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OAK RIDGE ELECTRON LINEAR

ACCELERATOR FACILITY

PROCEDURES and GUIDELINES

May 2004

OAK RIDGE ELECTRON LINEAR ACCELERATOR FACILITY
PROCEDURES AND GUIDELINES
APPROVALS

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ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
ASE	Accelerator Safety Envelope
DRCO	Division Radiological Control Officer
DSO	Division Safety Officer
EBIL	Electron Beam Injection Laboratory
ESH	Environment, Safety, and Health
HEPA	High-Efficiency Particulate Air
JHE	Job Hazard Evaluation
LSM	Laboratory Space Manager
MSDS	Material Safety Data Sheet
OM	ORELA Operations Manager
ORELA	Oak Ridge Electron Linear Accelerator
ORNL	Oak Ridge National Laboratory
P-AAA	Price-Anderson Amendment Act
PPE	Personnel Protective Equipment
Prox Card	Proximity Card allows building entrance through exterior doors
RCT	Radiological Control Technician
RWP	Radiological Work Permit
SAP	Primary ORNL database
SNM	Special Nuclear Material
WWW	World-Wide-Web reference to internet availability of information

DEFINITIONS

Accelerator Safety Envelope

The Accelerator Safety Envelope (ASE) is a document that defines the physical and administrative bounding conditions for safe operations based on identified issues from a facility safety analysis.

Authorized Person

A person who has been certified, through training or position, as qualified to perform specified tasks.

MUST

Parts of these Procedures which require compliance, alternate to ***WILL***.

Principal Investigator

The scientist in charge of an experiment who is responsible for its technical progress and management, and implementation of Work Control processes.

SHALL

Elements of these Procedures driven by the Accelerator Safety Envelope, therefore require absolute compliance. Violation requires accelerator shutdown.

SHOULD

Indicates a recommendation or that which is advised but not required.

WILL
Parts of these Procedures which require compliance, alternate to ***MUST***.

ORNL SBMS Work Control Subject Area
ORNL procedures and processes designed to ensure safe work.

OAK RIDGE ELECTRON LINEAR ACCELERATOR

FACILITY PROCEDURES AND GUIDELINES

1.0 INTRODUCTION

The Oak Ridge Electron Linear Accelerator (ORELA) is a Physics Division facility, located at the Oak Ridge National Laboratory (ORNL) in Building 6010 at the east end of the ORNL campus. Work at ORELA is covered by regulations and procedures that relate to employee and public safety, safeguarding of sensitive materials, and security for federal property within the ORELA building. The goal of this manual is to make procedures and guidelines of particular concern conveniently available to persons working at ORELA. This manual does not address subject areas covered by ORNL or Physics Division Procedures.

Elements of these **Procedures** driven by the **ASE, and which require absolute compliance,** can be identified by inclusion of the bold, italicized imperative ***SHALL*** in the requirement. A distinction is to be made between 1) **ORELA Procedures and derived requirements**, which flow from ORNL and Division requirements and include the imperative ***MUST*** or ***WILL*** in the requirement, and 2) ORELA Guidelines, which provide guidance on issues which are important to proper functioning of the facility, but do not require the strict compliance accorded to **Procedures**. The penalty for an ASE violation (***SHALL***) is immediate shutdown of the accelerator, while the consequence for a violation of ORNL and/or Division requirements (***MUST, WILL***) is an evaluation of the issue by ORELA line management, which may result in additional requirements.

The ORELA produces intense pulses of ~170-MeV electrons that generate bursts of fast neutrons for measurements of neutron cross sections and related quantities using flight-time spectrometry. The term “ORELA” usually refers to the facility, including its research equipment and sometimes includes the whole building that houses this facility (Building 6010, Oak Ridge National Laboratory).

This manual is a major update of one issued in March 1969, reissued with revisions in 1979 as ORNL/TM-6801, in July 1990 as ORNL/CF-90/95, and January 1992 as ORNL/CF-90/95/R2. It is viewable on the www from the Operations section of the Physics Division Home Page. It translates requirements of ORNL, Physics Division, and the Facility Authorization Basis Document into operating procedures for the ORELA facility, and defines how operations and experimental work are to be conducted at the facility.

The Facility Authorization Basis Document for ORELA is the *Accelerator Safety Envelope, Oak Ridge Electron Linear Accelerator, ORELA, Bldg. 6010. (ASE/6010/PHYS/R1), 7/16/03.* A copy is available from the ORELA Director.

2.0 FACILITY ACCESS PROCEDURE

2.1 Building 6010 Access

Access to Building 6010, which houses the ORELA facility, is controlled by prox card readers. Each person entering the building outside of normal working hours ***must*** use his/her own prox card to gain entrance**.** These hours include 8:00 pm to 6:00 am Monday through Friday, and all hours on weekends and holidays. Normal working hours are 6:00 am to 8:00 pm Monday through Friday. Foreign nationals ***must*** always run their prox card through the prox card reader, but during normal working hours all others can "piggyback" on the first person's prox card to open the door, as long as that person verifies all people entering are properly badged.

2.2 6010 Basement Access

Access to the accelerator, the basement area, and the Shield Test Station is restricted to approved experimenters, engineers, and support personnel of the ORELA staff by means of a scramble multiple-digit code locking system on all the doors leading to basement areas from the first floor of the building. Access Training ***must*** be completed before unescorted access to basement areas is granted by the ORELA Director or his designated alternate. A list of those approved ***will*** be maintained under the supervision of the ORELA Director. Personnel not approved for this access ***must*** be accompanied by a properly trained person who has such approval.

3.0 SAFETY

3.1 General Safety

The ORELA Operations Manager (OM) ***shall*** ensure that safety rules and procedures are followed for the operation of the accelerator. Enforcement of safety rules and procedures for the remainder of the facility are the responsibility of the ORELA Director.

3.2 Accelerator Operation and Safety

The accelerator is not a criticality hazard. Radiation hazards, other than from radioactive material and x-rays emitted from the klystrons, are created only by the electron beam itself. When the electron beam is shut off, only residual-induced radioactivities remain. Radiation associated with these activities is many orders of magnitude smaller than when the electron beam is on, and is dealt with in accord with applicable ORNL procedures.

In the case of a planned power outage, alternate sources of power ***must*** be provided to maintain accelerator vacuum, and to ensure continued operation of the 440 volt sump pumps in 6010 and the 85-and 150-m flight stations. In the case of an unplanned outage, a rapid evaluation should be carried out by the ORELA Operations Manager or delegate to ensure protection of the accelerator.

3.2.1 Accelerator Interlock Systems

When the accelerator beam is on, personnel ***shall*** not enter the Accelerator Room or the Magnet Room. To prevent such access, several independent interlock systems are incorporated into the controls for the accelerator. Accelerator access procedures, as given in this Manual, are followed. In particular, two independent redundant interlocks ***shall*** be operable on each access door to the Accelerator Room and on the escape hatch cover for the Magnet Room. The accelerator high-voltage supplies are disabled whenever the Accelerator Room key is not captured by the Control Room panel captive key lock. In addition, there are emergency plugs in the accelerator and magnet rooms. They provide an emergency method to disable the accelerator power supplies while in these rooms, thus preventing generation of beam. Note that only an authorized person ***shall*** insert a plug removed by another person.

If, during normal accelerator operation, it is necessary to shut off the electron beam or to have the accelerator remain off after a regularly scheduled shutdown in order to work on a flight path in one of the experiment areas (such as the electron room), each person involved in the “shutdown” ***shall*** remove a personnel plug and maintain control of it until the work is completed that required the “shutdown” condition, unless the ORELA Operator has removed a personnel plug from the panel adjacent to the entrance of the Accelerator Room and posted a sign stating “PERSONNEL PLUGS ARE NOT REQUIRED WHEN THIS SIGN IS DISPLAYED."

3.2.2 Interlock Bypass Requirements

If, for maintenance or troubleshooting purposes, it is necessary to bypass intentionally an Accelerator Room access control safety interlock or interlocks, such action ***shall*** be authorized by the Operations Manager, approved by Division Management with responsibility for ORELA, recorded in the ORELA operating log, posted at the console, terminated, and retested as soon as possible. The termination of the bypass condition ***shall*** also be recorded in the ORELA operating log.

