

End Station B High Power RF Equipment Lockout Procedure

Scope

This equipment lockout procedure (ELP) applies to high power radio frequency (RF) systems in End Station B where there is a possibility of exposure to microwave energy. High power RF equipment includes the drive amplifier of a klystron or a traveling wave tube. This ELP does not apply to low and very low power RF systems.

Roles and Responsibilities:

Project Manager Identifies the Person or Persons in Charge or securing the equipment.

Person in Charge Is designated by the Project Manager. The Person in Charge must:

- have a firm technical knowledge of the specific RF system being locked out
- been trained in RF safety at SLAC
- be qualified to perform LOTO on 480 volt electrical systems
- be authorized to execute this ELP by his/her supervisor

Worker The worker must:

- be qualified to perform LOTO
- possess personal LOTO lock(s) and tag(s)
- be authorized to work under this ELP by his/her supervisor

Procedure

Implementing this ELP is essential to ensure RF safety: if any aspect of the ELP or your task is unclear, contact the project manager, safety officer, or chair of the Non-Ionizing Radiation Safety Citizens Committee (NIRSC) for additional guidance.

1. The person in charge secures the RF hazard.

- The Person in Charge shall lock out the power source with an operations lock and a “Danger” tag. Important: the danger tag must include the person’s name, the date, and the reason for the lockout.
- If multiple power sources supply the RF system, check the equipment’s electrical hazard ELP and take the required steps to secure the system’s primary power source. For instance, if there is a 480 Volt and 120 Volt source, lock out the 480 volt source.
- If any joint that is to be disassembled is labeled with a safety tag, remove the tag.

2. Work is performed with proper application of the worker’s personal LOTO lock and tag.

- Before any work begins, workers must
 - verify that the project manager or designee has locked the RF system and, if applicable, removed any safety tags on any joint(s) to be disassembled
 - apply their personal LOTO lock and tag
 - Verify the “zero-hazard state” by the method described in the RF system’s power source electrical hazard ELP

- Once the assigned work is completed, the flanges must be properly re-assembled and tightened and all re-assembled flange connections must be marked with colored tape
 - All flanges, joints, gaskets, and connectors must be carefully examined for damage or defects prior to assembly
- Removal of the personal LOTO lock and tag signals the completion of the assigned work

3. **The person in charge releases the RF system for operation.**

- The Person in Charge must establish that the RF system is safe for operation as follows
 - Cross-check proper assembly and verify bolt tightness of all reassembled flanges and remove tape only from properly assembled flanges
 - Verify RF waveguide safety tags are installed on flange joints
 - Pressurize system (if applicable) and check for leaks using an applicable method such as checking the gauge for pressure loss or applying a leak detection aid such as “Snoop”
- If the work passes inspection,
 - Remove the operations lock and initial “Danger” tag
 - Apply “Warning” label to controls of RF drive amplifier or traveling wave tube to indicate that RF leak testing is required prior to continued operation

4. **A qualified person tests for RF leakage.**

- All marked joints must be tested except
 - Joints in accelerator tunnels, because there is no access during operation
 - Joints positioned out of reach, such as joints that are 10 or more feet above the work surface
 - Vacuum joints with metal-based vacuum seals if the system is vacuum tight prior to operation. If circumstances require that high power testing must be done prior to demonstrating a vacuum seal, RF leak testing must be carried out as described below.
- The initial test is conducted at the lowest appropriate power level.
 - Klystrons: use the lowest stable running conditions for klystron
 - RF drive systems: may be set to nominal operation power levels
- Check flanges for RF leakage. Testing equipment must be demonstrated to be in working condition prior to use. If using a high-sensitivity detector,
 - Establish a baseline radiation level for a well assembled flange
 - Identify flange pairs that exceed RF emission expectations
- Leak testing continues at the next higher power output level until the system is incrementally tested up to the highest practical level appropriate for the current RF program
 - Any excessive RF emission must be measured with a calibrated RF leakage detector
 - Any leakage must be stopped or controlled to below maximum permissible exposure levels or the system must be secured and removed from operation

MPE – Maximum Permitted Exposures^{c,d}

Band	Frequency (MHz)	MPE Power (mW/cm ²)	Wavelength (inch)
L-band	1,300	0.86	9.09
X-band	11,424	2.00	1.03

RF emission MPE is average of free-space power over a 10 inch by 10 inch area^e. Free space power is measured at distances exceeding the RF wavelength from any metal surface.

- The RF survey method and results must be documented in the applicable operations logbook
- Only remove the warning label on RF controls if no maximum permissible exposure levels are exceeded

Approval

_____ NLCTA Safety Officer	_____ Date
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^a High sensitivity RF leakage detectors are home-built detectors consisting of small pickup loops or antennas instrumented with a spectrum analyzer or an appropriate detector diodes and oscilloscope.

^b Calibrated RF leakage detectors may be borrowed from SLAC ES&H department.

^c Derived from “IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz”, IEEE Std C95.1-2005, Table 8: MPE for the upper tier (people in controlled environments).

^d Values shown are for pulsed RF have been reduced by a factor of 5 from the MPE in accordance with item f) of the notes for Table 8.

^e IEEE C95.1-2005 MPE measurement area for frequencies greater than 3 GHz is the average over a “100 λ²” area. Lower frequencies specify the average “over the length of the [human] body”. The End Station B has adopted the more restrictive method of an area approximately 10 λ_{X-band} square. Reference item a) of the notes for Table 8.