

Boeing - SSFL System of Procedures

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SOP C-401, RADIATION SAFETY PROGRAM, JULY 13, 2012, JAMES BARNES,

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1.0 APPLICABILITY

This procedure applies to radiological activities conducted at the Boeing Santa Susana Field Laboratory (SSFL) campus (“Boeing - SSFL”).

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The terms “shall,” “should,” “may,” etc. indicate procedural requirements or suggestions for good practices. These terms are intended to convey meanings typically used in quality assurance or standards documents (e.g., ANSI).

- “Shall” in this procedure denotes a mandatory requirement.
- “Should” denotes a recommended practice, but which is not required. “Should” is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required.
- “May” denotes an option. “May” indicates a course of action permissible within the limits of the procedure.

2.0 PURPOSE

- 2.1 This procedure implements the requirements of 10 CFR 835 (“Occupational Radiation Protection”) and California Regulatory Code (CCR) TITLE 17, *Public Health, Division 1, Chapter 5, Sanitation (Environmental), Subchapter 4, Radiation.*
- 2.2 This procedure implements the requirements of Boeing procedure PRO-1030, Control of Ionizing Radiation Hazards, at Boeing - SSFL. PRO-1030 provides for control over ionizing radiation hazards to the environment, members of the public, and individuals who work with or around ionizing radiation sources under the control of The Boeing Company.
- 2.3 This procedure tailors the requirements of PRO-1030 in order to address site-specific issues.

3.0 SCOPE

- 3.1 This procedure establishes practices for the conduct of radiological control activities at all Boeing - SSFL facilities utilizing radiation or radioactive materials. The procedure states Boeing - SSFL's positions and views on the best courses of action currently available in the area of radiological controls. Accordingly, the provisions in the procedure describe acceptable techniques, methods or solutions for using radioactive materials or radiation producing devices.

The procedure is intended to be consistent with all relevant statutory and regulatory requirements and shall be revised whenever necessary to ensure such consistency. Some of the procedural provisions, however, may go beyond minimum requirements of regulations. Following the course of action delineated in the procedure will result in achieving and surpassing related statutory or regulatory requirements.

- 3.2 Boeing - SSFL intends to incorporate by reference the provisions in this procedure into plans and procedures as appropriate.

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- 3.3 This procedure applies to all Boeing - SSFL activities. No action may be taken that violates the requirements of applicable regulations, or any plan schedule, or other procedure established explicitly by regulation.

The requirements of this program are modeled after 10 CFR 835, which is the basis for DOE regulations and requirements. The requirements of these regulations meet or exceed State of California requirements under Title 17. Exceptions to the provisions of this procedure may be explicitly proceduralized where State regulations stipulate alternate actions, limits, or activities.

- 3.4 Nothing in this procedure shall be construed as limiting actions that may be necessary to protect health and safety.

- 3.5 The Radiation Protection Program is operated under the provisions of the following licenses or authorizing agencies:

- State of California Broad Scope "A" License 0015-19,
- California Code of Regulations (CCR) Title 17, Subchapter 4; "Radiation."
- 10 CFR 835, "Occupational Radiation Protection." [DOE Operations at the former ETEC].

California regulations apply to non-DOE operations conducted at Boeing facilities at Boeing-SSFL.

DOE-related activities are conducted under 10 CFR 835 as described in the Radiation Protection Plan and contractual agreements between Boeing-SSFL and DOE.

- 3.6 This procedure does not describe non-ionizing radiation (NIR) safety, such as microwave radiation, laser operations, and radio-frequency safety. See the Boeing-SSFL Non-ionizing Radiation Safety Program for guidance in this area.

- 3.7 The following situations are not subject to the provisions of this procedure as they are exempt from regulatory controls:

- 3.7.1 Background radiation, radiation doses received as a patient for the purposes of medical diagnosis or therapy, or radiation doses received from participation as a subject in medical research programs are not subject to the provisions of this procedure as they are exempted from regulatory controls.

- 3.7.2 Radioactive material on or within material, equipment, and real property which is approved for release when the radiological conditions of the material, equipment, and real property have been documented to comply with the criteria for release set forth in a regulatorily authorized limit are not subject to the provisions of this procedure as they are exempted from regulatory controls.

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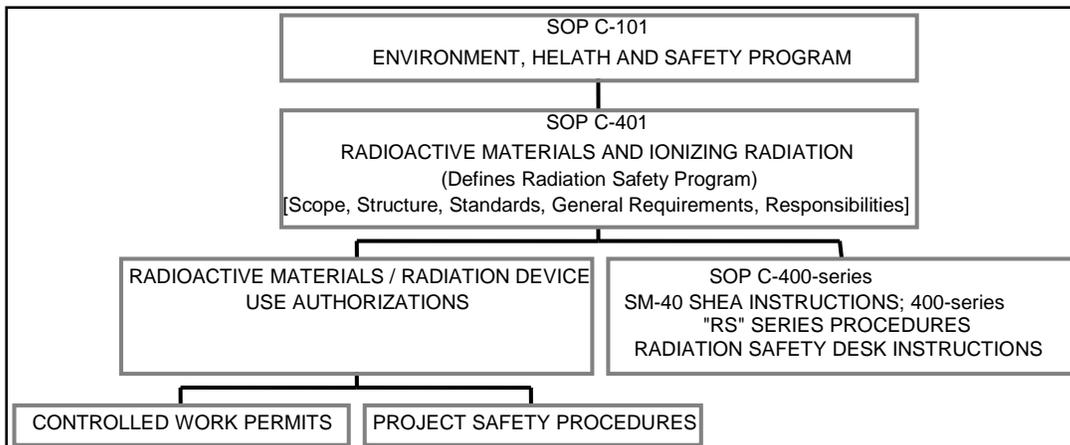
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- 3.8 Boeing – SSFL management shall be responsible for compliance with the requirements of applicable regulations, as described in this and related radiation safety procedures.
- 3.9 For those activities that are required by §§ 835.102 (Internal Audits), 835.901(e) (Training), 835.1202(a) (Source Inventory), and 835.1202(b) (Leak Testing of Accountable Sources), the time interval to conduct these activities may be extended by a period not to exceed 30 days to accommodate scheduling needs.

4.0 POLICY AND PROCEDURE

4.1 Radiation Protection Program Structure

- 4.1 The policies, requirements, standards, and implementing procedures for the Boeing - SSFL radiation safety program are issued in Boeing - SSFL documents as shown in the following flowdown schematic:



- 4.2 The Health, Safety, and Radiation Services Group (HS&RS) of Environmental Health & Safety (EHS) administers the radiation safety program. The Radiation Safety function (“Radiation Safety”) operates as a separate organizational function independent of the various Boeing - SSFL engineering, production and test operations, and has the responsibility and authority to establish safe practice standards and to halt unsafe operations.
- 4.3 [DELETED]
- 4.4 A Radiation Safety Officer (RSO) acts as the coordinator for state and federal license interfaces, and provides technical oversight of the radiation safety program.
- 4.5 Radiation Safety function of HS&RS

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- Design and administer the Boeing - SSFL Radiation Safety program.
- Issue and maintain the Use Authorization system (see Appendix 1).
- When convened, implement the Radiation Safety Committee review and authorization function.
- Review operations; equipment and facilities; procedures; radiation exposures; and radiological conditions for compliance with regulations and license requirements.
- Ensure that the ALARA Program is being effectively implemented.
- Provide dosimetry services and maintain personnel exposure records. Maintain exposure histories, in accordance with Boeing - SSFL procedures and practices.
- Advise users and management on changes in regulations and license conditions. Communicate information regarding incidents to appropriate personnel. Provide appropriate testimony and input for rulemaking activities.
- Implement final release surveys for decommissioned radiological facilities and remediated land. Coordinate with the Department of Energy and regulatory agencies to achieve release of these facilities for unrestricted use.
- Conduct environmental monitoring for radiation and radioactivity.
- Assist Boeing Library Services in acquiring appropriate reports, journals, and books related to radiation protection.
- Recommend and obtain radiological instrumentation and safety equipment.
- Maintain radioisotope inventory records. Smear test sources requiring periodic leak tests.
- Perform monitoring and surveillance as necessary.
- Provide information to the Boeing training tracking system (i.e., My Learning) which permits periodic notification of principal users / managers of worker qualifications and the date of expirations of workers' qualifications.
- Periodically review training requirements, and update curriculums as appropriate.
- Perform radiation safety training.

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- 4.6 Individuals responsible for developing and implementing measures necessary for ensuring compliance with the requirements of this radiation safety program shall have the appropriate education, training, and skills to discharge their responsibilities.
- 4.7 Written procedures shall be developed and implemented as necessary to ensure compliance with regulatory requirements, commensurate with the radiological hazards created by the activity and consistent with the education, training, and skills of the individuals exposed to those hazards.