3.2.3 Interlock Testing Requirements

During normal periods of operation, each interlock system is tested at intervals not to exceed 6 months. Each test ***shall*** be approved by the OM, who ***shall*** also maintain records of these tests. Any interlock which fails to operate properly is repaired and retested before the accelerator is operated. The checklist for personnel safety interlocks is provided in Table 3.2.3 in the Appendix.

3.2.4 Accelerator Access Procedure

Unless the ORELA operator has removed a personnel plug from the panel adjacent to the entrance of the Accelerator Room and posted a sign stating “PERSONNEL PLUGS ARE NOT REQUIRED WHEN THIS SIGN IS DISPLAYED," each unescorted person ***shall*** remove a personnel plug from this panel prior to entering the Accelerator Room and retain control of the plug while there. Only ORELA staff who have been assigned a personnel plug are authorized to escort visitors into the Accelerator Room. Work done in the Accelerator and Magnet Rooms is covered by the ORNL Work Control Subject Area, and specific conditions for work are listed in a Research Safety Summary. Before exiting from the Accelerator Room, personnel ***must*** check hands and feet for contamination as instructed by a sign posted near the exit.

3.2.5 Requirements in the Event of Access Violations

In the event of an access control violation, notification ***will*** be carried out in accordance with the Physics Division Procedure on Abnormal Event Response. The event ***shall*** be evaluated to see if it qualifies as an occurrence, and if so, ORNL occurrence reporting requirements will be followed. Accelerator operation ***shall*** cease until evaluation of the Control failure has been completed and all resulting actions have been implemented. At the appropriate time, the Division manager with responsibility for ORELA ***shall*** make a recommendation to the Division Director to restart accelerator operation, and that recommendation, if approved, will be sent to cognizant ORNL management for restart approval, in accordance with the ORNL Accelerator Safety Subject Area.

3.2.6 Accelerator Startup Requirements

As part of the normal accelerator start-up procedures and in order to be in compliance with ORELA Safety Documentation, the operator ***shall*** take the following safety-related actions before any electrons are accelerated:

1. Confirm Accelerator Room vacant, lock doors, confirm they are secure.

2. Lock Accelerator key, confirm if captive in lock.

3. Establish warning delay of approximately two minutes.

4. Check Accelerator Room audible alarm for 30 seconds.

The dates and times of the completion of these actions ***shall*** be recorded and initialed by the operator in the ORELA operating log. The current ORELA operating log is kept at the console; previous operating logs are kept in the Operations Office, Room M2.

In order to avoid unnecessary radiation exposure, the operator may omit the Accelerator Room and Magnet Room search after a relatively brief shutdown if a special procedure is employed to assure that no persons remain in the Accelerator Room or Magnet Room. The search may be omitted if the operator assures that each person entering the Accelerator Room carried a personnel plug, and if the operator can independently be sure that all who entered the Accelerator Room also exited. The operator may meet the latter condition by attending the open Accelerator Room door continuously to maintain a count of the persons within, or alternatively by entering the Accelerator Room and maintaining contact with any others while closing (which also locks) the Accelerator Room door(s) to prevent undetected entries.

Accelerator and magnet room maintenance is performed in accordance with the ORNL Work Control Subject Area, which addresses the use of RWP's to ensure radiological safety during maintenance work.

3.3 Safety of Experiments

3.3.1 Experiment Reviews

The Principal Investigator of each experiment is responsible for the safe operation of the equipment used in that experiment and for seeing that all safety regulations relating to that experiment are obeyed. New or significantly altered experiments ***must*** undergo an Experiment Review before the experiment is put into operation. The experimenter provides to the Division Safety Officer (DSO) a written memo describing the experiment, the samples to be used, the procedures to be followed, and the possible hazards or emergencies. The experimenter also provides a Material Safety Data Sheet (MSDS) if a chemically or physically hazardous material is to be used. The DSO ***will*** consult with the Division Radiological Control Officer (DRCO) and the facility RCT on questions of neutron and gamma-ray dose rates. The DSO may appoint a safety review committee, and may contact the Office of

Operational Safety for guidance. The DSO then obtains appropriate approvals from review committee members for the experiment, or recommends changes to be considered and implemented before approval will be granted. Records of these Experiment Reviews ***will*** be maintained by the Division Safety Officer.

For experiments involving use of Flight Path 6, the DSO ***must*** invite the DSO responsible for Bldg 5800, Room D-108 (near the 150-m station) to the review for those experiments.

3.3.2 Hazardous Material Sample Evaluation

Guidelines for evaluating if a radioactive sample is considered "hazardous" are given in Table 3.3.2 in the Appendix. The guidelines are useful during experiment design, and are based on health issues associated with exposure to the samples. They serve as administrative action level guidelines for assisting in sample size determination. If sample size can be limited to amounts less than "hazardous" in Table 3.3.2, regulatory and procedural requirements are lessened. If the sample amount exceeds the guideline limits, Section 3.3.3 lists requirements for working with the sample at ORELA. Other requirements may be imposed in the RWP(s) controlling the work.

3.3.3 Hazardous Material Sample Requirements

Non-radioactive hazardous material requirements will be identified during the experiment review. If the experiment is determined to involve use of samples containing hazardous amounts of radioactive material (using the guidelines in Table 3.3.2), the principal investigator ***must*** see that the following requirements are met and appropriate procedures followed:

1. Users ***must*** notify the ORELA Director and the DSO of any plans to use hazardous materials. If radioactive materials will be used, the DRCO must also be notified. (The DRCO consults with the facility RCT before reviewing and approving the use of such samples.)

2. A continuous air alpha monitor ***must*** be considered for each flight station where a hazardous sample containing alpha-emitting materials is in use.

3. Checks for contamination ***must*** be made by the facility RCT before the sample is taken to the experimental area, again after it is in the experimental setup, and periodically during the experiment.

4. An appropriate sign such as “PLUTONIUM IN USE” ***must*** be placed in a visible location just inside the flight station for notification of ORNL emergency services when hazardous samples are in use.
5. Personnel who touch sealed samples that contain hazardous amounts of alpha-active materials ***must*** check themselves for contamination with an alpha monitor prior to proceeding to other areas.
6. The need for a HEPA filter in the exit air stream from a flight station or location where a sealed sample is used which contains a hazardous amount (Table 3.3.2) of plutonium or other alpha active material that could be released in a particulate form ***must*** be evaluated. This HEPA filter ***must*** have been tested and shown to meet surveillance standards prior to the time the sample is to be utilized.

3.3.4 Special Nuclear Material Requirements

If special nuclear material (SNM) is to be brought in for an experiment, there are two aspects which ***must*** be considered. From a safeguards and security standpoint the facility ***must*** remain a Category IV Material Balance Area, and from a criticality safety standpoint, the fissionable material control limit ***must*** not be exceeded. This is currently 250 g of 235U fissile equivalent mass. If SNM is to be brought in, prior contact ***must*** be made with the Nuclear Material Control & Accountability organization for guidance from the safeguards and security standpoint, and the Nuclear Criticality Safety organization for guidance from the criticality safety standpoint. These contacts ***must*** be made as part of the Experiment Review process to ensure the planned experiment will not violate facility inventory limits. In addition, if a large amount of radioactive material of any kind is to be brought in, the facility radioactive material inventory ***must*** be reviewed to ensure the inventory remains below the Category III limit as defined in DOE-STD-1027-92.

