Title:	VAULT RADIATION SURVEY PROCEDURE		
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1.0 PURPOSE

This procedure describes the steps necessary to properly perform a RADIATION SURVEY. This procedure must be used after a Cyclotron run before Cyclotron radiation workers or any visitors enter the Cyclotron Vault for tours, inspection, maintenance, testing, etc. The survey results enable workers to estimate properly in advance any radiation exposure expected from performing any work in the area. The most recent Vault Radiation Survey forms are posted at the west vault door entrance to inform anyone entering the Vault of the radiation conditions in the Vault. Follow the LBL ALARA (As-Low-As Reasonably-Achievable) Policy for personal radiation exposure during all radiation surveys.

This survey is to be used to check only areas where beam had been generated or transported to in the just-completed run. For quick inspections during a break in a run, surveyors shall be allowed to monitor the intended working area only. Any other maintenance workers must await the survey results of the working area prior to any maintenance during a break in a run or following a run.

The scope of this procedure includes selecting an appropriate survey meter, testing the survey meter, entering the Cyclotron Vault, measuring the residual radiation in the Vault with an appropriate radiation survey meter, and recording the measurements taken on the Vault map of the Vault Radiation Survey form.

Those parts of the Cyclotron or experimental apparatus exposed to the accelerated ion beam may become activated. After the beam is removed, the activated parts may emit x rays, beta rays, and gamma rays. The energy, intensity, and duration of emission will vary widely, and are determined by:

A. The type of ion that was last accelerated;
B. The energy to which the ion beam was accelerated;
C. The chemical composition of the Cyclotron parts hit by the ion beam;
D. The duration of the ion beam exposure;
E. The decay mode and half life of the activated material.

Residual fields at any given point in the Vault rarely exceed a few tens of milliRoentgen per hour (mR/h).

The performance of this procedure adheres to the requirements of Radiation Work Authorization (RWA) 5083: 88-Inch Cyclotron Operation and Maintenance.

2.0 QUALIFICATION

This procedure is to be performed by a qualified radiation worker or Cyclotron Operator (a second radiation worker, operator, or a trainee, may accompany the qualified worker for safety or training purposes only.) Only people already trained in this procedure may survey the Vault.

This procedure may be performed by the persons who have completed NSD1002 "Vault Radiation Survey Procedure" training. The EH&S Training Reports database may be checked to find the names of the persons that have completed the required training for this procedure. Qualification, or requalification, is in effect as of the date indicated by the EH&S Training Reports database as the date taken.

3.0 HAZARD REVIEW

The performance of this procedure may subject personnel to the following potential hazards:

Radiation:

Hazard: After the run beam line components or experimental components may emit x rays, beta rays, and gamma rays as a result of becoming activated during the run.

Mitigation: Plan the survey to minimize the exposure using the following steps:

1. Plan the survey route. Seek to avoid prolonged exposure to intense fields.
2. Hold the survey meter at arm's length, minimizing exposure to the body.
3. Shield the body with other equipment, when possible.
4. Always seek to minimize the duration of exposure. Move safely but smartly; a quick in-and-out trip should be the goal. A survey should not take more than a few minutes.
5. Step back from spots where fields read above 100 mR/h to record readings. If fields above 100 mR/h are encountered, the field may be read at a distance to give a 100 mR/h reading, and that distance noted on the survey sheet (for example, '100mR/h at 2 meters distance'). Care should be taken so that the dose received is As-Low-As-Reasonably-Achievable (ALARA).
6. Determine which beam line was last used. Most radiation surveys made during or after heavy ions runs can be made with no dose to the surveyor. During and after light ion runs, fields can be well over 1 R/h or higher and measurable doses may be received.
7. Delay the survey until necessary.
8. The LBL ALARA (As-Low-As Reasonably-Achievable) Policy for personal radiation exposure applies to all radiation surveys. Do not approach high radiation areas so closely that your body enters a field ≥100 mR/h in strength. If the radiation fields encountered in the Vault are too high to make a survey, **STOP THE SURVEY**. Leave the Vault, and close the concrete Vault door. Notify the Radiation Control Technician (RCT). Post the "Survey Not Done" sign at the Vault outer gate.