5.0 REQUIREMENTS

5.1 Radiological Units

- 5.1.1 Unless otherwise specified, the quantities used in the records required by the Boeing – SSFL radiation safety program shall be clearly indicated in special units of curie, rad, roentgen, or rem, including multiples and subdivisions of these units, or other conventional units, such as, dpm, dpm/100 cm² or mass units.
- 5.1.2 SI units, becquerel (Bq), gray (Gy), and sievert (Sv), may be provided parenthetically for reference with scientific standards.
- 5.1.3 Notwithstanding the above, SI units may be used for external reporting or other uses unrelated to compliance to radiation safety regulations.
- 5.1.4 Table 1 provides the relationship between the various units used in radiation safety vocabulary.

5.2 ALARA Program

- 5.2.1 Measures shall be taken to maintain radiation exposure in controlled areas “As Low as Reasonably Achievable” (ALARA) through engineered and administrative controls.

Optimization methods shall be used to assure that occupational exposure is maintained ALARA in developing and justifying facility design and physical controls.

- 5.2.2 The primary methods used shall be engineered controls (e.g., confinement, ventilation, remote handling, and shielding).
- 5.2.3 For specific activities where use of engineered controls is demonstrated to be impractical, administrative controls shall be used to maintain radiation exposures ALARA.

Administrative controls shall be employed only as supplemental methods to control radiation exposure.

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- 5.2.4 During the design of new DOE-related facilities or modification of existing DOE facilities, the design objective for controlling personnel exposure from external sources of radiation in areas of continuous occupational occupancy (2000 hours per year) shall be to maintain exposure levels below an average of 0.5 millirem (5 μ Sv) per hour and as far below this average as is reasonably achievable. The design objectives for exposure rates for potential exposure to a radiological worker where occupancy differs from the above shall be ALARA and shall not exceed 20 percent of the applicable standards in Section 5.6.1 (derived from § 835.202).

The design or modification of a DOE-related facility and the selection of materials shall include features that facilitate operations, maintenance, decontamination, and decommissioning.

- 5.2.5 During the design of new DOE-related facilities or modification of existing DOE-related facilities, the following objectives shall be adopted:
- Regarding the control of airborne radioactive material, the design objective shall be, under normal conditions, to avoid releases to the workplace atmosphere and in any situation, to control the inhalation of such material by workers to levels that are ALARA; confinement and ventilation shall normally be used.
 - During routine operations, the combination of engineered and administrative controls shall provide that:
 - The anticipated occupational dose to general employees shall not exceed the limits established at Section 6.5.1; and
 - The ALARA process is utilized for personnel exposures to ionizing radiation.

5.3 Radiation Protection Program

- 5.3.1 All Boeing – SSFL activities performed in support of DOE activities shall be conducted in compliance with the documented radiation protection program (RPP) as approved by the DOE.

Activities performed under State of California regulations or Radioactive Material Licensure shall be conducted in accordance with the DOE program, unless the State requirements are more stringent than those of the DOE. Such situations are identified in Boeing procedures or other control media.

- 5.3.2 The DOE may direct or make modifications to the Boeing – SSFL RPP.

The State of California may direct program changes via licensing amendments or regulatory changes. Where these result in more restrictive requirements than called for by DOE, Boeing—SSFL procedures shall be amended as described in section 5.3.1.

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- 5.3.3 The content of the RPP shall be kept commensurate with the nature of the activities performed. Section 5.2 (ALARA) describes measures for applying the as low as reasonably achievable (ALARA) process to occupational exposure.
- 5.3.4 The RPP specifies the existing and/or anticipated operational tasks that are intended to be within the scope of the RPP. Except as provided in Section 5.3.8 (§ 835.101(h)), any task outside the scope of a RPP shall not be initiated until an update of the RPP is approved by DOE.
- 5.3.5 The RPP addresses the implementation of each part of 10 CFR 835. The RPP is implemented through designated Boeing – SSFL procedures.
- 5.3.6 Where changes to 10 CFR 835 require implementation over time, the RPP shall include plans, schedules, and other measures for achieving compliance with regulations.
- 5.3.7 An update of the RPP shall be submitted to DOE:
- Whenever a change or an addition to the RPP is made;
 - Prior to the initiation of a task not within the scope of the RPP; or
 - Within 180 days of the effective date of any modifications to this 10 CFR 835.
- 5.3.8 Changes, additions, or updates to the RPP may become effective without prior DOE approval only if the changes do not decrease the effectiveness of the RPP and the RPP, as changed, continues to meet the requirements of 10 CFR 835. Proposed changes that decrease the effectiveness of the RPP shall not be implemented without submittal to and approval by the DOE.

An RPP update shall be considered approved 180 days after its submission unless rejected by DOE at an earlier date.

5.4 Internal Audits

Internal audits / reviews of program performance should be conducted on an annual basis. The audits / reviews should include an examination of program content and implementation. Such audits / reviews shall ensure that each functional element of the Radiation Safety Program is reviewed no less frequently than every 36 months.

5.5 Control of Radioactive Contamination

- 5.5.1 Any area in which contamination levels exceed the values specified in Table 2 of this part shall be controlled in a manner commensurate with the physical and chemical characteristics of the contaminant, the radionuclides present, and the fixed and removable surface contamination levels.

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- 5.5.2 Appropriate controls shall be maintained and verified which prevent the inadvertent transfer of removable contamination to locations outside of radiological areas under normal operating conditions.
- 5.5.3 Except as provided below, material and equipment in contamination areas, high contamination areas, and airborne radioactivity areas shall not be released to a controlled area if:
- Removable surface contamination levels on accessible surfaces exceed the removable surface contamination values specified in Table 2; or
 - Prior use suggests that the removable surface contamination levels on inaccessible surfaces are likely to exceed the removable surface contamination values specified in Table 2.
- 5.5.4 Material and equipment exceeding the removable surface contamination values specified in Table 2 may be conditionally released for movement on-site from one radiological area for immediate placement in another radiological area only if appropriate monitoring is performed and appropriate controls for the movement are established and exercised.
- 5.5.5 Areas accessible to individuals where the measured total surface contamination levels exceed, but the removable surface contamination levels are less than, corresponding surface contamination values specified in Table 2, shall be controlled as follows when located outside of radiological areas:
- The area shall be routinely monitored to ensure the removable surface contamination level remains below the removable surface contamination values specified in Table 2; and
 - The area shall be conspicuously marked to warn individuals of the contaminated status.
- 5.5.6 Individuals exiting contamination, high contamination, or airborne radioactivity areas shall be monitored, as appropriate, for the presence of surface contamination.
- 5.5.7 Protective clothing shall be required for entry to areas in which removable contamination exists at levels exceeding the removable surface contamination values specified in Table 2.
- 5.5.8 Material and equipment with fixed contamination levels that exceed the total surface contamination values specified in Table 2 may be released for use in controlled areas outside of radiological areas only under the following conditions:

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- Removable surface contamination levels are below the removable surface contamination values specified in Table 2; and
- The material or equipment is routinely monitored and clearly marked or labeled to alert personnel of the contaminated status.

5.6 Exposure Limits for Ionizing Radiation

5.6.1 The occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year¹:

- A total effective dose of 5 rems (0.05 Sv);
- The sum of the equivalent dose to the whole body for external exposures and the committed equivalent dose to any organ or tissue other than the skin or the lens of the eye of 50 rems (0.5 Sv);
- An equivalent dose to the lens of the eye of 15 rems (0.15 Sv); and
- The sum of the equivalent dose to the skin or to any extremity for external exposures and the committed equivalent dose to the skin or to any extremity of 50 rems (0.5 Sv).

5.6.2 All occupational doses received during the current year, except doses resulting from emergency exposures authorized in accordance with § 835.1302 or other applicable regulations, shall be included when demonstrating compliance with regulatory requirements.

5.6.3 Doses from background, therapeutic and diagnostic medical radiation, and participation as a subject in medical research programs shall not be included in dose records or in the assessment of compliance with the occupational dose limits.

5.6.4 The total effective dose during a year shall be determined by summing the effective dose from external exposures and the committed effective dose from intakes during the year.

5.6.5 Determinations of the effective dose shall be made using the radiation and tissue weighting factor values provided in Table 3.

5.6.6 Planned Special Exposures as described in 10 CFR 835.204 and 10 CFR 20.1206 are *not* authorized for use at Boeing – SSFL.

5.6.7 Non-uniform exposures of the skin from X-rays, beta radiation, and/or radioactive material on the skin are to be assessed as described in Table 4.