3.4 Structural Barriers for Flight Stations

3.4.1 Direct Beams

During routine operation of the accelerator, each region where an ORELA beam crosses a flight station ***shall*** be barricaded by a structural barrier approved by the Operations Manager, unless that beam is blocked by a locked beam stop for which the key is under the control of the Operations Manager. Beam stops are normally locked in a closed position for flight paths not in use. If a structural barrier for a flight path is to be removed, the experimenter ***shall*** first notify the Operations Manager who ***shall*** lock the beam stop in

the closed position before granting approval to remove the structural barrier. Except for special circumstances, the OM ***shall*** not unlock it until the structural barrier is replaced. During experiment setup or troubleshooting, the Operations Manager may approve operation of the accelerator with personnel in a flight station without the relevant beam stop being locked even though there is no structural barrier along a beam line in that station. For this purpose he ***shall*** either assure that the beam stop blocks the beam, or he will temporarily transfer control of that flight station key to the experimenter. While the experimenter controls the key, he ***shall*** at all times maintain active supervision of access to the flight station to assure that at least one of the following conditions applies:

3.4.1.1 The beam stop, though unlocked, blocks the beam of concern when persons are in the flight station, or

3.4.1.2 A Radiological Control Technician (RCT) is present with any personnel in that flight station, or

3.4.1.3 The flight station has been surveyed and posted by a RCT during the current experiment. This survey ***shall*** be for the maximum beam strength conditions attainable with the shadow bar, collimators, filters, etc. in place that are a permanent part of the flight path equipment for the current experiment.

At the end of the period of such experiment setup or troubleshooting, the structural barrier ***shall*** be replaced or the flight station door ***shall*** be locked, and control of the key ***shall*** be returned to the Operations Manager so that routine accelerator operation can resume.

The structural barriers ***shall*** be sufficient to prevent persons from inadvertently placing an extremity (hands and arms below the elbow or feet and legs below the knee) into an ORELA beam where the dose-equivalent rate to the extremity could exceed 30 rem/h.

The Operations Manager ***shall*** not unlock the beam stop for a particular flight path unless (a) such an extremity barrier is in place, or (b) in addition to the presence of the head and torso barrier it has been determined that the maximum possible dose-equivalent rate to an extremity for the planned accelerator operation would be less than 30 rem/h even if all filters and beam attenuators which are not secured in the beam were to be removed. Other options for specific tests or experiments ***must*** be documented, reviewed, and approved by the DRCO, the ORELA Director, and the Operations Manager.

This 30-rem/h exclusion from requirement of an extremity barrier ***will*** be established by (a) having the facility RCT measure the dose-equivalent rate in the beam with beam conditions similar to those produced with all filters and beam attenuators removed except those which are secured in the beam, or (b) relying on a value measured previously with filter and attenuator conditions which are sufficiently similar.

The dose-equivalent rate in the beam for either (a) or (b) ***will*** be computed for the planned accelerator operating condition with all filters and beam attenuators removed except for those which are secured in the beam. If the maximum possible dose-equivalent rate to an extremity for the planned operating condition would be greater than 30 rem/h (assuming that the flux from ORELA should be averaged over 100 cm^2 due to the motion of the extremity while it is in the region of a small beam) with such filters and beam attenuators removed, the beam stop for that flight path ***shall*** be locked until an extremity barrier is installed and approved.

A Structural Barrier Log ***shall*** be maintained by the Operations Manager to identify the present status for each flight station and beam line of (a) the structural barrier or locked flight station in lieu thereof, and (b) the beam stop lock or a beam-blocking shield in lieu thereof. Any person responsible for changing the status of a structural barrier, beam-stop lock, or beam-blocking shield ***shall*** obtain the approvals indicated above and notify the Operations Manager or his designated alternate of the change to assure that this log ***shall*** remain current.

3.4.2 Scattered Beams

When samples or other materials are placed directly in a neutron beam in a flight station, the dose rate from scattered radiation can be of concern under the ALARA principle. This concern is higher for the short flight paths that occur in the Electron Room, and for large area beams. Control of exposure from scattered radiation is based on the maximum dose rate that could be measured at the structural barrier during the current experiment with the scattering material in the beam. The Primary Investigator is responsible for verifying that the experiment ***will*** meet the conditions for the scattered dose rate at the structural barrier discussed below in items (1), (2), and (3).

An experiment or the experimenter ***must*** satisfy the following conditions:

(1) Except for cases covered under (2) below, experiments are configured so that the maximum attainable dose equivalent rate at the structural barrier is less than 0.1 rem/hr for the "thickest" scatterer planned for use in the beam.

(2) If an experiment is being performed normally at a low ORELA power level and it is impracticable to employ a structural barrier so large in diameter as to meet the 0.1 rem/hr limit at the structural barrier should the power level increase to the 50-kW ORELA maximum, the ALARA principle is satisfied if the following three conditions are satisfied:

a. The dose equivalent rate at the structural barrier can not exceed 0.1 rem/hr if the ORELA beam power should increase to twice the value normally used in the experiment.

b. A radiation monitor is employed by an RCT that alarms locally if the dose equivalent rate at the structural barrier reaches 0.1 rem/hr. Alternatively, a beam power limiter may be employed to close the experimenters beam stop if the power or radiation production level increases to the value that would produce greater than 0.1 rem/hr at the structural barrier.

c. The maximum attainable dose equivalent rate at the structural barrier is less than 1 rem/hr.

(3) If an experimenter needs to change material in the beam and the change might produce a greater scattered radiation dose than was observed during the survey that established compliance with (1) or (2), the scattered radiation ***must*** be surveyed by an RCT under the altered condition before the system is left unattended with the beam stop open.

The term "maximum attainable dose equivalent rate" refers to the condition with the "thickest" planned scatterer in place, the one that produces the greatest dose rate from scattered beam, with the maximum ORELA beam power of 50 kW even though the experiment normally employs a far lower power, and with the shadow bar, collimators, filters, etc., in place that are a permanent part of the flight path equipment for that experiment. (A "permanent" flight path equipment component is one that cannot inadvertently fall out of the beam line or be removed by actuating control switches, valves, etc.)

3.4.3 Flight Tube Windows

Any change in material or dimension of the thin “window” at the end of an evacuated flight tube whose volume is comparable to that of the flight station ***must*** be addressed during the experiment review. A file of each dimension-material combination ***must*** be kept in the Division Safety Office.

4.0 RADIOLOGICAL SAFETY AND INDUSTRIAL HYGIENE

4.1 General Radiological Safety

Only those ORELA staff members who have been assigned a personnel plug are authorized to escort visitors into the Accelerator Room.

4.2 Radiological Surveys of Accelerator Room

Radiological surveys are completed in accordance with the facility radiation surveillance plan.

4.3 Radiological Surveys for ORELA Experiments

4.3.1 Requests for Surveys

Radiological surveys are performed by facility RCTs in the Electron Room and the other flight stations at the request of experimenters, an experiment review committee, Facilities and Operations Project Leader, the Division RCO, or other ORELA staff members. Experimenters should ask for a survey if they are in doubt whether these procedures require one. Particular care is required in planning unusual or one-of-a-kind operations. Radiological Work Permits ***must*** be used for work with radioactive material or work in radiological areas.

4.3.2 Experimenter’s Responsibility to Persons Working Around Experimenter’s Own Equipment.

In accord with the ALARA principle, the experimenter has the responsibility to take the following actions to protect those working around his own equipment from receiving unnecessary radiation exposure:

4.3.2.1 The experimenter ***must*** inform the facility RCT and the Division DRCO of plans for flight path changes and the general nature of each planned experiment with respect to the expected range of beam strength, presence of objects that scatter beam, use of radioactive materials, the locations where the experimenters need to work with the beam “on,” etc. This should be done during the Experiment Review.

The RCT and the DRCO ***must*** be informed of changes in the flight path that might substantially increase radiation exposures. If changes are significant, the experimenter ***must*** request another Experiment Review.

4.3.2.2 The experimenter ***must*** assure that unnecessary significant exposures are avoided during revision of flight path equipment. Before such work, a survey ***will*** be made by the RCT where work is to be performed, and under the appropriate beam conditions. Appropriate controls ***must*** be established for each case.

If safety or the recorded survey depends on the work being performed with the accelerator "off," then the persons involved ***must*** secure accelerator personnel plugs while the work is being done. The accelerator ***must*** be "off" whenever a person's head or torso could be on the beam centerline with open beam stop.