4.0 PROCEDURE

4.1 SURVEY PREPARATION

Before the procedure for the survey can be started, the following preparations are necessary.

4.1.1. Select a radiation survey meter from the following list of meters approved for use in this procedure (this list may be modified by the Cyclotron's RCT)

LRL- I-70 Beta-Gamma Survey Meter (Anton-type)
Victoreen- Inovision 450/451
Bicron- RSO-50 Survey Meter
Meridian- 5085 Neutron Survey Meter (Health Physics Instruments)

4.1.2. Verify that the selected meter is in current calibration (based upon the "calibration due" date).

4.1.3. Check that the meter battery is adequately charged.

4.1.4. Check the meter with a known radiation source (if reasonably available). (Zero the meter in a low-background-radiation area)

4.1.5. Start with the meter set to its most sensitive range.

4.1.6. Record the meter type, the DOE property number, and the meter calibration due date on the Radiation Survey form (blank forms are always kept on a clipboard at the west Vault door)

4.2 VAULT SURVEY

The radiation dose to a person making a survey shall be kept to a minimum. Any dose must be commensurate with the benefit gained from taking the survey. Follow the radiation hazard mitigation measures (Section 3.0) to minimize exposure during the survey.

4.2.1. Verify with the Control Room that the Cyclotron RF System is switched off, using the 12 kV Breaker. With the operator's permission open the Vault door using the Vault Castell key from the Control Room.

4.2.2. Open the outer gate and inner west controlled area gate. Enter the Vault.

NOTE

The white Vault lights are essential for safe movement through the Vault and to ensure that you have enough light to read the survey meter and record readings. Do not proceed into the Vault unless the white lights are operating.

4.2.3. At the west entrance measure the field with the meter held forward at arm's length. If the measured field strength exceeds a few mR/h as you approach the north port, go to step **4.2.4. High Fields**, of this procedure. (Such a field as you approach the north port may be coming from the staging line and/or the deflector, indicating that fields around the cyclotron and beam lines may be much higher than usual.) Otherwise proceed to step 4.2.**5 Normal Fields**.

4.2.4. **High Fields**: Do not approach high radiation areas so closely that your body enters a field ≥100 mR/h in strength. If the radiation fields encountered in the Vault are too high to complete a survey (i.e. receiving > 1 mR during the survey), then **STOP THE SURVEY**. Leave the Vault, and close the concrete Vault door. Notify the RCT. Post the "Survey Not Done" sign at the Vault outer gate.

Post any areas that are 5 mR/h at 30 cm or greater as a **Radiation Area**, indicating when the survey was made and the level recorded. Post any areas that are 100 mR/h at 30 cm or greater as a **High Radiation Area**. Record these areas on the survey form.

Record on the Vault Radiation Survey form the strength of the fields measured, where the measurements were made, and the distance from the estimated radiation source for each measurement. Also attach a note to the Castell key that indicates that no survey of the Vault has been made yet and return the key to rack A-9 in the Control Room. Advise the RCT and the Operator in Charge of the conditions. The RCT or Operation Supervisor will complete the survey as soon as practical.

4.2.5. **Normal Fields**: Proceed carefully through the Vault. Read and record the residual radiation levels around the cyclotron and along the beam line last used, as shown on the Vault Radiation Survey form. Mark directly on the floor map form to indicate any high radiation areas you find, recording the field strength and distance at which the field was read. Locate and record the general source of the fields, if possible (e.g., the staging line after the quadrupole magnets).

4.2.6. Leave through the west Vault door, closing the inner and outer gate behind you.

4.2.7. Post the Vault Radiation Survey form at the west door of the vault. The survey is complete.

5.0 RECORDS

Records generated by performance of this procedure are to be in compliance with RPM, Section 1.18, Records Management. Records generated through implementation of this procedure consist of completed Vault Radiation Survey forms and/or entries made in the Vault logbook (located at the west vault door). The old Vault Radiation Survey forms are kept in the Survey binder in the control room and are controlled by the RCT.

6.0 REVIEW OF PROCEDURE

Under the guidelines for DOE Order 420.2B, this procedure will be reviewed at least once every three years, or sooner if changes occur that may impact the appropriateness or implementation of this procedure.