¹ DOE (ICRP 60) terminology is utilized in description of dosimetric terms. California and NRC used ICRP 30 terminology. Table 8 of this procedure provides the comparison between the two systems of terms.

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- 5.6.8 The equivalent dose limit for the embryo/fetus from the period of conception to birth, as a result of occupational exposure of a declared pregnant worker, is 0.5 rem (0.005 Sv).

Substantial variation above a uniform exposure rate that would satisfy the limits provided in § 835.206(a) shall be avoided.

If the equivalent dose to the embryo/fetus is determined to have already exceeded 0.5 rem (0.005 Sv) by the time a worker declares her pregnancy, the declared pregnant worker shall not be assigned to tasks where additional occupational exposure is likely during the remaining gestation period.

- 5.6.9 The dose limits for minors occupationally exposed to radiation and/or radioactive materials at a Boeing - SSFL activity are 0.1 rem (0.001 Sv) total effective dose in a year and 10 percent of the occupational dose limits specified at in Section 6.5.1 (above).
- 5.6.10 The total effective dose limit for members of the public exposed to radiation and/or radioactive material during access to a controlled area is 0.1 rem (0.001 Sv) in a year.
- 5.6.11 Boeing – SSFL imposes additional Administrative Control Levels (ACLs) that are below the regulatory dose limits described in this section. These ACLs are specified in Table 5.
- 5.6.12 All doses exceeding the limits specified in Section 5.6.1 shall be recorded in the affected individual's occupational dose record.

When the conditions under which a dose was received in excess of the limits specified in Section 5.6.1 have been eliminated, operating management shall notify the Head of the responsible DOE field organization.

Operations which have been suspended as a result of a dose in excess of the limits specified in Section 5.6.1 (§ 835.202), may be resumed only with the approval of DOE.

- 5.6.13 A general employee whose occupational dose has exceeded the numerical value of any of the limits specified above as a result of an authorized emergency exposure may be permitted to return to work in radiological areas during the current year providing that all of the following conditions are met:
- Approval is first obtained from the Site Director, Boeing - SSFL and the Head of the responsible DOE field organization;
 - The individual receives counseling from radiological protection and medical personnel regarding the consequences of receiving additional occupational exposure during the year; and
 - The affected employee agrees to return to radiological work.

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5.6.14 Occupational doses received as a result of excluded activities and radioactive material transportation, (i.e. those listed in paragraphs §§ 835.1 (b)(1) through (b)(4) and (b)(7)), shall be included to the extent practicable when determining compliance with the occupational dose limits at Section 5.6.1.

Occupational doses resulting from authorized emergency exposures and planned special exposures shall not be considered when determining compliance with the dose limits at Section 5.6.1.

5.7 Concentrations of radioactive material in air

The derived air concentration (DAC) values given in Table 6 shall be used in the control of occupational exposures to airborne radioactive material.

5.8 Monitoring of Individuals and Areas

5.8.1 Monitoring of individuals and areas shall be performed to:

- Demonstrate compliance with regulatory requirements;
- Document radiological conditions;
- Detect changes in radiological conditions;
- Detect the gradual buildup of radioactive material;
- Verify the effectiveness of engineered and administrative controls in containing radioactive material and reducing radiation exposure; and
- Identify and control potential sources of individual exposure to radiation and/or radioactive material.

5.8.2 Instruments and equipment used for monitoring shall be:

- Periodically maintained and calibrated on an established frequency;
- Appropriate for the type(s), levels, and energies of the radiation(s) encountered;
- Appropriate for existing environmental conditions; and
- Routinely tested for operability.

5.8.3 For the purpose of monitoring individual exposures to external radiation, personnel dosimeters shall be provided to and used by:

- Radiological workers who, under typical conditions, are likely to receive one or more of the following:

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- An effective dose of 0.1 rem (0.001 Sv) or more in a year;
- An equivalent dose to the skin or to any extremity of 5 rems (0.05 Sv) or more in a year;
- An equivalent dose to the lens of the eye of 1.5 rems (0.015 Sv) or more in a year;
- Declared pregnant workers who are likely to receive from external sources an equivalent dose to the embryo/fetus in excess of 10 percent of the gestation period dose limit;
- Occupationally exposed minors likely to receive a dose in excess of 50 percent of the applicable limits at § 835.207 in a year from external sources;
- Members of the public entering a controlled area likely to receive a dose in excess of 50 percent of the limit at § 835.208 in a year from external sources; and
- Individuals entering a high or very high radiation area.
- Who could be in proximity to radiation producing equipment or radioactive materials under such conditions that a significant exposure could occur in an off-normal situation.

External dose monitoring practices shall be adequate to demonstrate compliance with the dose limits established in Section 6.5.1. The Boeing – SSFL external dosimetry has been excepted from DOELAP accreditation.

5.8.4 For the purpose of monitoring individual exposures to internal radiation, internal dosimetry programs (including routine bioassay programs) shall be conducted for:

- Radiological workers who, under typical conditions, are likely to receive a committed effective dose of 0.1 rem (0.001 Sv) or a committed equivalent dose of 1 rem (0.01 Sv) to a restrictive organ or more from all occupational radionuclide intakes in a year;
- Declared pregnant workers likely to receive an intake or intakes resulting in an equivalent dose to the embryo/fetus in excess of 10 percent of the limit stated at § 835.206(a);
- Occupationally exposed minors who are likely to receive a dose in excess of 50 percent of the applicable limit stated at § 835.207 from all radionuclide intakes in a year; or
- Members of the public entering a controlled area likely to receive a dose in excess of 50 percent of the limit stated at § 835.208 from all radionuclide intakes in a year.

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Internal dose monitoring programs implemented to demonstrate compliance with this section shall be adequate to demonstrate compliance with the dose limits stipulated in Section 6.5.1. The Boeing – SSFL internal dosimetry program has been excepted from DOELAP accreditation for internal dosimetry.

5.8.5 Monitoring of airborne radioactivity shall be performed:

- Where an individual is likely to receive an exposure of 40 or more DAC-hours in a year; or
- As necessary to characterize the airborne radioactivity hazard where respiratory protective devices for protection against airborne radionuclides have been prescribed.

Real-time air monitoring shall be performed as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material.

5.8.6 The estimation of internal dose shall be based on bioassay data rather than air concentration values unless bioassay data are:

- unavailable;
- inadequate; or
- internal dose estimates based on air concentration values are demonstrated to be as or more accurate.

5.9 Training and Qualifications for Access to Controlled Areas

5.9.1 Each individual shall demonstrate knowledge of the radiation safety requirements, commensurate with the hazards in the area and required controls, by successful completion of an examination and performance demonstrations:

- Before being permitted unescorted access to controlled areas; and
- Before receiving occupational dose during access to controlled areas at Boeing – SSFL.
- Before performing unescorted assignments as a radiological worker.

5.9.2 Radiation safety training shall include the topics listed in Table 7, to the extent appropriate to each individual's prior training, work assignments, and degree of exposure to potential radiological hazards.

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5.9.3 When an escort is used in lieu of training in accordance with paragraph (a) or (b) of this section, the escort shall:

- Have completed radiation safety training, examinations, and performance demonstrations required for entry to the area and performance of the work; and
- Ensure that all escorted individuals comply with the documented radiation protection program.

5.9.4 Radiation safety training shall be provided to individuals when there is a significant change to radiation protection policies and procedures that may affect the individual and at intervals not to exceed 24 months. Such training provided for individuals qualified for unescorted access to controlled areas shall include successful completion of an examination.

5.10 Sealed and Accountable Radioactive Source Control

5.10.1 Sealed radioactive sources shall be used, handled, and stored in a manner commensurate with the hazards associated with operations involving the sources.

5.10.2 Each accountable sealed radioactive source shall be inventoried at intervals not to exceed six months. This inventory shall:

- Establish the physical location of each accountable sealed radioactive source;
- Verify the presence and adequacy of associated postings and labels; and
- Establish the adequacy of storage locations, containers, and devices.

5.10.3 Except for sealed radioactive sources consisting solely of gaseous radioactive material or tritium, each accountable sealed radioactive source shall be subject to a source leak test upon receipt, when damage is suspected, and at intervals not to exceed six months. Source leak tests shall be capable of detecting radioactive material leakage equal to or exceeding 0.005 μCi .

An accountable sealed radioactive source found to be leaking radioactive material shall be controlled in a manner that minimizes the spread of radioactive contamination.

Notwithstanding the above, an accountable sealed radioactive source is not subject to periodic source leak testing if that source has been removed from service. Such sources shall be stored in a controlled location, subject to periodic inventory, and subject to source leak testing prior to being returned to service.