If safety or the recorded survey depends on the beam stop blocking the beam, then the beam stop ***must*** be locked closed during the work. If radiation survey data are made obsolete because a shadow bar is changed or substantial beam filters are removed, a resurvey ***must*** be performed.

If collimators, etc., are to be disassembled and work performed at locations or under circumstances different from prior recorded surveys, a new survey of the work areas ***must*** be performed.

4.3.2.3 Prior to use of a significantly revised flight path, a survey ***must*** be performed and recorded by an RCT of the radiation levels at locations where work will be performed during the experiment. This survey ***must*** take into account the various conditions of beam stops, samples, and filters that can occur. Note that any radiation fields from experiments on adjacent flight paths ***must*** be considered.

The experimenter ***must*** consider whether a lower dose to himself or to others could reasonably be achieved, and if so, adopt the revised plan.

4.3.3 Experimenter's Responsibility to Persons Working on Other Projects Near His Experiment

The experimenter ***must*** also protect those working on other projects from receiving unnecessary radiation exposure by:

Coordinating with the facility RCT when the experiment is initiated to assure that any radiation area around one's flight path is surveyed under conditions corresponding to the maximum field expected during the experiment. If the experiment is then changed (for example, by removing a substantial beam "filter") so that the radiation field could increase, the experimenter ***will*** notify an RCT, who ***must*** recheck the radiation levels.

4.4 Use of Chemical Hoods in ORELA

The three chemical hoods in the basement of ORELA were designed with a prefilter and a HEPA filter, and are exhausted through stack No. 4 (a domex exhaust vent cap) on the roof of Building 6010. The hood in the clean room on the second floor also has a HEPA filter and is exhausted through stack No. 2. The User ***must*** record in the hood logbook (located at each hood) the materials and quantities used during in their work, and the duration of the work.

Before a hood is used, the user ***must*** verify that there is adequate air flow into the hood and that the air flow has been certified for the marked sash position by the Quality organization. HEPA filters ***must*** be tested and meet surveillance standards. The sash should be placed at the correct position (indicated on each hood) to insure adequate air flow. Hood usage should be identified during the experiment review process.

The hood in the EBIL clean room is not to be used for radioactive material.

The hoods in the basement are for appropriate temporary tasks, and not for storage! Hood power ***must*** be on when radioactive material is present, and this becomes an issue during a power outage. If your use of a hood will require an elapsed time greater than one week, consult with the DSO. (Note that when a hood is not in active use, the fan power could fail without your knowledge.)

Hood training ***must*** be completed prior to use of any ORELA hood.

5.0 SAFEGUARDING SENSITIVE MATERIAL DURING USE

The security of nuclear materials (actinides, lithium-6, deuterium, and tritium) at ORELA is considered in three parts: materials in storage, materials in use during normal working hours (6:00 am to 8:00 pm Monday through Friday), and materials in use during off-shift working hours. Most nuclear materials at ORELA not in use are stored in Air Force safes with combination locks. Some neutron sources such as plutonium and beryllium mixtures are stored in wall safes and secured with special padlocks. The wall safes consist of a steel pipe embedded in a concrete wall and a cap which can be locked on the portion of the pipe extending a few inches out of the concrete. Access to nuclear materials and/or sources is through the Division Material Balance Coordinator or Alternate.

Nuclear materials ***must*** be used only in the experiment stations in Building 6010 or in one of the five experiment stations exterior to Building 6010. Each experiment station in which $\gtrsim$1.0 grams of special nuclear materials (e.g., enriched uranium, ^{233}U, and the isotopes of plutonium) or >45 grams of ^{6}Li are in use ***must*** be secured with a lock with a limited number of keys to that station. (For fissionable material accountability record keeping, quantities are rounded off to the nearest gram. Hence, a 0.8-gm sample would be inventoried as 1 gram. For safeguard purposes, we interpret that the actual mass applies, i.e. 0.8 grams is <1 gram.) Keys for all experiment stations containing nuclear material in use are kept by the Material Balance Coordinator or Alternate. During normal working hours, the locked experiment stations provide the main safeguard for the material. The Security Department should be contacted during the experiment review to determine if a security plan is required when using SNM.

During off-shift hours, extra protection is available since all exterior doors (including the escape hatch in the 20-Meter Station) are equipped with entry alarms which may be utilized. The five exterior experiment stations also have entry alarms which may be utilized. The signals from the entry alarms can be annunciated at the operator's station in Building 6010 and at Protective Force Headquarters. The Protective Force investigates all unauthorized entry alarms during off-shift hours. If your entry approaches off-shift time and the entry alarms are utilized it is prudent to contact the Protective Force to inform them of your entry to an exterior experiment station.

When a special nuclear material having a mass $\gtrsim$1.0 grams and less than 250 g for ^{235}U or 200 g for ^{239}Pu or ^{233}U is in use, specific requirements ***must*** be met which are listed below. (Use of samples of ^{235}U greater than 250 g, or of ^{239}Pu or ^{233}U greater than 200 g require additional security measures which ***must*** be established before the material can be transferred.) The Principal Investigator of the experiment in which a special nuclear material in this quantity is to be used ***must*** follow the procedure listed below.

5.1 Safeguarding Sensitive Materials Requirements

5.1.1 Authorized Person List
A list of persons authorized to have access to the experiment area ***must*** be provided to the ORELA Director or his designated alternate. (It should be noted that in addition to the persons listed as using special nuclear materials in experiments, craftsmen may assist in certain phases of the experiments.)

5.1.2 General Requirements
Lock the flight station when the special nuclear material is placed in use in a particular station. Notify the ORELA Director or his designated alternate that a special nuclear material is in use in the station, and also after it is removed. Ensure that the special nuclear material is removed from the experiment station when the experiment is completed, is properly packaged, and is returned to storage.

5.1.3 Requirements to move SNM
All transfers of special nuclear material ***must*** involve the Division Material Balance Area Coordinator to ensure proper tracking and documentation is completed.

Gold and other precious metals are used in experiments and may, from time to time, be kept in combination safes by Division staff members who are the responsible "custodians" for the safekeeping of such materials. Each month those individuals receive an inventory of the material they are responsible for. Every year, all items of the inventory are weighed and/or counted by a representative from the Security Department. The Physics Division Director appoints a Precious Metals Coordinator responsible for tracking Division precious metals.

6.0 CONTROLLING ACCELERATOR CHANGES

6.1 Design Change Requirements

To control physical changes to the accelerator, the plans for all design changes to the accelerator and its directly associated equipment are reviewed and approved by the ORELA Operations Manager prior to implementation. All design changes on equipment involved in Sections 3.1-3.4 of the Accelerator Safety Envelope ***shall*** be made through the use of formal design change memos and approved by the ORELA Operations Manager prior to implementation.

6.2 Spare Parts Inventory and Use

ORELA spare parts held in the formal private inventory (referred to as the ORELA inventory) for future use are identified by an ORELA inventory record number as well as by an ORELA item identification. ORELA inventory control documentation is accessible by use of this ORELA inventory record number. This inventory is for accelerator use only.

6.3 Purchase of Parts Falling Under P-AAA

Purchase of any parts which fall under P-AAA jurisdiction ***must*** be ordered and evaluated according to P-AAA requirements. These include parts associated with equipment called out in the ASE, as well as non-accelerator-related radiological equipment such as PPE, HEPA filters, etc. The Division P-AAA Officer may be consulted for guidance.

7.0 ACCELERATOR MAINTENANCE

The operations staff maintains an informal ORELA Maintenance Log of components and systems that are believed to need maintenance. If the cause of an observed irregularity has not been identified, the symptoms are recorded. The ORELA Operations Manager or designee supervises the scheduling of the necessary maintenance work. Under the present ORELA schedule, maintenance

is usually performed on Monday morning after a weekend shut down. Problems observed by the experimenters attributed to ORELA should be brought to the attention of the ORELA Operations Manager.

7.1 ASE-Related Equipment Failures

All equipment failures related to the Accelerator Safety Envelope ***shall*** be documented and promptly corrected. Prior to renewing machine operation, surveillance checks are completed and approved by the Operations Manager or a designated alternate.