REVISION HISTORY

1 June 2006: Updated and approved as V 1.0 to reflect current operating practices and implementation.

7.0 GLOSSARY

HIGH-RADIATION AREA: Any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 100 mrem in one hour 30 cm from the radiation source or from any surface that the radiation penetrates.

mR/h: milliRoentgen per hour. For beta and gamma radiation 1 Roentgen equals 1 Rem.

mRem: millirem . The unit of radiation dose to people (a REM is one Roentgen-Equivalent-Man)

OCCUPATIONAL DOSE LIMIT: Per LBL Radiological Control Manual (LBL PUB-3113), the administrative occupational exposure is limited to 100 mRem per year. There are exceptions, but prior written approval of the Radiological Control Manager (EH&S) is required.

RADIATION AREA: Any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 5 rem in one hour 30 cm from the radiation source or from any surface that the radiation penetrates.

8.0 REFERENCES

1. LBL Publication 3000: Health and Safety Manual, Section 21.
2. LBL Publication 3113, LBL Radiological Control Manual.
3. DOE Order: DOE O 420.2B, *Safety of Accelerator Facilities*
4. EH&S RWA 5083: 88-Inch Cyclotron Operation and Maintenance

9.0 ATTACHMENT

Attachment A. Vault Radiation Survey form. Changes to the survey form do not warrant revision to the procedure.

Attachment A
Vault Radiation Survey

RWA # _____ BLDG./ROOM _____ DATE: _____ CLASS: (I, II, or III) ____

Purpose of Survey: ☐ Routine Work ☐ Monthly ☐ Other: _____

Type of Survey: ☐ Radiation ☐ Contamination ☐ Other: _____

PROCEDURES:

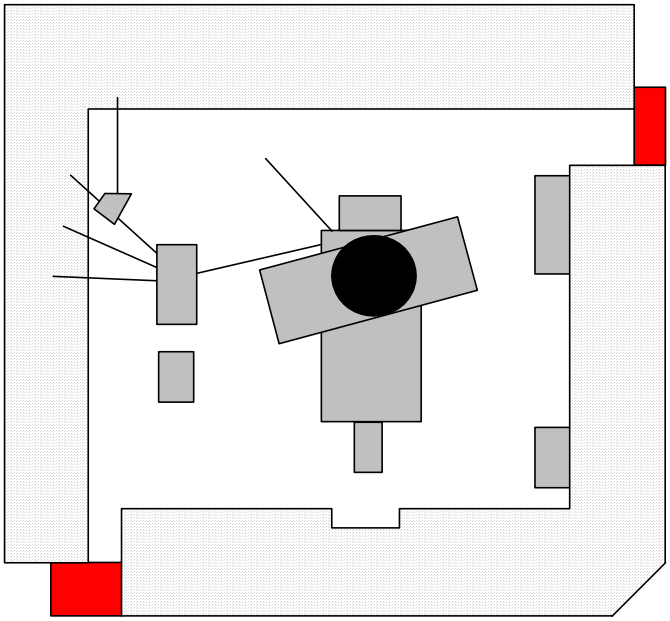
Contamination Survey <dpm>

- Working surfaces and floor areas are smear tested for removable contamination.
- An area of approximately 100 square centimeters is covered by each smear.
- Results are reported as net (background corrected) counts per minute <cpm> on the sketch below.

Area Radiation Survey <mrem/hr>

- Radiation exposure rates are measured at work areas.
- Readings are reported as millirem per hour on the sketch below.
- Except where noted, readings are for gamma and/or beta radiation measured at beam line height.
- Known sources of radiation are noted on the sketch, but all areas should be monitored due to frequent changes.

*****FILE COPY OF THIS SURVEY IN THE RADIOLOGICAL WORK JOURNAL*****



SURVEY INSTRUMENT INFORMATION

	Survey Meter #1:	Survey Meter #2:	Survey Meter #3:	Scintillation Counter
• Manufacturer				
• Model #				
• DOE #				
• Source check				**not applicable**
• Background				
• Calibration date				

Performed by _____

Signature _____ **Date** _____