147	$2 \times 10^0$
	Pm-148m (a)	$7 \times 10^{-1}$
	Pm-149	$6 \times 10^{-1}$
	Pm-151	$6 \times 10^{-1}$
<b>Polonium (84)</b>	Po-210	$2 \times 10^{-2}$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY TBq</u></b>
<b>Praseodymium (59)</b>	Pr-142	$4 \times 10^{-1}$
	Pr-143	$6 \times 10^{-1}$
<b>Platinum (78)</b>	Pt-188 (a)	$8 \times 10^{-1}$
	Pt-191	$3 \times 10^0$
	Pt-193	$4 \times 10^1$
	Pt-193m	$5 \times 10^{-1}$
	Pt-195m	$5 \times 10^{-1}$
	Pt-197	$6 \times 10^{-1}$
	Pt-197m	$6 \times 10^{-1}$
<b>Plutonium (94)</b>	Pu-236	$3 \times 10^{-3}$
	Pu-237	$2 \times 10^1$
	Pu-238	$1 \times 10^{-3}$
	Pu-239	$1 \times 10^{-3}$
	Pu-240	$1 \times 10^{-3}$
	Pu-241 (a)	$6 \times 10^{-2}$
	Pu-242	$1 \times 10^{-3}$
	Pu-244 (a)	$1 \times 10^{-3}$
<b>Radium (88)</b>		
	Ra-223 (a)	$7 \times 10^{-3}$
	Ra-224 (a)	$2 \times 10^{-2}$
	Ra-225 (a)	$4 \times 10^{-3}$
	Ra-226 (a)	$3 \times 10^{-3}$
Ra-228 (a)	$2 \times 10^{-2}$	
<b>Rubidium (37)</b>	Rb-81	$8 \times 10^{-1}$
	Rb-83 (a)	$2 \times 10^0$
	Rb-84	$1 \times 10^0$
	Rb-86	$5 \times 10^{-1}$
	Rb-87	Unlimited
	Rb (nat)	Unlimited