8.0 ACCELERATOR OPERATION

8.1 Request for Accelerator Operation

In order to create a schedule for accelerator operation, each Principal Investigator requesting accelerator time ***must*** complete a form "Request for Accelerator Operation" (Table 8.1, Appendix) and submit it to the ORELA Director. At or after a scheduling meeting of ORELA users, the operating schedule for the next period is formulated by the ORELA Director, distributed to experimenters and interested parties, and posted at the console. Normally one experiment is designated as the Principal Experiment and others using the beam are Secondary Experiments. Minor changes to the operating schedule may be made depending on circumstances. However, if major changes to the schedule are needed, another scheduling meeting may be convened.

8.2 Documentation of Accelerator Performance

The normal schedule for accelerator operation for experimenters is from Monday (starting after completion of normal maintenance tasks) to about 7:00 a.m. Saturday. The operator or attendant runs the accelerator at the beam conditions specified on the operating schedule posted at the console (or as close as practical) unless directed otherwise by the ORELA Director, the ORELA Operations Manager, or the Principal Investigator of the Primary Experiment. Experimenters may request that they be notified of changes in accelerator operating conditions by completing a form called "Experimenter's Instructions to Operator", available at the ORELA console. The ORELA Operations Manager specifies the machine operating performance parameters for which values are to be entered periodically into the Operating Log. Detailed start-up, run and shutdown guidelines, as well as procedures addressing safety items relating to accelerator startup have been developed and are followed. The operator initials that the safety-related items (see Section 3.2) have been performed and records the date and times in the ORELA Operating Log.

Under the supervision of the ORELA Operations Manager, records are maintained for each ORELA injector electron gun. The records cover production, processing, testing, installation, operating experience, and maintenance of that gun.

The ORELA Personnel Safety Interlock System Schematic is maintained in an up-to-date form. Other drawings are updated, based on the best available corrected prints and drawing corrections using accepted practices.

8.3 Accelerator Operators

Three groups of ORELA staff are authorized to provide different levels of accelerator operation. ORELA engineering staff trained as operators are authorized to perform all Operator functions at ORELA under all circumstances. ORELA Operators, after proper on-the-job training by the engineering staff, are authorized to operate ORELA for experimental work and development work as determined after an evaluation by the engineering staff. A third class, ORELA Attendants, after proper training, are authorized to maintain operation initiated by engineers or Operators, reset accelerator trips, and shut the accelerator down, but not perform significant tuning functions or any start-up functions. Attendants are normally members of the experimental staff rather than the Operations staff. Start-up functions have ESH-related activities and only engineers or Operators are authorized to perform those functions. Operator and Attendant training are done in accordance with the ORELA Training Procedure. A current list of Operators and Attendants ***must*** be maintained by the OM.

Operation of ORELA can be monitored remotely. Members of the Holifield Radioactive Ion Beam Facility are also authorized to perform the Attendant functions at ORELA.

9.0 QUALITY ASSURANCE ISSUES

9.1 ASE-Required Documentation

The ORELA Operations Manager ***shall*** be responsible for maintenance of the following ASE related documents. These files, with their normal storage locations (or as determined by Operations Manager), are as follows:

9.1.1 Interlock Bypass Authorization and Termination (ASE 4.1.2)	ORELA Operating Log
9.1.2 Accelerator Start-Up Checklist (ASE 4.4.1)	ORELA Operating Log

9.1.3 Personnel Safety Interlock Checklist (ASE 4.4.2)	File cabinet #1 at console
9.1.4 ASE Equipment Failure Documentation (ASE 4.4.3)	File cabinet #1 at console
9.1.5 Updated and corrected drawings for personnel safety interlock system, as of 5/90, and revisions, access control system, emergency-plug interlock system, and audible warning device system (ASE 4.4.4)	File cabinet #1 at console
9.1.6. Design Change Memos on ASE-Related Equipment (ASE 4.3)	OM

9.2 Additional Required Documentation

Additional documents required by these Procedures, which fall under the responsibility of the OM, are as follows:

9.2.1 Structural Barrier Log	OM
9.2.2 List of Operators and Attendants	OM

9.2.3 Additional documents required by these Procedures, and the responsible persons, are as follows:

Experiment Review Documentation	DSO
Flight Tube Window Documentation	DSO
Hood Logbooks	LSM
Sensitive Materials Authorized User List	ORELA Director

9.3 Additional Documentation

Finally, there are operational documents included here for completeness which fall under the responsibility of the OM:

9.3.1 ORELA Electron Gun Records	File Cabinet #1, EBIL
9.3.2 A list of the original drawings of the ORELA facilities, or "reproducibles" thereof, stored by ORNL Engineering	File Cabinet #1, console
9.3.3 The best available corrected prints and drawing corrections of the accelerator systems as of 7/1/89.	Operations Office, M2
9.3.4 Drawings or prints showing accelerator changes and drawing corrections made after 7/1/89.	Operations Office, M2

ASE related records ***shall*** be retained for the life of the facility.

10.0 TRAINING

Training ***shall*** be done in accord with the ORELA Facility Training Program, the ORELA Facility Training Procedure, and the Physics Division Training Procedure.

The operating staff of the accelerator (including Attendants) ***shall*** receive training on ASE requirements and the documents concerning such training are stored in a file cabinet at the console.

10.1 ORELA Training Requirements Review Matrix Role

ORELA experimenters and support personnel ***shall*** take training on ASE requirements specific to the ORELA facility, including administrative controls. The ORELA Training Requirements Review Matrix, (Table 10.1, taken from the ORELA Facility Training Program) identifies potentially hazardous activities in the accelerator room and the experimental areas, and defines the training needed to mitigate those hazards at ORELA. Re-training ***must*** be completed in accordance with the schedule given in the Requirements Matrix. A Physics Division Training Requirements Review Form ***must*** be filled out for each ORELA experimenter and support person by the appropriate supervisor. Records of those trained are maintained in SAP. ORELA staff and users ***must*** complete this training before having access to the scramble locks on doors leading to the accelerator level (see Section 2, FACILITY ACCESS).

In addition to the general industrial and ORNL-specific training provided and documented through their parent administrative units, support personnel assigned to the ORELA may receive facility-specific training covering safety-related equipment and administrative controls related to their work, but not covered in the ORNL-wide training. Facility-specific retraining ***must*** be completed biennially. Support personnel temporarily at ORELA who have not received applicable training ***must*** not do work requiring training until the training is completed.

11.0 PROCEDURES FOR MODIFYING THIS DOCUMENT

When a procedure outlined in this manual is changed, the revised version ***must*** be approved at a minimum by the ORELA Operations Manager, ORELA Director, and appropriate Physics Division Line Manager at the Group Leader or higher level. The updated approval sheet will be distributed with the updated sections. Justification for revisions ***must*** be documented, and a history file of changes ***must*** be maintained by the ORELA Director.

When revisions and replacement sections are distributed, it is the responsibility of the individual receiving the changed sections (or someone delegated by him) to insert the replacement pages and to remove and destroy the superseded pages. All revised sheets ***will*** be dated and the revised Table of Contents ***will*** show latest revision dates. The ORELA Director will authorize replacement of ORELA documents on the www.

Table 3.2.3 Personnel Safety Interlock Checklist

PERSONNEL SAFETY INTERLOCK CHECK LIST

DATE _____

1. Magnet Room and Accelerator Room emergency plugs (6 each) _____
2. Magnet Room escape hatch (2 each) _____
3. Accelerator Room door switches (2 per door; 3 doors) _____
4. Personnel plugs at Accelerator Room entrance (40 each) _____
5. Accelerator Room door key switch _____
6. Check siren and 30 second run time _____
7. Check Accelerator Room door locks _____

The following four items are non-ASE related:

8. Mod. No. 1: Shorting stick (3 each), shorting bar, and door interlocks (5 each) _____
9. Mod. No. 2: Shorting stick (3 each), shorting bar, and door interlocks (5 each) _____
10. Mod. No. 3: Shorting stick (3 each), shorting bar, and door interlocks (5 each) _____
11. Mod. No. 4: Shorting stick (3 each), shorting bar and door interlocks (5 each) _____

Signed _____

Signed _____

ALL ITEMS ON FORM REVIEWED AND APPROVED _____

Table 3.3.2.
Summary from R. W. Peelle's letter dated January 11, 1988, entitled "How Much Radioactive Material Content Is Required for a Sample to be Considered "Hazardous". .
The Summary has been updated to reflect current terminology, but no numerical values or recommendations have changed. It also has been reviewed using currently available numerical values for Derived Air Concentrations, etc. and results were unchanged from the original analysis. To ensure the original letter and its analysis remain available, it is included on the following pages.