Notwithstanding the above, an accountable sealed radioactive source is not subject to periodic inventory and source leak testing if that source is located in an area that is unsafe for human entry or otherwise inaccessible.

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5.11 Entry Control to Radiological areas

5.11.1 Personnel entry control shall be maintained for each radiological area. The degree of control shall be commensurate with existing and potential radiological hazards within the area.

5.11.2 One or more of the following methods shall be used to ensure control:

- Signs and barricades;
- Control devices on entrances;
- Conspicuous visual and/or audible alarms;
- Locked entrance ways; or
- Administrative controls.

No control(s) shall be installed at any radiological area exit that would prevent rapid evacuation of personnel under emergency conditions.

5.11.3 Written authorizations

Written Authorizations shall be required to control entry into and perform work within radiological areas. These authorizations shall specify radiation protection measures commensurate with the existing and potential hazards.

5.11.4 Signs and Labeling

5.11.4.1 Except as otherwise described in Radiation Safety procedures or permitted in regulations, postings and labels shall include the standard radiation warning trefoil in black or magenta imposed upon a yellow background.

Radioactive material labels applied to sealed radioactive sources may be excepted from the above color specifications.

5.11.4.2 Signs required by this subpart shall be clearly and conspicuously posted and may include radiological protection instructions.

5.11.4.3 The posting and labeling requirements may be modified to reflect the special considerations of activities conducted at private residences or businesses. Such modifications shall provide the same level of protection to individuals as the existing provisions in this procedure.

5.11.5 Controlled and Radiological Area Posting

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5.11.5.1 Each access point to a controlled area (as defined in § 835.2) shall be posted whenever radiological areas or radioactive material areas exist in the area. Individuals who enter only controlled areas without entering radiological areas or radioactive material areas are not expected to receive a total effective dose of more than 0.1 rem (0.001sievert) in a year.

Signs used for this purpose may be selected by the contractor to avoid conflict with local security requirements.

5.11.5.2 Each access point to radiological areas and radioactive material areas shall be posted with conspicuous signs bearing wording indicated in Table 2.

5.11.6 Labeling of Radioactive Materials

Each item or container of radioactive material shall bear a durable, clearly visible label bearing the standard radiation warning trefoil and the words "Caution, Radioactive Material" or "Danger, Radioactive Material." The label shall also provide sufficient information to permit individuals handling, using, or working in the vicinity of the items or containers, to take precautions to avoid or control exposures.

Labeling is not required in the following circumstances:

- For materials used, handled, or stored in that are posted and access controlled, and where sufficient information is provided to permit individuals to take precautions to avoid or control exposures; or
- For materials where the quantity of radioactive material² is:
 - [For DOE regulated operations] less than one tenth of the values specified in appendix E of 10 CFR 835 and less than 0.1 Ci;
 - [For State of California regulated operations] exempted from labeling or posting requirements as described in 10 CFR 20.1905. These exemptions are listed in Table 2; or
- For materials packaged, labeled, and marked in accordance with the regulations of the Department of Transportation or DOE Orders governing radioactive material transportation; or
- For materials that are inaccessible, or accessible only to individuals authorized to handle or use them, or to work in the vicinity; or
- For materials that are installed in manufacturing, process, or other equipment, such as reactor components, piping, and tanks.

² See Table 2 for values for typical isotopes found at Boeing – SSFL

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5.11.7 Special Requirements for High and Very High Radiation Areas

5.11.7.1 One or more of the following controls shall be used for each entrance or access point to a high radiation area where radiation levels exist such that an individual could exceed an equivalent dose to the whole body of 1 rem (0.01 Sv) in any one hour at 30 centimeters from the source or from any surface that the radiation penetrates:

- A control device that prevents entry to the area when high radiation levels exist or that, upon entry, causes the radiation level to be reduced below the level that defines a high radiation area;
- A device that functions automatically to prevent use or operation of the radiation source or field while individuals are in the area;
- A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the high radiation area and the supervisor of the activity are made aware of the entry;
- Entryways that are locked. During periods when access to the area is required, positive control over each entry is maintained;
- Continuous direct or electronic surveillance that is capable of preventing unauthorized entry;
- A control device that will automatically generate audible and visual alarm signals to alert personnel in the area before use or operation of the radiation source and in sufficient time to permit evacuation of the area or activation of a secondary control device that will prevent use or operation of the source.

In addition to the requirements for high radiation areas, additional measures shall be implemented to ensure individuals are not able to gain unauthorized or inadvertent access to very high radiation areas.

No control(s) shall be established in a high or very high radiation area that would prevent rapid evacuation of personnel.

5.11.7.2 The following measures shall be implemented for each entry into a high radiation area:

- The area shall be monitored as necessary during access to determine the exposure rates to which the individuals are exposed; and
- Each individual shall be monitored by a supplemental dosimetry device or other means capable of providing an immediate estimate of the individual's integrated equivalent dose to the whole body during the entry.

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5.11.8 Exceptions to Posting and Labeling Requirements

5.11.8.1 Areas may be excepted from the posting requirements for periods of less than 8 continuous hours when placed under continuous observation and control of an individual knowledgeable of, and empowered to implement, required access and exposure control measures.

5.11.8.2 Areas may be excepted from the radioactive material area posting requirements when:

- The material is located in a posted radiological area; or
- Each item or container of radioactive material is labeled such that individuals entering the area are made aware of the hazard; or
- The radioactive material of concern consists solely of structures or installed components which have been activated (i.e. such as by being exposed to neutron radiation or particles produced in an accelerator).

5.11.8.3 Areas containing only packages received from radioactive material transportation labeled and in non-degraded condition need not be posted until the packages are monitored (See SOP C-405).

5.11.8.4 The requirements for access control and posting, and for labeling of radioactive materials, do not apply to radioactive material transportation by DOE or a DOE contractor conducted:

- Under the continuous observation and control of an individual who is knowledgeable of and implements required exposure control measures, or
- In accordance with Department of Transportation regulations or DOE orders that govern such movements.

5.12 Emergency exposure situations.

5.12.1 The risk of injury to those individuals involved in rescue and recovery operations shall be minimized.

5.12.2 Operating management shall weigh actual and potential risks against the benefits to be gained.

5.12.3 No individual shall be required to perform rescue action that might involve substantial personal risk.

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5.12.4 Each individual authorized to perform emergency actions likely to result in occupational doses exceeding the values of the limits provided at Section 6.5.1 shall be trained and briefed beforehand on the known or anticipated hazards to which the individual will be subjected.

5.13 Dosimetry Recordkeeping

5.13.1 Records shall be maintained to document compliance with regulations and with the radiation protection program.

5.13.2 Unless otherwise specified in this subpart, records shall be retained in accordance with the Boeing record retention policies³. Notwithstanding this, records related to DOE operations at Boeing – SSFL must be retained securely until final disposition is authorized by DOE.

As negotiated between Boeing – SSFL and DOE¹, all records required by this section shall be transferred to the DOE upon cessation of activities at the site that could cause exposure to individuals.

5.13.3 Except as indicated below, records shall be maintained to document doses received by all individuals for whom monitoring was conducted, to document unplanned doses exceeding the monitoring thresholds of Section 5.8.3, and to document authorized emergency exposures.

- Recording of the non-uniform equivalent dose to the skin is not required if the dose is less than 2 percent of the limit specified for the skin in Section 5.6.1.
- Recording of internal dose (committed effective dose or committed equivalent dose) is not required for any monitoring result estimated to correspond to an individual receiving less than 0.01 rem (0.1 mSv) committed effective dose. The bioassay or air monitoring result used to make the estimate shall be maintained and the unrecorded internal dose estimated for any individual in a year shall not exceed the applicable monitoring threshold at Section 5.8.3.

5.13.4 The records required by this section shall:

- Be sufficient to evaluate compliance with the dose limits of this procedure;
- Be sufficient to provide dose information necessary to complete reports required by regulations.

³ These records are considered to be business records of The Boeing Company. The mechanism of retention and ultimate transfer shall be arranged via Boeing – SSFL legal and the Department of Energy.

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5.13.5 Records shall include the results of monitoring used to assess the following quantities for external dose received during the year:

- The effective dose from external sources of radiation (equivalent dose to the whole body may be used as effective dose for external exposure);
- The equivalent dose to the lens of the eye;
- The equivalent dose to the skin; and
- The equivalent dose to the extremities.

5.13.6 Records shall include the following information for internal dose resulting from intakes received during the year:

- Committed effective dose;
- Committed equivalent dose to any organ or tissue of concern; and
- Identity of radionuclides.

5.13.7 Records shall include the following quantities for the summation of the external and internal dose:

- Total effective dose in a year;
- For any organ or tissue assigned an internal dose during the year, the sum of the equivalent dose to the whole body from external exposures and the committed equivalent dose to that organ or tissue; and
- Cumulative total effective dose.
- Include the equivalent dose to the embryo/fetus of a declared pregnant worker.