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY TBq</u></b>
<b>Rhenium (75)</b>	Re-184	$1 \times 10^0$
	Re-184m	$1 \times 10^0$
	Re-186	$6 \times 10^{-1}$
	Re-187	Unlimited
	Re-188	$4 \times 10^{-1}$
	Re-189 (a)	$6 \times 10^{-1}$
	Re (nat)	Unlimited
<b>Rhodium (45)</b>	Rh-99	$2 \times 10^0$
	Rh-101	$3 \times 10^0$
	Rh-102	$5 \times 10^{-1}$
	Rh-102m	$2 \times 10^0$
	Rh-103m	$4 \times 10^1$
	Rh-105	$8 \times 10^{-1}$
<b>Radon (86)</b>		
	Rn-222 (a)	Rn-222 (a)
<b>Ruthenium (44)</b>	Ru-97	$5 \times 10^0$
	Ru-103 (a)	$2 \times 10^0$
	Ru-105	$6 \times 10^{-1}$
	Ru-106 (a)	$2 \times 10^{-1}$
<b>Sulphur (16)</b>	S-35	$3 \times 10^0$
<b>Antimony (51)</b>	Sb-122	$4 \times 10^{-1}$
	Sb-124	$6 \times 10^{-1}$
	Sb-125	$1 \times 10^0$
	Sb-126	$4 \times 10^{-1}$
<b>Scandium (21)</b>	Sc-44	$5 \times 10^{-1}$
	Sc-46	$5 \times 10^{-1}$
	Sc-47	$7 \times 10^{-1}$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY</u></b> <b><u>TBq</u></b>
	Sc-48	$3 \times 10^{-1}$
<b>Selenium (34)</b>	Se-75	$3 \times 10^0$
	Se-79	$2 \times 10^0$
<b>Silicon (14)</b>	Si-31	$6 \times 10^{-1}$
	Si-32	$5 \times 10^{-1}$
<b>Samarium (62)</b>	Sm-145	$1 \times 10^1$
	Sm-147	Unlimited
	Sm-151	$1 \times 10^1$
	Sm-153	$6 \times 10^{-1}$
<b>Tin (50)</b>	Sn-113 (a)	$2 \times 10^0$
	Sn-117m	$4 \times 10^{-1}$
	Sn-119m	$3 \times 10^1$
	Sn-121m (a)	$9 \times 10^{-1}$
	Sn-123	$6 \times 10^{-1}$
	Sn-125	$4 \times 10^{-1}$
	Sn-126 (a)	$4 \times 10^{-1}$
<b>Strontium (38)</b>	Sr-82 (a)	$2 \times 10^{-1}$
	Sr-85	$2 \times 10^0$
	Sr-85m	$5 \times 10^0$
	Sr-87m	$3 \times 10^0$
	Sr-89	$6 \times 10^{-1}$
	Sr-90 (a)	$3 \times 10^{-1}$
	Sr-91 (a)	$3 \times 10^{-1}$
	Sr-92 (a)	$3 \times 10^{-1}$
<b>Tritium (1)</b>	T(H-3)	$4 \times 10^1$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY TBq</u></b>
<b>Tantalum (73)</b>	Ta-178 (long lived)	$8 \times 10^{-1}$
	Ta-179	$3 \times 10^1$
	Ta-182	$5 \times 10^{-1}$
<b>Terbium (65)</b>	Tb-157	$4 \times 10^1$
	Tb-158	$1 \times 10^0$
	Tb-160	$6 \times 10^{-1}$
<b>Technetium (43)</b>	Tc-95m (a)	$2 \times 10^0$
	Tc-96	$4 \times 10^{-1}$
	Tc-96m (a)	$4 \times 10^{-1}$
	Tc-97	Unlimited
	Tc-97m	$1 \times 10^0$
	Tc-98	$7 \times 10^{-1}$
	Tc-99	$9 \times 10^{-1}$
	Tc-99m	$4 \times 10^0$
<b>Tellurium (52)</b>	Te-121	$2 \times 10^0$
	Te-121m	$3 \times 10^0$
	Te-123m	$1 \times 10^0$
	Te-125m	$9 \times 10^{-1}$
	Te-127	$7 \times 10^{-1}$
	Te-127m (a)	$5 \times 10^{-1}$
	Te-129	$6 \times 10^{-1}$
	Te-129m (a)	$4 \times 10^{-1}$
	Te-131m (a)	$5 \times 10^{-1}$
	Te-132 (a)	$4 \times 10^{-1}$
<b>Thorium (90)</b>	Th-227	$5 \times 10^{-3}$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY TBq</u></b>
	Th-228 (a)	$1 \times 10^{-3}$
	Th-229	$5 \times 10^{-4}$
	Th-230	$1 \times 10^{-3}$
	Th-231	$2 \times 10^{-2}$
	Th-232	Unlimited
	Th-234 (a)	$3 \times 10^{-1}$
	Th (nat)	Unlimited
<b>Titanium (22)</b>	Ti-44 (a)	$4 \times 10^{-1}$
<b>Thallium (81)</b>	Tl-200	$9 \times 10^{-1}$
	Tl-201	$4 \times 10^0$
	Tl-202	$2 \times 10^0$
	Tl-204	$7 \times 10^{-1}$
<b>Thulium (69)</b>	Tm-167	$8 \times 10^{-1}$
	Tm-170	$6 \times 10^{-1}$
	Tm-171	$4 \times 10^1$
<b>Uranium (92)</b>	U-230 (fast lung absorption) (a) (c)	$1 \times 10^{-1}$
	U-230 (medium lung absorption)(a) (d)	$4 \times 10^{-3}$
	U-230 (slow lung absorption) (a) (e)	$3 \times 10^{-3}$
	U-232 (fast lung absorption) (c)	$1 \times 10^{-2}$
	U-232 (medium lung absorption) (d)	$7 \times 10^{-3}$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY TBq</u></b>
	U-232 (slow lung absorption) (e)	$1 \times 10^{-3}$
	U-233 (fast lung absorption) (c)	$9 \times 10^{-2}$
	U-233 (medium lung absorption) (d)	$2 \times 10^{-2}$
	U-233 (slow lung absorption) (e)	$6 \times 10^{-3}$
	U-234 (fast lung absorption) (c)	$9 \times 10^{-2}$
	U-234 (medium lung absorption) (d)	$2 \times 10^{-2}$
	U-234 (slow lung absorption) (e)	$6 \times 10^{-3}$
	U-235 (all lung absorption types)(a), (c), (d), (e)	Unlimited
	U-236 (fast lung absorption) (c)	Unlimited
	U-236 (medium lung absorption) (d)	$2 \times 10^{-2}$
	U-236 (slow lung absorption) (e)	$6 \times 10^{-3}$
	U-238 (all lung absorption types) (c), (d), (e)	Unlimited
	U (nat)	Unlimited
	U (enriched to 20% or less) (f)	Unlimited
	U (dep)	Unlimited
<b>Vanadium (23)</b>	V-48	$4 \times 10^{-1}$
	V-49	$4 \times 10^1$
<b>Tungsten (74)</b>	W-178 (a)	$5 \times 10^0$
	W-181	$3 \times 10^1$