Guidelines:

The following internal guidelines interpret the term "hazardous" as it applies to radioactive samples used in experiments at ORELA.

1. Sample construction and use in a new ORELA project is reviewed and approved by the Experiment Review Committee if a sealed sample of bound material to be used contains as much as 0.1 mg of ^{239}Pu or inhalation equivalent, or if an unsealed sample of bound-solid material contains as much as 1 µg of ^{239}Pu or equivalent. All samples of nonsolid or powdered radioactive material ***must*** be reviewed.

2. If a sealed sample containing as much radioactivity as 1 g ^{239}Pu or equivalent is to be used in a flight station from which air exhausts through the ORELA stack, the HEPA filter for that station ***must*** be tested unless such certification has been obtained during the previous year. For a remote flight station that exhausts near ground level, the corresponding limit is 0.01 g ^{239}Pu or equivalent.

3. For a singly-sealed sample containing alpha-particle radioactivity equivalent in hazard to 1 mg ^{239}Pu or more, a continuous alpha air monitor is operated in the flight station where the sample is used and any person who handles the sample monitors his fingers before leaving that flight station. If the sample is doubly sealed, these precautions are invoked if samples contain more than 1 g ^{239}Pu or equivalent.

   During the experiment review, the limits in items 2 and 3 above may be modified for particular samples or uses. Such modifications ***should*** be documented and approved by the DRCO and the ORELA Director.

   The complete Peelle document is included on the following pages.

INTRA-LABORATORY CORRESPONDENCE
OAK RIDGE NATIONAL LABORATORY

January 11, 1988

To: ORELA Staff and Experimenters

From: R. W. Peele (initialed here)

Subject: How much radioactive material content is required for a sample to be considered "hazardous" with respect to the ORELA Final Safety Analysis Report and Operational Safety Requirements.

SUMMARY:

The following internal guidelines interpret the term "hazardous" as it applies to radioactive samples used in experiments at ORELA.

(1) Sample construction and use in a new ORELA project is reviewed and approved by the EPMD Radiation Control Officer if a sealed sample of bound material to be used contains as much as 0.1 mg of ^{239}Pu or inhalation equivalent, or if an unsealed sample of bound-solid material contains as much as 1 µg of ^{239}Pu or equivalent. All samples of nonsolid or powdered radioactive material must be reviewed.

(2) If a sealed sample containing as much radioactivity as 1 g ^{239}Pu or equivalent is to be used in a flight station from which air exhausts through the ORELA stack, the HEPA filter for that station must be tested to the specification listed in the FSAR unless such certification has been obtained during the previous year. For a remote flight station that ex- hausts near ground level, the corresponding limit is 0.01 g ^{239}Pu or equivalent.

(3) For a singly-sealed sample containing alpha-particle radioactivity equivalent in hazard to 1 mg ^{239}Pu or more, a continuous alpha air moni- tor is operated in the flight station where the sample is used and any person who handles the sample monitors his fingers before leaving that flight station. If the sample is doubly sealed, these precautions are invoked if samples contain more than 1 g ^{239}Pu or equivalent.

(4) During the experiment review (1), the limits in items (2) and (3) above may be modified for particular samples or uses. Such modification should be documented.

DETAILS:

Our safety documents require specific actions when we utilize samples, taken to be enclosed and sealed, that contain “hazardous quantities” of radioactive material. There are four different requirements. (1) The experimenter is to have new projects involving hazardous samples reviewed by the Division Safety and Radiation Control Officer. [FSAR Sec. 4.2.5, OSR Sec. 5.1.f]. (2) A HEPA filter is to be installed in the air outlet from the flight station, and must have been checked during the year before the experiment. [FSAR Sec. 4.2.5, OSR Sec. 4.5]. (3) Persons who handle samples containing alpha-active material are to check themselves for contamination before leaving the flight station. [FSAR Sec. 4.2.5, OSR Sec. 5.1.f.]. (4) A continuous alpha air monitor is operated in each flight station where a sample is in use that contains a hazardous amount of alpha-emitting material. (SAR Sec. 4.2.4, OSR Sec. 4.6.). It is implied that standard health physics procedures define the minimum amount of material in a sample for it to be considered “hazardous.” The purpose of this note is to apply radiation protection guidelines to quantify the limits that trigger these various precautions.

Such limits cannot be derived unambiguously, so this memo attempts to be reasonable rather than scholarly. Limits are stated in terms of ^{239}Pu or its inhalation equivalent, based on the assumption that air contamination will be limiting. Estimates are rough, but experiments to back them up would involve great expense and would risk more exposure than arises in the use of the samples. Estimates are based primarily on the July 1987 edition of the ORNL Health Physics Procedures Manual, NBS Handbook 69, ICRP-30, Draft DOE Order 5480.11 dated 8-2-87, and the release fractions estimated in the Final Safety Analysis Report. The new DOE Order being prepared to cover radiological protection will conform more nearly to publication ICRP-30 (1979) than to the decades-old NBS Handbook 69 on which the current Health Physics Procedures Manual was largely based. The concepts for considering internal dose have changed considerably, so where guidelines differ this memo will lean toward using the more modern references.

<u>Converting the limits for different radioisotopes.</u> The HP Procedures Manual presently contains extensive tables of HEP (Hazard Equivalent Plutonium) values in Section A-7 for inhalation hazard. [For example, the value for ^{240}Pu is given as 0.084 g to be equivalent to 1 g of ^{239}Pu.] This table is from a 1963 a TM report. Since the values listed there for a given chemical element are not inversely proportional to the specific activities of the various isotopes, and since the Maximum Permissible (air) Concentrations (MPC’s) in NBS Handbook 69, the Annual Limits on Intake (ALI) in ICRP-30 and the Derived Air Concentrations (DAC) of the Draft DOE Order give about the same disintegration rates for all the plutonium alpha emitters, the MPC values from Handbook 69 or the ALI values from ICRP-30 should be used in preference to the HEP factors listed in the 7/87 ORNL Health Physics Procedures Manual.

<u>What fraction of the contents of a sealed sample could be released?</u> The ORELA Final Safety Analysis Report treats release of sample contents as follows:

a) The cases analyzed involve 1-g samples of ^{239}Pu in sealed fission chambers. These are "singly-sealed." By implication, the heavier doubly-sealed samples used for transmission measurements are estimated to be correspondingly tighter – i.e., apt to leak no more material than a 1-g ^{239}Pu fission chamber when subjected to the same insult.

b) In Section 5.2.2 of the FSAR it is assumed that about 10^{-5} of the active material in a fission chamber could be released and become air-borne in an accident with no fire.

c) In Section 5.4 of the FSAR it is estimated that in a fire 10^{-3} of the plutonium in a fission chamber could become airborne.

These estimates are plausible considering that the evaporated deposits we now use seem to be well bonded to the backing foils.

<u>What size release from the sample would be hazardous?</u> Should a seal break and some radioactive material start to diffuse through the air, what level of release would be hazardous? The Appendix to the memo contains a series of notes gleaned from the references. Note that these references deal primarily with planned or routine exposures, while here we are concerned with accident conditions which we intend never to occur. The following items summarize author's findings from the notes in the Appendix:

(a) For alpha emitters, the bone is the target, and exposures may be averaged over years. In the old language we accept an accidental exposure dose commitment tolerance of 40 rem to the bone based on an annual figure given for tolerable routine exposure. In the newer language of ICRP-30, we assume the entire ALI for one accidental exposure and the weighting system takes care of the equivalence to a 5 rem [0.05 Sievert] whole body equivalent dose limit.

