The conventional safety aspects of the E-Field tests were reviewed on March 9, 2010. A brief description\(^1\) was given to the reviewers. The scope of this memo is to review and document the radiation safety aspects of the review.

The R&D efforts for the tests will occur in two phases. The first phase will use a HV device on loan from Cornell. The device is capable of 150kV operations and has an existing power supply that can produce 2 mA at 125 kV. Afterwards a BNL device will be installed for tests to 400 kV and the power supply was not specified. It is desired that the shielding be established for both phases and that the interlocks and administrative procedures can be phased with the equipment.

125 kV Operation

A proposed preliminary layout is shown in Figure 1. The wall is constructed with light concrete blocks that are 2.5 feet thick. The blocks have interleaved edges to avoid cracks. The source of x-rays will be the plates at HV inside the HV tank which is not shown in the figure. The inside of the tank will be approximately 3 feet from the inside of the shield wall. The clean room area for assembly is shown in Fig. 1.

The radiation dose inside the HV area will depend on the amount of energy that can be released from electrons traveling across the potential difference of the plates inside the tank. NCRP Report No. 51 can be used\(^2\) to get a conservative estimate of the x-ray levels inside the area. The dose rate for 1 micro-Amp of 200 kVp electrons is 322 mrad/hr at 1 foot. The power supply has a maximum current of 2 mA and a maximum voltage of 125kV. Dose rates at the power supply maximum\(^3\) would be 200 rads/hr at a foot, although the device would be expected to fail in a short time. The reduction of x-rays due to the tank wall can be accounted for when the details of the tank are clarified. The amount of energy that can be released in a spark is estimated to be less than 1 J based on the capacitance of the device. The power supply current will be limited by a resistor. When used at Cornell it was limited to 83 micro-Amps. The resulting x-ray dose at one foot would be 8,300 mrad/hr for 83 micro-Amps. The proposed operations procedure suggested not allowing more than a few micro-Amps of current.
The Tenth Value Layer (TVL) for concrete at 200 kVp is 8.4 cm. The 2.5 feet of light concrete reduces the x-rays by more than $10^{-9}$. The distance will also reduce the dose by a factor of 25, providing a total reduction of $2.5 \times 10^{-11}$. Microshield was used for an isotropic source of 200 keV x-rays to check the results. The dose reduction combining the distance and shielding was $4.9 \times 10^{-8}$. The difference between the two methods is primarily due to the fixed energy of the x-ray source in MicroShield. The TVL for concrete at 125kVp is 6.6 cm. There is expected to be no detectable dose outside the concrete. The area is has a concrete roof. The roof should be extended to provide more overlap than shown in Fig. 1.

The x-rays can reach the proposed location of the door by one bounce off the labyrinth wall. If the source location is 15 feet from the wall, using albedo coefficients it is estimated that reflected dose at the gate for 2 micro-Amps of electrons across the plates would be 0.1 mrem/hr.

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**400 keV Operation**

The dose rate at 400 keV is 1.8 rads/hr at a foot for one micro-Amp of electrons. The power supply has not been defined. Limiting to a few micro-amps during normal operations would keep routine levels at less than 5 rads/hr.

The TVL at 400 keV is 10.9 cm of concrete. The 2.5 feet of light concrete would reduce the dose by $10^{-7}$ and the reduction with distance provides another factor of $2.5 \times 10^{-2}$. Dose rates outside the shielding are not expected to be an issue. For a current of 2 micro-Amp the dose rate at the door would be 0.45 mrem/hr.

**Recommendations**

*(Ck-fy2010-EDM-709)* The plan is to limit the current of the 125kVp test such that the area does not require interlocks. The current will be limited by resistors which will be reviewed and
controlled so that the maximum current is less than 8.3 micro-amps which will result in dose rates less than 1 rad/hr at a foot in the test area. The access to the area will be controlled by a locked gate. Trained operators will be allowed to open the gate. A review of the current limits, procedure, and posting is required by a subcommittee.

(Ck-fy2010-EDM-710) The device needs to be registered as a Radiation Generating Device (RGD).

(Ck-fy2010-EDM-711) The controls on the 400kVp testing will be reviewed when more information is available.

References

3. The curve in reference 2 has been extrapolated by a power law to obtain a reduction in dose rate for the voltage of 125kVp. A reduction of 0.3 is used.
4. NCRP Report No. 49, Structural shielding design and Evaluation for Medical Use of X-Rays and gamma Rays of Energies up to 10 MeV, 1976, see Table 27. These are broad beam attenuation TVLs.
5. MicroShield Version 7, Grove Software Incorporated, Lynchburg, VA.

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RSC EDM file
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