<b><u>ELEMENT</u></b>	<b><u>ISOTOPE</u></b>	<b><u>QUANTITY</u></b> <b><u>TBq</u></b>
	W-185	$8 \times 10^{-1}$
	W-187	$6 \times 10^{-1}$
	W-188 (a)	$3 \times 10^{-1}$
<b>Xenon (54)</b>	Xe-122 (a)	$4 \times 10^{-1}$
	Xe-123	$7 \times 10^{-1}$
	Xe-127	$2 \times 10^0$
	Xe-131m	$4 \times 10^1$
	Xe-133	$1 \times 10^1$
	Xe-135	$2 \times 10^0$
<b>Yttrium (39)</b>	Y-87 (a)	$1 \times 10^0$
	Y-88	$4 \times 10^{-1}$
	Y-90	$3 \times 10^{-1}$
	Y-91	$6 \times 10^{-1}$
	Y-91m	$2 \times 10^0$
	Y-92	$2 \times 10^{-1}$
	Y-93	$3 \times 10^{-1}$
<b>Ytterbium (70)</b>	Yb-169	$1 \times 10^0$
	Yb-175	$9 \times 10^{-1}$
<b>Zinc (30)</b>	Zn-65	$2 \times 10^0$
	Zn-69	$6 \times 10^{-1}$
	Zn-69m (a)	$6 \times 10^{-1}$
<b>Zirconium (40)</b>		
	Zr-88	$3 \times 10^0$
	Zr-93	Unlimited
	Zr-95 (a)	$8 \times 10^{-1}$
	Zr-97 (a)	$4 \times 10^{-1}$

(a) Values include contributions from daughter nuclides with half-lives less than 10 days.

- (b) The quantity may be determined from a measurement of the rate of decay or a measurement of the radiation level at a prescribed distance from the source.
- (c) These values apply only to compounds of uranium that take the chemical form of UF<sub>6</sub> , UO<sub>2</sub> F<sub>2</sub> and UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub> in both normal and accident conditions of transport.
- (d) These values apply only to compounds of uranium that take the chemical form of UO<sub>3</sub> , UF<sub>4</sub> , UCl<sub>4</sub> and hexavalent compounds in both normal and accident conditions of transport.
- (e) These values apply to all compounds of uranium other than those specified in (c) and (d) above.
- (f) These values apply to *unirradiated uranium* only.

A2.1.1. Treat a mixture of radionuclides resulting from the natural decay of a single-parent radionuclide as a single source of the parent.

A2.1.2. When using several isotopes or a mixture of isotopes, base the required nuclear safety review on the normalized total quantity of radioactive material present. The normalized total is the sum of the ratios of the individual isotopes to their respective threshold quantities as shown in [Figure A2.1](#). If the normalized totals exceeds 1.00 a safety analysis summary is required. HQ AFSC/SEW must complete a nuclear safety review and obtain launch approval from OATSD(NCB).