(b) At least for plutonium, air contamination governs the hazard. The less-serious insoluble plutonium is assumed here since the oxide is the most likely chemical form. [In the language of ICRP-30, the Class Y values apply because clearing from the lungs is slow.] One considers the 50-yr dose commitments consequent to breathing Pu-containing particles assumed, for lack of information, to have a particle size of 1 μ.

(c) The conversion factor that is used in the ORELA FSAR, 3 rem 50-yr commitment per nCi uptake of ^{239}Pu from the air, with the 40 rem accident tolerance in (a), leads to 13 nCi or 500 Bq (alpha/s), about 0.2 μg of ^{239}Pu, as an annual uptake limit. This is just the Class Y ALI from ICRP-30 that would be applicable to PuO_2 particulates. [1 ng ^{239}Pu has activity 61 pCi or 2.3 Bq].

(d) The Class Y Derived Air Concentration (DAC) or ^{239}Pu of 0.2 Bq/m^3 from ICRP-30 corresponds to the uptake in (c) assuming a 2000-hr exposure with an aggregate workday breathing volume of 2400 m^3 as assumed in the FSAR. For a short-term accidental exposure we can afford a correspondingly greater air concentration. We use this modern DAC value.

(e) The ORNL continuous alpha air monitors are sufficiently sensitive to give an alarm in about 0.5 H hours starting with a fresh filter if the air concentration of ^{239}Pu oxide is such that a worker will inhale a week's (0.02) fraction of the Class W ALI in H hours of quiet breathing.

(f) The standard ORNL alpha-sensitive probe has sensitive area 70 cm^2 with a counting efficiency of 15%. It is reasonable to try to detect a contamination level of about 2 ng ^{239}Pu or equivalent on a worker's fingers to check for an accidental release from a sample. One would have to detect ~0.5 cts/s, which can be done using a 10-s counting time on each hand.

Based on a) through f), estimates can be made to obtain the desired limiting sample contents.

(1) A bound solid sample containing less than 1 µg ^{239}Pu equivalent need not be reviewed even if it is not sealed, because accidental dispersal of the whole sample would not produce a serious hazard considering that an individual could not inhale a large share of the whole sample. A sealed sample of up to 0.1 mg ^{239}Pu equivalent in a bound solid form can be similarly unregulated because of the protection provided by even unreviewed containment.

(2) The HEPA filters installed in air exhaust streams protect those outside the ORELA facility from exposure. The FSAR indicates that complete accidental release up the ORELA stack of 1 mg ^{239}Pu or equivalent gives a person's bone a 2.4-rem dose commitment at 100 m from the stack. Applying the 10^{-3} factor applicable to particulate release from a sealed sample in a fire implies that a filter is not really required for a sample smaller than 1 g if exhaust is through the stack. A limit of 0.01 g is applied to the remote flight stations that exhaust air near ground level in a lightly controlled area. Because the HEPA filter precaution is easy to satisfy, for extra conservation no credit is taken for double-sealed samples, and for smaller samples the filters are retained but not specially recertified.

(3) If a singly-sealed sample can release 10^{-5} of its contents to the air as indicated in the FSAR, then one handling a sealed 1-mg ^{239}Pu or equivalent sample having a broken seal could have a hand contaminated with the detectable level of about 2 ng. [A fractional release this large is unlikely unless damage to the sample is obvious.] A doubly sealed sample is considered about 10^3 times more secure, particularly for non-obvious damage to the seals.

(4) A 1-mg sample of ^{239}Pu, if it should release 10^{-5} of its activity to air without air turnover being effective, would place 10 ng in the air of the flight station postulated in our FSAR to have volume 10 m^3, yielding 1 ng per m^3. In two hours an air monitor if present would pump 10 m^3 through its filter, placing the 10 ng of ^{239}Pu on the filter if one ignores exponential effects. At 45% counting efficiency this would give about 10 counts/s, the alarm level. [Given no radon background, this would be adequate warning. In practice, it would be enough to produce alarms that the health physicist could distinguish from radon.] A person breathing the 1 ng/m^3 concentration would experience an air concentration about 10 times the plutonium oxide

DAC for that two hours; he would thus receive about 0.01 ALI in the time period required for the alarm to sound. [Staff members infrequently spend that long in one visit to a flight station.] If the concentration were higher as for leakage from a sample containing more activity, the alarm would go off sooner, and the maximum dose commitment would be similar. This is a small dose commitment for an unlikely event, but it is worth providing monitoring for such samples under the ALARA principle. A much smaller sample is unlikely to leak enough activity to the air to be detectable, considering that our flight stations are larger than assumed and there is air turnover. From the appropriate perspective of annual uptake, a less active sample does not have the practical potential to exceed 0.1 DAC averaged over an important time interval.

Conclusions on how much radioactive content is required for a sample to be considered "hazardous"

1. Review of sample construction and use in new projects or experiment setups is required for sealed bound-solid samples larger than 0.1 mg ^{239}Pu or inhalation equivalent, and for bound-solid unsealed samples larger than 1 µg of ^{239}Pu. All nonsolid or powdered samples of hazardous substances must be reviewed. Once a particular sample has been reviewed for use in a particular project or experiment setup, use of the sample in that setup need not be reviewed again. Reviews must be documented.

2. If a sample containing as much radioactivity as 1 g ^{239}Pu or equivalent is to be used in a flight station that exhausts through the ORELA stack, the HEPA filter for that station must have been tested during the previous year to the specification listed in the OSR. If the sample is to be used in a remote station that exhausts at ground level, the lower limit is 0.01 g.

3. An alpha-particle contamination monitor is to be used before leaving the flight station by any person who handles a sample that contains more alpha-active material than the applicable limit below. In this check enough care is to be taken to observe an alpha-particle counting rate as large as 30/min on either hand that touched the sample container. A suggested counting procedure is to take a 10-s count on each hand. If two impulses are recorded in either test, then a half-minute count should be taken and a background check made. Any real count over background should be investigated by the health physicist using smear techniques. The lower limits are:

1 mg ^{239}Pu or equivalent if the sample is singly sealed, or
1 g ^{239}Pu or equivalent if the sample is doubly sealed.

4. If a sample contains as much alpha activity as the limits in item (3) above, a continuous alpha air monitor is operated in the flight station where the sample is in use.

The limits for items 2-4 above may be modified for a particular sample during the experiment review. If important radioactivity other than alpha activity is involved, the review should establish alternative monitoring techniques to items (3) and (4) above.

It is recognized that according to Handbook 69 the 1 and 3 Ci Am-Be neutron sources presently at ORELA are equivalent in inhalation hazard, if converted to particulates in the air, to 6 and 20 g ^{239}Pu samples. [R. L. Macklin's Pu-Be source contains just under 1 g of ^{239}Pu.] However, we believe the construction of these sources has been thoroughly reviewed. Traditionally, such sources have been constructed to high standards with double welded containment. These sources are not considered "samples" for the purpose of this note.

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APPENDIX

The section references are to the ORNL Health Physics Procedures Manual unless otherwise specified.

a) Appendix A-12 notes that the Radiation Protection Standards in DOE Order 5480.11 give limits for 50-year dose commitments for internal exposure that are numerically equal to the limits for dose from external exposure. The ALI values in ICRP-30 are also based on the dose commitment concept, as are the Derived Air Concentrations of draft DOE Order 5480.11.

