Tech Note on the Radiation Hazard from Operating CEBAF RF Separators in a Test Stand Outside the Accelerator Enclosure.

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Electron beam extraction at the south linac for transport to a selected experimental hall is provided by an RF separator system that operates at 1/3-harmonic of the 1497 MHz base RF frequency. (1) The design of CEBAF RF deflecting or separator cavities is such that they dynamically give a transverse kick to the beam. RF separators use IOTs as 499MHz power amplifiers. The RF establishes a gradient across pole tips in the separator. This gradient provides a “kick” to a particular beam bunch. The magnitude of the kick depends on the magnitude and phase of the RF in the kicker cavity to that of the time of arrival of a particular beam bunch. Since RF separators combine vacuum and high voltage potential, an x-ray hazard may be present. Normally, the hazard is inconsequential since the RF separators are located in the shielded accelerator enclosure.

Occasionally, RF separators are operated in a test mode outside the shielded accelerator enclosure and as a “stand-alone” unit completely separated from a beam line. Usually, operating an RF separator in this way affords an opportunity to test the unit by “pushing the envelope.” The JLab ES&H Manual identifies the combination of vacuum and high voltage > 10kV as a potential source of x-rays and points to an evaluation of this hazard by competent staff. It’s useful to put an upper bound on the potential x-ray hazard from an RF separator cavity in

According to Kurt Hovater, the nominal operations parameters for a standard CEBAF RF separator are:

- Gradient across the pole tips: 5.00E+06 volts/m
- Pole tip distance: 1.50E-02 m
- Max. energy input: 2000 watts

Based on this information, several other parameters are easily calculated:

- Max. pole tip gradient: 7.50E+04 volts
- Calculated current: 2.67E+01 milliamps

Using an x-ray source term 2.88E-01 rad/milliamp-min at one meter (for electrons on W) across a potential of 70 kV (2), the estimated dose rate at one meter would be 7.68E+00 rad/min at a continuous current of 2.67E+01 milliamps. This estimated dose rate would be lower due to self-shielding by the RF separator body and the lower Z of the separator Cu acting as a “target” for the electrons.

The attenuation factor for 70 kVp x-rays by 0.5 in. Fe (or Cu) is 7.00E-06 (3). Correcting for lower Z of Cu results in a reduction in the x-ray source term by 0.5. (4) Combining these terms and changing the time unit from minutes to hours results in an estimated dose rate of 1.6E-03 rad/hr. Even if this dose rate were continuous, it would be lower than the posting threshold for a Radiation Area. Radiological controls associated with this dose rate are adequately addressed by routine radiological controls currently employed at Jefferson Lab. Radiological controls for operating an RF Separator in a test stand outside the accelerator enclosure would normally be addressed in a Radiation Control Operating Procedure written for that purpose.

(1) THE CONTINUOUS ELECTRON BEAM ACCELERATOR FACILITY: CEBAF at the Jefferson Laboratory, Annu. Rev. Nucl. Part. Sci. 2001. 51:413–50 Copyright © 2001 by Annual Reviews. All rights reserved.
(2) GE Maxiray-125B constant kV tube at 70 kV, page 6-44, Table 6.9.1, 3rd Edition Rad Health Handbook
(3) NCRP-51 Appendix E.13
(4) NCRP-51 Appendix E.3