**Figure A2.1. Mixed Isotopes.**

$$\frac{\text{Isotope A (TBq)}}{\text{Threshold A (TBq)}} + \frac{\text{Isotope B (TBq)}}{\text{Threshold B (TBq)}} + \frac{\text{Isotope C (TBq)}}{\text{Threshold C (TBq)}} \dots < 1.00$$

**EXAMPLE:**

1.2 x 10<sup>-4</sup> TBq of Pu-238 is 1.2 x 10<sup>-4</sup>TBq/1.0 x 10<sup>-3</sup> or 12 percent of the analysis threshold limit for Pu-238.

0.5 TBq of Nb-95 is 0.5TBq/1.0Tbq, or 50 percent of the analysis threshold limit for Nb-95.

7.0 TBq of Be-7 is 7.0TBq/20 TBq, or 35 percent of the analysis threshold limit of BE-7.

Therefore, the normalized total is 97 percent and an SAS would not be required.

### Attachment 3

#### GUIDE FOR SAFETY ANALYSIS SUMMARY (SAS)

**A3.1. Safety Analysis Summary (SAS).** You must prepare an SAS for any planned launch of radioactive material when the total quantity of radioactive material exceeds the analysis threshold quantity listed in [Attachment 2](#) or as specified by HQ AFSC/SEW. Prepare the SAS according to this attachment and send two copies to HQ AFSC/ SEWE.

**A3.1.1. Mission Description.** Include system, radioactive material, and mission profile descriptions.

**A3.1.1.1. System Description:**

A3.1.1.1.1. Program name.

A3.1.1.1.2. Launch vehicle description.

A3.1.1.1.3. Spacecraft or missile, and payload description.

**A3.1.2.** Describe each radionuclide separately, if applicable. Each radioactive material description consists of:

A3.1.2.1. Radionuclides.

A3.1.2.2. Modes of decay and associated intensities.

A3.1.2.3. Activity (in Terabecquerels).

A3.1.2.4. Radiation levels, with particular emphasis on areas accessible to personnel.

A3.1.2.5. Proposed use.

A3.1.2.6. Location on launch vehicle and payload.

A3.1.2.7. Manufacturer and source identification number.

A3.1.2.8. Nuclear Regulatory Commission or Agreement State sealed source and device registry number and the license or permit authorizing possession, if applicable.

A3.1.2.9. Source construction, including the chemical and physical form.

A3.1.2.10. Construction materials.

A3.1.2.11. Dimensions.

A3.1.2.12. Design criteria.

A3.1.2.13. Other information pertinent to assessing source integrity in normal and extreme operating conditions and potential accident environments.

**A3.1.3. Mission Profile:**

A3.1.3.1. Launch facility identification.

A3.1.3.2. Proposed launch date.

A3.1.3.3. Launch azimuth.

A3.1.3.4. Mission profile description, including orbital or flight parameters.

A3.1.3.5. Mission duration.

A3.1.3.6. Impact predictions, if applicable.

**A3.2. Normal Mission Analysis.** This analysis should address:

A3.2.1. Nuclear and radiation safety considerations throughout the mission, including handling from installation through flight and post-flight.

A3.2.2. Disposing of radioactive material. Identify the license or permit under which you will receive recovered materials, if applicable.

**A3.3. Accident Evaluation.** This evaluation should address:

A3.3.1. All mission phases, including prelaunch, launch, ascent, orbital, reentry, impact, and post impact.

A3.3.2. Potential accident scenarios, environments, and contingency options.

A3.3.3. Mission failure evaluation, including launch vehicle, payload, and source failure mode analyses and associated probabilities.

A3.3.4. Source response to accidents and potential consequences to the public and the environment.

A3.3.5. Any additional information pertinent to the SAS.

**Attachment 4****LAUNCH FORECAST REPORT FORMAT**

**A4.1.** A forecast of all scheduled launches involving radioactive materials or nuclear systems during the next quarter must reach HQ AFSC/SEW at least 15 calendar days before the start of each calendar-year quarter. This report is exempt from the requirements of AFI 37-124, *Management and Control of Information Report* (formerly AFR 4-38). The forecast should include:

**A4.2.** Program name.

**A4.3.** Launch vehicle, site, and date.

**A4.4.** Impact area or orbital parameters.

**A4.5.** Specific radioisotopes and associated activities (in Terabecquerels).

**A4.6.** Type of nuclear system or device, if applicable.