5.13.8 Documentation of all occupational doses received during the current year, except for doses resulting from planned special exposures and emergency exposures authorized by regulations, shall be obtained to demonstrate compliance with annual dose limits specified in Section 5.6.1.

If complete records documenting previous occupational dose during the year cannot be obtained, a written estimate signed by the individual may be accepted to demonstrate compliance.

5.13.9 For radiological workers whose occupational dose is monitored in accordance with Section 5.8.3 (§ 835.402), reasonable efforts shall be made to obtain complete records of prior years occupational internal and external doses.

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- 5.13.10 The records specified in this section that are identified with a specific individual shall be readily available to that individual.
- 5.13.11 Data necessary for future verification or reassessment of the recorded doses shall be recorded.
- 5.14 Operational Recordkeeping
- 5.14.1 The following information shall be documented and maintained:
- Results of monitoring for radiation and radioactive material [surface contamination checks performed on personnel when exiting Contamination Areas, High Contamination Areas, or Airborne Radioactivity Areas does *not* require documentation (See 10 CFR 835.1102(d)];
 - Results of monitoring used to determine individual occupational dose from external and internal sources;
 - Results of monitoring for the release and control of material and equipment from Contamination, High Contamination, and Airborne Radioactivity Areas; and
 - Results of maintenance and calibration performed on instruments and equipment used for radiological monitoring.
- 5.14.2 Training records shall be maintained, as necessary, to demonstrate compliance with the training requirements stipulated in Section 5.9.
- 5.14.3 Actions taken to maintain occupational exposures as low as reasonably achievable, including the actions required for this purpose, as well as facility design and control actions shall be documented.
- 5.14.4 Records shall be maintained to document the results of internal audits and other reviews of program content and implementation.
- 5.14.5 Written declarations of pregnancy, including the estimated date of conception, and revocations of declarations of pregnancy shall be maintained.
- 5.14.6 Changes in equipment, techniques, and procedures used for monitoring shall be documented.
- 5.14.7 Records shall be maintained as necessary to demonstrate compliance with the regulatory requirements for sealed radioactive source control, inventory, and source leak tests.
- 5.15 Reports to Individuals

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- 5.15.1 Radiation exposure data for individuals monitored in accordance with regulatory requirements shall be reported as specified in this section. The information shall include all data stipulated in Section 6.9.5.

Each notification and report shall be in writing and include: the identifier "Boeing – Santa Susana Field Laboratory", the name of the individual, and the individual's social security number (preferred), the individual's BEMSID, or another unique identification number.

- 5.15.2 Upon the request from an individual terminating employment, records of exposure shall be provided to that individual as soon as the data are available, but not later than 90 days after termination.

If requested, a written estimate of the radiation dose received by that employee based on available information shall be provided at the time of termination.

- 5.15.3 On an annual basis, Radiation Safety prepares a radiation dose report for each individual monitored in accordance with Section 5.8.3 during the year.

Visitors and non-radiological workers who were provided personal dosimetry, but who did not meet the requirements for mandatory monitoring under Section 5.8.3 may be provided annual reports at the discretion of the Radiation Safety Officer or Manager, Health, Safety and Radiation Services.

- 5.15.4 Detailed information concerning any individual's exposure shall be made available to the individual upon request of that individual, consistent with the provisions of the Privacy Act (5 U.S.C. 552a).

- 5.15.5 When Boeing - SSFL is required to report (for occurrence reporting and processing pursuant to regulatory requirements to a regulatory agency) any exposure of an individual to radiation and/or radioactive material, Boeing - SSFL shall also provide that individual with a report on his or her exposure data included therein.

Such a report shall be transmitted at a time not later than the transmittal to the Department.

5.16 Receipt of Packages Containing Radioactive Materials

Packages containing radioactive material are monitored and handled as described in SOP C-405, *Instructions for Receipt of Packages Containing Radioactive Materials*.

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TABLE 1

Relationships of Radiological Units

Units of Dose

1 rem	=	1,000 millirem
1 millirem (mrem)	=	1,000 microrem
1 Sievert (Sv)	=	100 rem
1 millisievert (mSv)	=	100 millirem

Units of Activity

1 Becquerel (Bq)	=	1 disintegration per second
1 Becquerel	=	60 disintegrations per minute (dpm)
1 Curie (Ci)	=	3.7E+10 Becquerels
1 microcurie (uCi)	=	37,000 Becquerels
1 picocurie (pCi)	=	0.037 Becquerel
1 picocurie	=	2.2 disintegrations per minute

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Table 2 Guidelines for Posting Radiological Areas and Labeling Radioactive Materials

Table 2.1: Criteria for Posting Radiation Areas

TYPE OF AREA	DOSE RATE CRITERIA	POSTING
Radiation Area	$> 0.005 \text{ REM/hr}$ and $\leq 0.1 \text{ REM/hr}$	<u>Required:</u> "CAUTION" RADIATION AREA" <u>Optional:</u> "TLD Required for Entry" "RWP Required for Entry" "Dose Rate Range: _____ to _____ mr"
High Radiation Area	$> 0.1 \text{ REM/hr}$ and $\leq 500 \text{ RAD/hr}$	<u>Required:</u> "CAUTION" or "DANGER" "HIGH RADIATION AREA" <u>Optional:</u> "TLD Required for Entry" "Self-indicating Dosimeter Required for Entry." "RWP Required for Entry" "Dose Rate Range: _____ to _____ mR"
Very High Radiation Area	$> 500 \text{ RAD/hr}$	<u>Required:</u> "GRAVE DANGER" "VERY HIGH RADIATION AREA" "SPECIAL CONTROLS REQUIRED FOR ENTRY" <u>Optional:</u> "Dose Rate Range: _____ to _____ mR"
Hot Spot	(As a guideline) 5 times general area dose rate and $> 0.1 \text{ REM/hr}$	<u>Suggested:</u> "CAUTION" "HOT SPOT"

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Posting Contamination, High Contamination and Airborne Radioactivity Areas Labeling Radioactive Materials

Table 2.2: Surface Contamination Values¹ in dpm/100 cm²

Radionuclide	Removable ^{2,4}	Total (Fixed + Removable) ^{2,3}
Isotope Unknown		
Beta-Gamma Emitters	100	500
Alpha Emitters	20	100
If isotopic content of the contamination is known, the following limits may be used in lieu of the default values listed above.		
U-nat, U-235, U-238, and associated decay products	⁷ 1,000	⁷ 5,000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20	500
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	200	1,000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above ⁵	1,000	⁸ 5,000
Tritium and STCs ⁶	10,000	See Footnote 6

¹ The values in this table, with the exception noted in footnote 6 below, apply to radioactive contamination deposited on, but not incorporated into the interior or matrix of, the contaminated item. Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides apply independently.

² As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

³ The levels may be averaged over one square meter provided the maximum surface activity in any area of 100 cm² is less than three times the value specified. For purposes of averaging, any square meter of surface shall be considered to be above the surface contamination value if: (1) from measurements of a representative number of sections it is determined that the average contamination level exceeds the applicable value; or (2) it is determined that the sum of the activity of all isolated spots or particles in any 100 cm² area exceeds three times the applicable value.

⁴ The amount of removable radioactive material per 100 cm² of surface area should be determined by swiping the area with dry filter or soft absorbent paper, applying moderate pressure, and then

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assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. (Note - The use of dry material may not be appropriate for tritium.) When removable contamination on objects of surface area less than 100 cm² is determined, the activity per unit area shall be based on the actual area and the entire surface shall be wiped. It is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

- 5 This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched.
- 6 Tritium contamination may diffuse into the volume or matrix of materials. Evaluation of surface contamination shall consider the extent to which such contamination may migrate to the surface in order to ensure the surface contamination value provided in this appendix is not exceeded. Once this contamination migrates to the surface, it may be removable, not fixed; therefore, a "Total" value does not apply. In certain cases, a "Total" value of 10,000 dpm/100 cm² may be applicable either to metals of the types from which insoluble special tritium compounds are formed, that have been exposed to tritium, or to bulk materials to which insoluble special tritium compound particles are fixed to a surface.
- 7 These limits apply only to the alpha emitters within the respective decay series.

DOE 5400.5 and U.S. NRC Health Physics Position #221, *Lower Limit of Detection (LLD) for Potentially Contaminated Oil*, describes criteria for releasing radioactive material that has been contaminated in depth or volume, such as activated material or smelted contaminated material. The policies and methodology described in these documents shall be applied to the release of such materials from facilities. Unless waived by the Radiation Safety Officer or Manager, Health, Safety and Radiation Services, on a case basis, any detectable volumetric radioactivity above normal background levels determines a classification of the material as radioactive.