The same page of Appendix A-12 states that "Work areas in which there may be a release of activity which could reasonably result in an internal deposition such that a quarterly dose commitment (3 rem whole body, 10 rem bone, and 5 rem other organs) is exceeded, should be provided with continuous air monitors."

b) Table 1 from Appendix A-1 gives single intake quantities to deliver permissible dose rates to specified tissues. (i) Three micrograms inhaled soluble ^{239}Pu is quoted to give 0.11 rem/wk or a 50-y dose commitment of 280 rem. This corresponds to 400 ng for an uptake that would induce a 40 rem annual or accidental 50-y dose commitment to the bone. (ii) 100 ng insoluble ^{239}Pu via lymph nodes is quoted to give 0.3 rem/wk or a 50-y dose of 750 rem. This implies about 2.4 ng absorbed in the lung would give an annual or accident tolerance 50-y dose commitment of 20 rem. Since this lymph sensitivity is not mentioned elsewhere as so extreme, and since the relative MC values even in Handbook 69 for soluble and insoluble Pu seem inconsistent with this extreme sensitivity, the result in (ii) is disregarded below. For a single event, we consider a limit of ~0.1 μ of inhaled ^{239}Pu, like an annual tolerance rather than the lifetime limit of 3 μg. There is inherent conservatism for us, since an ORELA person will experience of the order of one such event and the limit is an annual dose tolerance.

ICRP-30 inherently includes the exposure of all sensitive organs. On page 107, for the inhalation of 1-μ particles of Class Y compounds, the ALI for ^{239}Pu is Bq, 500 Bq, corresponding to 220 ng. For Class W compounds the ALI is given as 200 Bq or ~90 ng.

c) NBS Handbook 69, dated 1959, gives 40 hr week air MPC's of $2x10^{-12}$ for soluble ^{239}Pu based on bone, and $4x10^{-11}$ for insoluble Pu based on lung, in units μCi/cc or Ci/m^3. The first corresponds to 0.1 Bq/m^3, the second to 2 Bq/m^3. If all the ^{239}Pu sticks in the lungs, a worker exposed for a year, 2000 hr. at the MPC of 0.1 Bq/m^3 for soluble Pu, at the standard breathing rate takes up 0.1*2400 m^3 = 240 Bq or about 100 ng.

Page 3.2 of HP Procedures gives a tolerance for unidentified alpha air contamination for a 40 hr week of 1 α/s/m^3. The MPC from Handbook 69 is supposed to apply if the source material is identified. Note that this limit is between the 0.1 and 2.0 Bq/m^3 of the previous paragraph.

ICRP-30 gives a Class Y Derived Air Concentration (DAC) of 0.2 Bq/m^3 for ^{239}Pu. 2000 hours of breathing gives the correspondence to the 500 Bq ALI. For Class W compounds, this reference gives 0.08 Bq/m^3.

Attachment 1 to the draft DOE Order 5480.11 gives DAC values equivalent to 0.08 Bq/m^3 for W Class solubility and 0.1 Bq/m^3 for Class Y solubility. Plutonium Oxide is assigned to Class Y.

d) Our SAR quotes and uses a 50 y dose commitment conversion factor of 3 mrem/pCi for ^{239}Pu in bone marrow. This corresponds to about 0.08 rem/Bq, which implies about 200 ng of ^{239}Pu uptake for a 40 rem accident dose commitment. This is consistent with the modern ALI value of 500 Bq for solubility Class Y.

The SAR also assumed that in 10 min a worker would breathe 2% of the volume of a 10 m^3 room - - somewhat smaller than any room we have. Ten minutes might be a reasonable estimate for the length of an unknowing exposure.

e) According to the HP Instruments Manual, the alpha air monitor pumps 3 ft^3/min or 5 m^3/hr through a filter seen by the alpha-particle detector. It has 45% counting efficiency. That implies that the 0.2 Bq/m^3 DAC of Class Y ^{239}Pu would in this instrument give after 1 h a 30 count/min rate, very often less than the radon rate of up to 50 or even 500! If the ALI of ^{239}Pu were to be inhaled in a day of constant exposure before the release is recognized, the air contamination would be 50 Bq/m^3, and the 600 cpm alarm threshold would be reached in just minutes starting with a clean filter. (The instrument seems most effective for sporadic relatively high concentrations, since it requires 20 hours to reach the alarm point at the ^{239}Pu oxide DAC.) The draft DOE Order 5480.11 states that ambient air monitoring shall be performed in areas with the potential to exceed 10% of any DAC.

f) Appendix A-3 sets the upper limit of alpha surface contamination for an unregulated zone at an average of 30 d/m/100 cm^2, with a maximum level ten times as high, for direct reading. The tolerances are given as one tenth that high for transferable activity. These values seem to be based on an argument irrelevant to us concerning air contamination derived from loose surface contamination. Table 5 in Section 2.5 of the HP manual gives a recommended maximum contamination of hands of 300 d/m/100cm^2, equivalent to 5 Bq or 2 ng of ^{239}Pu on that area. These values seem consistent with the limits given in Attachment 2 of the draft DOE Order 5480.11. This limit also seems consistent with the above paragraphs and reasonable since Pu activity takes up by mouth is not as serious as by air, and since only a small hand contamination can become airborne again. The standard ORNL alpha-sensitive probe has a sensitive area of about 70 cm^2 and a 15% solid angle, so would register about 30 cpm for 5 Bq of surface alpha contamination spread over 100 cm^2. [The alpha probe at the 20-m station gave 1 $\pm$.3 background counts/min in a single trial.]

RWP:ll

cc: F. C. Maienschein
G. F. Maskewitz, EPMD Quality Officer
K. M.Wallace

Table 8.1. Oak Ridge Electron Linear Accelerator Experimenter's Request for Accelerator Operation

OAK RIDGE ELECTRON LINEAR ACCELERATOR EXPERIMENTER'S REQUEST FOR ACCELERATOR OPERATION

Name _____ Date _____

Requested Starting Date _____ Amount of Time Requested _____

Repetition Rate _____ pps Pulse Width _____ ns Target _____

Average Beam Power _____ kw Electron Energy _____ MeV

Flight Path _____ Flight Station(s) _____ Lab _____

Data handling Requirements: _____

_____

Measurement _____ Energy Range _____

Complete the remainder of this form only for new experiments:

Brief Description of Equipment: _____

_____

_____

_____

Use of Hazardous Chemicals or Radioactive Samples: _____

_____

_____

Description of Collimators and Physical Barriers: _____

_____

_____

_____

Approved: _____ Date: _____
ORELA Director

Table 10.1 Training Requirements Review Matrix

TABLE A. ORELA GENERAL TRAINING QUALIFICATION REQ.										ORELA FACILITY SPECIFIC TRAINING QUAL. REQ.							
FUNCTION	MODULE	GET	Rad Wrkr I	Rad Wrkr II	HazCom Gen & Site-Spec	LO/TO	Confined Space Ent/Att	E1 Safety	Crane Op	6010 Unesc. Access	6010 Basement Unesc. Access	Expmt. Safety	Local Emerg. Squad	ORELA Qual. Oper. Training	ORELA Atten-dant	ORELA Interlock Check	ORELA Procedures
Minimum retraining frequency		D	D	D	D	D	D	D	D	B	B	B	A	A	A	D	D
Unescorted Access to 6010 for Staff and Guests										x							
Unescorted Access to 6010 basement										x	x						
Access to radiation areas or controlled areas where beam may be present			x							x	x						
Access to high radiation/contamination areas				x						x	x						
Experimenters		o	x	o	o			o		x	x	o			o		o
Unescorted access to Accelerator room		x	x							x	x						
Unescorted access to Target room		x		x						x	x						
Access to filter boxes				x	x					x	x						
Approved ORELA Operator		x		x	x	o	o	o	o	x	x		x	x			o
Approved ORELA Attendant		x	x							x	x				x		o
Operations Manager		x		x	x	o	o	x	o	x	x	x	x	o	o		o
Facility Manager		x	x		x	o	o			x	x	x	o				o
F&O Maintenance Personnel*		x		o	o	o	o	o	o	x	x						
Bldg. 6010 Emergency Squad		x	o							x	x		x				
ORELA Emergency Response Personnel*		x		x						x	x						
ORELA Engineer		x		x	x	o	x	o	o	x	x	x	o				o
Perform Interlock Checks		x	x		x			x		x	x	x				x	o
*Through MOU Agreements																	

Symbol "x" indicates a mandatory requirement; symbol "o" indicates an applicable requirement.

A = annual; B = biennial; D = minimum retraining frequency defined in training document or specified by ORNL requirements.