- 8 Equivalent to 100 counts per minute above background on a typical pancake thin-window frisker probe with greater than 10% efficiency.

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Table 2.3: Posting Criteria for Contamination, High Contamination, Soil Contamination, and Airborne Areas

TYPE OF AREA	CRITERIA	POSTING
Contamination	Levels (dpm/100 cm ²) $\geq 1 \text{ X Table 6.1 values}$ but $\leq 100 \text{ X Table 6.1 values}$	<u>Required:</u> "CAUTION" "CONTAMINATION AREA" [If present] "HOT PARTICLES" <u>Optional Additional:</u> "RWP Required for Entry" "Contamination Range: _____ to _____ dpm/100cm ² "
High Contamination	Levels (dpm/100 cm ²) $> 100\text{X Table 6.1 values}$	<u>Required:</u> "CAUTION" or "DANGER" "HIGH CONTAMINATION AREA" [If present] "HOT PARTICLES" <u>Optional Additional:</u> "RWP Required for Entry" "Contamination Range: _____ to _____ dpm/100cm ² "
Soil Contamination	Contaminated soil not releasable in accordance with DOE 5400.5	<u>Required:</u> "CAUTION" "RADIOACTIVE MATERIALS" <u>Optional Additional:</u> "Authorized Personnel Only" or "Keep Out"
Airborne Radioactivity	Concentrations (uCi/cc) > 10% of any DAC value (Tables 6.2 & 6.3)	<u>Required:</u> "CAUTION" or "DANGER" "AIRBORNE RADIOACTIVITY AREA" <u>Optional Additional:</u> "RWP Required for Entry" "Respiratory Protection Required"

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Table 2.4: Criteria for Labeling and Posting Radioactive Material Areas for Common Isotopes at Boeing—SSFL⁽¹⁾

Nuclide	10 CFR 835 Appendix E		State of California 10 CFR 20; App C	
	Nuclide Activity Reference Limit (mCi)	Labeling / Posting Activity Reference Limit (uCi) ⁽²⁾	Nuclide Activity Labeling Limit (uCi)	Posting Activity (uCi) ⁽²⁾
Am-241	2.30E+01	2.30E+03	0.01	0.1
Co-60	1.80E+01	1.80E+03	1	10
Cs-137	6.00E+01	6.00E+03	10	100
Eu-152	3.10E+01	3.10E+03	1	10
Eu-154	3.10E+01	3.10E+03	1	10
Eu-155	3.70E+02	3.70E+04	10	100
H-3	1.60E+08	1.60E+10	1,000	10,000
Po-210	1.10E+03	1.10E+05	0.1	1
Pu-238	2.50E+01	2.50E+03	0.001	0.01
Pu-239	2.30E+01	2.30E+03	0.001	0.01
Pu-240	2.30E+01	2.30E+03	0.001	0.01
Ra-226	1.20E+03	1.20E+05	0.1	1
Sr-90	7.70E+03	7.70E+05	0.1	1
Tc-99	6.80E+06	6.80E+08	100	1,000
Th-230	3.10E+01	3.10E+03	0.001	0.01
U-238	8.40E+01	8.40E+03	100	1,000

- (1) For program consistency, the lesser of the DOE or State of California labeling and posting limits are applied as a routine action. The specific limits above may be substituted at the discretion of the Radiation Safety Officer or the Manager, Health, Safety and Radiation Services.
- (2) Or greater than 100 uCi, whichever is the smaller activity.

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Table 2.5: Labeling Requirements for Radioactive Materials

ITEM/MATERIAL	REQUIRED LABELING
Equipment, components and other items that are radioactive, potentially radioactive or have been exposed to radioactive contamination or activation sources	"CAUTION" "RADIOACTIVE MATERIAL"
Sealed and unsealed radioactive sources or associated storage containers	"CAUTION, RADIOACTIVE MATERIAL" or labeling consistent with NRC or Agreement State License conditions.
[OPTIONAL SUPPLEMENTAL LABEL] Equipment, components and other items with actual or potential internal contamination	"CAUTION" "INTERNAL CONTAMINATION" or "CAUTION" "POTENTIAL INTERNAL CONTAMINATION"
[OPTIONAL SUPPLEMENTAL LABEL] Components, equipment or other items with fixed contamination	"CAUTION" "FIXED CONTAMINATION"

Table 2.6: Posting Requirements for Radioactive Material Areas

AREA CONDITIONS	REQUIRED POSTING
Any area within a controlled area, accessible to individuals, in which items or containers of radioactive material exist and the total activity of radioactive material exceeds the posting limits in Table 6.5.	"CAUTION" "RADIOACTIVE MATERIAL"

Note: "Radioactive Material Management Area" (RMMA) posting is required for selected DOE facilities. See Boeing - SSFL Procedure N001TI000339 for guidance and facility listings.

Exemptions from labeling requirements for California Licensed Material

Labeling is not required for:

- (a) Containers holding licensed material in quantities less than the quantities listed in appendix C to part 20; or
- (b) Containers holding licensed material in concentrations less than those specified in table 3 of appendix B to part 20; or
- (c) Containers attended by an individual who takes the precautions necessary to prevent the exposure of individuals in excess of the limits established by this part; or

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- (d) Containers when they are in transport and packaged and labeled in accordance with the regulations of the Department of Transportation, or Labeling of packages containing radioactive materials is required by the Department of Transportation (DOT) if the amount and type of radioactive material exceeds the limits for an excepted quantity or article as defined and limited by DOT regulations 49 CFR 173.403 (m) and (w) and 173.421–424.
- (e) Containers that are accessible only to individuals authorized to handle or use them, or to work in the vicinity of the containers, if the contents are identified to these individuals by a readily available written record (examples of containers of this type are containers in locations such as water-filled canals, storage vaults, or hot cells). The record must be retained as long as the containers are in use for the purpose indicated on the record; or
- (f) Installed manufacturing or process equipment, such as reactor components, piping, and tanks; or
- (g) Containers holding licensed material (other than sealed sources that are either specifically or generally licensed) at a facility licensed under Parts 50 or 52 of this chapter, not including non-power reactors, that are within an area posted under the requirements in §20.1902 if the containers are:
 - (1) Conspicuously marked (such as by providing a system of color coding of containers) commensurate with the radiological hazard;
 - (2) Accessible only to individuals who have sufficient instruction to minimize radiation exposure while handling or working in the vicinity of the containers; and
 - (3) Subject to plant procedures to ensure they are appropriately labeled, as specified at §20.1904 before being removed from the posted area.

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Table 3

RADIATION WEIGHTING FACTORS¹, w_R

Type and energy range	Radiation weighting factor
Photons, electrons and muons, all energies	1
Neutrons, energy < 10 keV ^{2,3}	5
Neutrons, energy 10 keV to 100 keV ^{2,3}	10
Neutrons, energy > 100 keV to 2 MeV ^{2,3}	20
Neutrons, energy > 2 MeV to 20 MeV ^{2,3}	10
Neutrons, energy > 20 MeV ^{2,3}	5
Protons, other than recoil protons, energy > 2 MeV	5
Alpha particles, fission fragments, heavy nuclei	20

- ¹ All values relate to the radiation incident on the body or, for internal sources, emitted from the source.
- ² When spectral data are insufficient to identify the energy of the neutrons, a radiation weighting factor of 20 shall be used.
- ³ When spectral data are sufficient to identify the energy of the neutrons, the following equation may be used to determine a neutron radiation weighting factor value:

$$w_R = 5 + 17 \exp \left[\frac{-(\ln(2E_n))^2}{6} \right] \quad \text{Where } E_n \text{ is the neutron energy in MeV.}$$

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TISSUE WEIGHTING FACTORS FOR VARIOUS ORGANS AND TISSUES

Organs or tissues, T	Tissue weighting factor, w_T
Gonads	0.20
Red bone marrow	0.12
Colon	0.12
Lungs	0.12
Stomach	0.12
Bladder	0.05
Breast	0.05
Liver	0.05
Esophagus	0.05
Thyroid	0.05
Skin	0.01
Bone surfaces	0.01
Remainder ¹	0.05
Whole body ²	1.00

¹ "Remainder" means the following additional tissues and organs and their masses, in grams, following parenthetically: adrenals (14), brain (1400), extrathoracic airways (15), small intestine (640), kidneys (310), muscle (28,000), pancreas (100), spleen (180), thymus (20), and uterus (80). The equivalent dose to the remainder tissues ($H_{\text{remainder}}$), is normally calculated as the mass-weighted mean dose to the preceding ten organs and tissues. In those cases in which the most highly irradiated remainder tissue or organ receives the highest equivalent dose of all the organs, a weighting factor of 0.025 (half of remainder) is applied to that tissue or organ and 0.025 (half of remainder) to the mass-weighted equivalent dose in the rest of the remainder tissues and organs to give the remainder equivalent dose.

² For the case of uniform external irradiation of the whole body, a tissue weighting factor (w_T) equal to 1 may be used in determination of the effective dose.

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Table 4

Non-Uniform Exposure of the Skin

Non-uniform exposures of the skin from x-rays, beta radiation and radioactive materials on the skin, including hot particles **shall** be assessed and recorded as specified in the table below:

DOE Facilities:

AREA OF SKIN IRRADIATED	METHOD OF AVERAGING, ADDING TO OTHER DOSES RECEIVED, AND RECORDING NON-UNIFORM SKIN DOSE
$\geq 100 \text{ cm}^2$	<ul style="list-style-type: none"> • averaged over the 100 cm^2 of the skin receiving the maximum dose, • added to any uniform equivalent dose also received by the skin, and • recorded as the equivalent dose to any extremity or skin for the year.
$> 10 \text{ cm}^2$ and $< 100 \text{ cm}^2$	<p>the non-uniform equivalent dose (H) to the irradiated area received during the year shall be</p> <ul style="list-style-type: none"> • added to any uniform equivalent dose also received by the skin and • recorded as the equivalent dose to any extremity or skin for the year. <p>[H is the equivalent dose averaged over the 1 cm^2 of skin receiving the maximum absorbed dose, D, reduced by the fraction f, which is the irradiated area in cm^2 divided by 100 cm^2 (i.e., H = fD). In no case shall a value of f less than 0.1 be used.]</p>
$< 10 \text{ cm}^2$	<p>The non-uniform equivalent dose shall be averaged over the 1 cm^2 of skin receiving the maximum dose. This equivalent dose shall:</p> <ul style="list-style-type: none"> • Be recorded in the individual's occupational exposure history as a special entry; and • Not be added to any other equivalent dose to any extremity or skin for the year.

If the application of these DOE criteria results in a dose assignment exceeding the NRC or State of California guidelines described in the following section, then the individual shall be permitted to work only in DOE facilities for the Remainder of the calendar year.

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Licensed Facilities⁴:

Doses of record *should* be assigned consistent with the guidelines described above. However, the following additional criteria *should* be applied:

1. Except as provided for hot particles, doses shall be assigned to the representative body part based upon the highest "point of entry" dose determined for the body part. No "averaging" of dose across the body part is permitted.
2. For the exposure of an individual above the limits of 10 CFR 20.1201 that results from a hot particle in contact with the skin, the beta emission must be limited to less than 1×10^{10} beta particles (75 uCi-hrs). This is the Beta Emission Criterion.

Unless it can be determined that the particle was never in contact with the skin (for example, if the particle was between two layers of clothing), the hot particle will be assumed to have been in contact with the skin throughout the possible irradiation period, even if the particle was found on the hair or clothing of the exposed individual.

3. If it can be determined that the particle was never in contact with the skin, the skin dose (as opposed to the emission rate) shall be limited to less than 50 rad at a depth of 7 mg/cm² averaged over an area of 1 cm² in the region of the highest dose. This is the Skin Dose Criterion.
5. The beta emission criterion or the skin dose criterion will be used for each hot particle exposure. There are no quarterly or annual limitations.
6. When determining whether a hot particle exposure has exceeded the limits of either 10 CFR 20.1201, the beta emission criterion, or the skin dose criterion, hot particle exposures will not be added to skin doses from sources other than hot particles, nor will hot particle exposures from different particles be summed unless the different particles result in doses to the same area (location) of skin.

⁴ Although California has not promulgated specific guidelines for hot particle exposure, the NRC guidelines shall be applied to State licensed facilities.

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Table 5

Summary of Administrative Control Levels (ACLs) and Regulatory Dose Limits

TYPE OF EXPOSURE	QUARTER -Boeing – SSFL ACL - [Regulatory Limit]	ANNUAL -Boeing – SSFL ACL - [Regulatory Limit]
Radiological Worker: Whole Body (TED (formerly TEDE) = internal + external)	-1.00 REM -	-2.0 REM - [5.0 REM]
Lens of Eye (Equivalent Dose)	-1.00 REM -	-4 REM - [15 REM]
Extremity: 1) hands and arms below the elbow 2) feet and ankles	-5.00 REM -	-20 REM - [50 REM]
Skin of the Whole Body ⁵	-3.00 REM -	-12 REM - [50 REM]
Any organ or tissue (other than lens of eye) [sum of the equivalent dose to the whole body for external exposures and the committed equivalent dose (formerly Committed Dose Equivalent)]	-1 REM -	-50 REM - [50 REM]
Declared Pregnant Worker: Embryo/Fetus (Equivalent Dose)	AVERAGE DOSE RATE OVER GESTATION PERIOD -0.05 REM/month - Substantial variation above this uniform exposure rate shall be avoided.	-0.5 REM - [0.5 REM] [conception to birth]

⁵ See Table 4 for guidance on non-uniform exposure of the skin.

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TYPE OF EXPOSURE	QUARTER - Boeing – SSFL ACL - [Regulatory Limit]	ANNUAL - Boeing – SSFL ACL - [Regulatory Limit]
Minors and Students (under age 18): Total Effective Dose (internal + external)	N/A	- 0.1 REM - [0.1 REM] and 10% of other listed occupational dose limits
Escorted Personnel⁶ and public: Total Effective Dose (internal + external)	N/A	- 0.1 REM - [0.1 REM]

Both Quarter and Annual Limits **shall** apply to all Boeing - SSFL personnel as the maximum permissible exposure. Individuals working in DOE facilities may exceed quarterly administrative limits only with the prior, specific approval of the Site Director, Boeing - SSFL.

Occupational doses resulting from authorized emergency exposures **shall not** be considered when determining compliance with the dose limits.

Total Effective Dose shall be determined by summing the Effective Dose (t) from external exposures and the Committed Effective dose from intakes.

⁶ Applies to personnel who have not completed training in accordance with training requirements described in this procedure.

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Table 6

Derived Airborne Concentration (DAC) values for common Boeing – SSFL Isotopes

Values of Derived Air Concentrations for the most common isotopes encountered at Boeing - SSFL are provided below: Retention Classes are default values, and may be changed based upon further analysis of internal intake behaviors. Full listings of ALIs and DACs can be found in 10 CFR 835 (for DOE operations) and 10 CFR 20 (for California licensed operations).

DOE Operations (Extracted from 10 CFR 835; Appendix A)

Radionuclide	Absorption Type ¹			Stochastic or organ or tissue ²
	µCi/mL			
	F	M	S	(F/ M/ S)
H-3 (Water)	2 E-05	2 E-05	2 E-05	St/St/St
H-3 (Elemental)	2 E-01	2 E-01	2 E-01	St/St/St
STC (Insoluble)	1 E-05	6 E-06	2 E-06	St/St/St
STC (Soluble)	1 E-05	1 E-05	1 E-05	St/St/St
Co-60	-	7 E-08	3 E-08	/St/St
Sr-90	1 E-08	-	7 E-09	BS/ /St
Y-90	-	3 E-07	3 E-07	/St/St
Cs-137	8 E-08	-	-	St/ /
Eu-152	-	2 E-08	-	/St/
Eu-154	-	1 E-08	-	/St/
U-235	5 E-10	3 E-10	8 E-11	BS/St/ET
U-238	5 E-10	3 E-10	8 E-11	BS/St/ET
Pu-238	-	6 E-12	5 E-11	/BS/St
Pu-239	-	5 E-12	6 E-11	/BS/BS
Pu-240	-	5 E-12	6 E-11	/BS/BS

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Radionuclide	Absorption Type ¹			Stochastic or organ or tissue ² (F/ M/ S)
	μCi/mL			
	F	M	S	
Pu-241	-	2 E-10	2 E-09	/BS/BS
Am-241	-	5 E-12		/BS/

- 1) A dash indicates no values given for this data category.
- 2) A determination of whether the DACs are controlled by stochastic (St) or deterministic (organ or tissue) dose, or if they both give the same result (E), for each absorption type, is given in this column. The key to the organ notation for deterministic dose is: BS = Bone surface, ET = Extra thoracic, K = Kidney, L = Liver, and T = Thyroid. A blank indicates that no calculations were performed for the absorption type shown.

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State of California Licensed Operations

Isotope	Retention Class	NRC/CA OCCUPATIONAL DAC (uCi/cc)	NRC/CA OFFSITE (EFFLUENT) RELEASE DAC (uCi/cc)
Co-60	Y	1 E-8	5E-11
Sr-90	Y	2 E-9	6E-12
Cs-137	D	6 E-8	2E-10
Pu-239	W	3 E-12	2E-14
Eu-152	W	1 E-8	3E-11
Eu-154	W	8 E-9	3E-11
U-235	Y	2 E-11	6E-14

[State of California] To maintain ongoing compliance with the National Emissions Standards for Hazardous Air Pollutants (NESHAPS) for radionuclides, the radiation exposure from environmental effluent releases to the maximally exposed member of the general public will not exceed 10 mrem per year as determined using the USEPA-provided computer code "CAP-88 PC."

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Table 7

Basic Training Topics to Be Covered for Access To Radiological Areas

Basic radiological fundamentals and radiation protection concepts
Risk of radiation exposure, including both acute high-level dose effects (Acute Radiation Syndrome) , and chronic low-level exposures (i.e., cancer and genetic effects)
Risk of prenatal radiation exposure
Visitor and management responsibilities for radiation safety
ALARA, including individual responsibilities for implementing ALARA measures
Techniques used to manage doses and maintain doses ALARA, including physical design features, administrative controls, limits, alarms, and other measures
Radiological protection policies and procedures
Individual rights and responsibilities as related to implementation of the facility radiation protection program
Adherence to radiological posting and labeling
Individual exposure reports that may be requested from Radiation Safety
Applicable emergency procedures
Training for issuance of dosimeters, where applicable.

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Table 8
Comparison of ICRP 30 System and ICRP 60 System of Dosimetric Terminology

ICRP 30 System (NRC, State of California)	ICRP 60 System (Department of Energy)
Committed effective dose equivalent	Committed effective dose
Committed dose equivalent	Committed equivalent dose
Cumulative total effective dose equivalent	Cumulative total effective dose
Deep dose equivalent	Equivalent dose to the whole body
Dose equivalent	Equivalent dose
Effective dose equivalent	Effective dose
Lens of the eye dose equivalent	Equivalent dose to the lens of the eye
Quality factor	Radiation weighting factor
Shallow dose equivalent	Equivalent dose to the skin or Equivalent dose to any extremity
Weighting factor	Tissue weighting factor
Total effective dose equivalent	Total effective dose

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Appendix 1

Management of Use Authorizations

A. Authorization to Possess or Use Radioactive Materials or Radiation Producing Equipment

Any planned procurement and use of radioactive materials or radiation producing equipment must be reviewed by the Radiation Safety Officer (RSO) in order to determine the need for radiological controls. Based upon this review, the need for a Use Authorization will be established.

Common types of radiation producing equipment are:

1. X-ray machines of any type (e.g., irradiators, cabinets, diffraction units, fluorescence units, etc.)
2. Electron beam welders
3. Electron Microscopes
4. Certain types of high power lasers
5. Charged beam accelerators
6. Certain types of magnetrons
7. Certain types of high voltage rectifiers

Common types of equipment or situations involving radioactive materials are:

1. Industrial Analyzers (e.g., depth gauging devices, soil moisture analyzers, alloy analyzers, lead content analyzers, etc.)
2. Conduct of Decontamination and Decommissioning activities
3. Packaging and disposal of radioactive materials
4. Chemical spectrographic analyzers (Ni-63 check sources)
5. Spryton triggers (C-14)
6. Smoke detectors (Am-241)
7. Safety Signs (Tritium)
8. Static Removers and Ionizers (Po-210)

B. Determination of Need and Requirements for Initial Request for Use Authorization

Based upon the RSO review, a determination for the need of a Use Authorization will be made. If a Use Authorization is required, the RSO will request the sponsoring department to designate a Principal User and to submit a request for authorization. The following information *should* be provided in this request:

1. A description of the process, briefly explaining the need for the radiation producing equipment or the need to possess radioactive materials.

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The description *should* be in sufficient detail to permit an assessment of potential hazards which could occur. A flow chart *should* be provided when appropriate (such as for complex manufacturing or utilization processes).

2. A description of the facility and equipment or radioactive materials to be used. The description *should* be in sufficient detail to permit an understanding of the manner in which the device or materials will function. Specific location and use history of the facility or location *should* be provided. A general description of other activities occurring the vicinity *should* be provided.

A floor plan *should* be provided with significant facility details identified (e.g., shielding (type and thickness), entrances and exits, "step-off" lines, sinks, hoods or other enclosures, control panels, interlocks, alarm annunciators, air or radiation monitors, etc.).

For radioactive materials, information regarding the required physical and chemical form, quantities, and types of containers *should* be provided to permit an assessment of the requested materials against regulatory and license conditions.

Provisions for receipt and storage of the material *should* be addressed.

For radiation producing equipment, a description of the device, along with its maximum operating parameters (e.g., tube kilovolts, current, etc.) *should* be provided to permit an assessment of potential radiation fields. Model Numbers of the device *should* be provided to permit timely notification of regulatory agencies, where required.

3. A specification of engineered safeguards, such as shielding, enclosures, ventilation, and interlock and alarm systems, *should* be provided. Where facility modifications are anticipated, an outline schedule of completion *should* be provided.

4. A list of pertinent operating procedures *should* be provided, with a brief description of the subject matter of each procedure.

5. A discussion of the qualifications of the principal user, including a brief discussion of the individual's qualifications and training for the oversight of a radiological activity.

A proposed list of Authorized Users for the operation *should* also be provided, including a brief description of the activities they are to be performing under the Authorization.

The Users will be expected to meet the training and qualification criteria of the Use Authorization prior to its approval.

6. A list of any operations forms or logs to be maintained in conjunction with the proposed operations (e.g., facility logs, equipment maintenance logs, experiment logs, etc.). Copies of any proposed forms *should* be provided.

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7. A description of the form, quantity, and rate of generation of radioactive waste. A description of the arrangements made for the disposal of the materials *should* be provided, including budgeting information for the costs of disposal or long-termed storage⁷.

The discussion *should* address plans for ultimate disposal of the radioactive materials, removal and cleanup or disposal of any contaminated equipment, and the final decontamination and verification survey of the facility, including funding sources.

8. A description of the means for maintaining control and security for the material and devices in use or in storage.

C. Analysis of Application for Authorization

The RSO will analyze the submitted application, ensuring that the proposed use meets the requirements of this procedure. The RSO (or designee) will prepare a Use Authorization, describing all pertinent controls to be applied to the activity.

A Use Authorization may be activated with the signature of the RSO and the Manager, HS&RS.

D. Authorization File

An "Authorization File" will be created and maintained by Radiation Safety. This file will collect all correspondence, specialized inspection data, and other pertinent documentation for the life of the authorization. Copies of the authorization will be distributed to:

1. The principal user
2. The user's manager
3. The user's Approval Authority
4. Protective Services
5. The Manager, Health Safety and Radiation Services
6. The RSO
7. Additional individuals determined to have a need to know.

E. Changes to Authorization

If significant changes, outside the scope of the existing authorization, become necessary, the principal user will notify the RSO in writing (or by electronic mail) and will describe the proposed changes. This request will undergo the review and approval process described in A through D above. Until the Authorization is amended, the project changes may not be implemented.

F. [DELETED]

⁷ At this writing, access to disposal sites for radioactive wastes from California licensees is very restricted. As a result, these materials must be placed into long-term storage on Boeing--SSFL property. Requests for the procurement of radioactive materials will be closely scrutinized against this constraint, and the requesting department will be expected to provide funding for the maintenance of such storage.

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H. Responsibilities Of A Radioactive Material Or Radiation Producing Device Principal User

Radioactive materials and radiation producing devices at Boeing - SSFL are placed under the control of Principal Users. These individuals are designated by name in the Use Authorizations. The Use Authorization is prepared by the RSO and is approved by Chairman of the Radiation Safety Committee.

Principal Users are qualified for their assignments based on training and experience in the technology, equipment, and safety requirements for the specific radioactive materials and radiation producing devices under their control.

Principal Users are responsible for the following activities defined in their Use Authorizations:

1. Complying to the provisions of the Use Authorization.
2. Notifying of the Radiation Safety Officer for approval of changes for the Use Authorization.
3. Processing the annual renewal of the Use Authorization.
4. Monitoring the activities of authorized users to ensure compliance to radiation safety rules and regulations. Assuring that unauthorized persons do not use radioactive materials or radiation producing equipment.
5. Assuring the physical security and safe use of radioactive materials and radiation producing equipment.
6. Notifying the Radiation Safety Officer or his designees of radiological incidents including malfunctioning safety devices.
7. Arranging for the proper transfer and disposal of radioactive materials and radiation producing equipment when they are no longer required.