William S. Higgins
Radiation Physics Science Department
Environment, Safety, and Health Section
630.840.4318
higgins@fnal.gov

# Memorandum

25 August 2020

**To:** Wayne Schmitt

**From:** Bill Higgins

**Subject:** Accelerator Safety Envelope limits for MTA beamline

Recently a new shielding assessment [Reference 1] has been completed for the MeV Test Area (MTA). The new configuration of the shielding, particularly the penetrations, requires a fresh evaluation of the Accelerator Safety Envelope (ASE) limits.

In order to calculate an ASE intensity limit for MTA, I began with the Incremental Shielding Assessment worksheets from the shielding assessment. The ASE limits beam intensity to a level where an accident produces no more than 500 millirem in an hour. What is the maximum intensity that will not exceed this limit?

Deficiencies in the shielding are identified in the worksheets. I will assume that these deficiencies have been mitigated by means described in the shielding assessment Phase II documents: several penetrations filled in the MTA experiment hall, and an interlocked detector added on the berm above the target.

The two Labyrinths and Penetrations worksheets include one for a "beam trajectory" accident, in which beam at normal operating intensity is lost at an arbitrary location along the beamline, and one for a "beam intensity" accident, in which the full intensity of the Linac is conveyed cleanly to the experimental target near the downstream end of the MTA experiment enclosure. Category 4 corresponds to a limit of 500 millirem per hour, as does Category 9. On the two Labyrinths and Penetrations sheets, I changed the category to 4 for the rows with category values 1, 2, or 3. On these sheets, no rows had categories between 6 and 8, signifying the presence of an interlocked detector.

I set the primary beam energy to 400 MeV and the cycle time to .067 seconds (15 Hz).

I then varied the intensity, in protons per pulse, until I found the largest value that would not produce a failure. On the Labyrinths and Penetrations beam worksheets, a failure occurs when the Dose for Proposal exceeds the Allowed Dose.

In the case of the beam trajectory accident, this calculation led to an intensity of 3.91E11 protons per pulse, or 2.11E16 protons per hour.

Above this intensity, the first failure occurs in a beam trajectory accident near the sand-filled 20-inch Ceiling Vent in the MTA experiment enclosure. So this accident is the limiting case that will set the ASE intensity limit.

(For beam intensity accidents, the loss point at the experimental target is, in general, more distant from the mouths of penetrations than is the case for beam trajectory accidents. The dose rates are lower, even for the case of full Linac intensity. On the "L&P (Beam Intensity Accident)" worksheet, I retained this full Linac value of 6.56E12 protons per pulse, or 3.54E17 protons per hour, and did not vary it.)

Regarding overburden shielding, on the Longitudinal and Transverse worksheets, I changed all categories relying on passive shielding to 4A or 4C as appropriate, and all categories relying on an interlocked detector to 9A (none required 9C).

One may vary intensity to find the earliest failure in the corresponding Longitudinal and Transverse worksheets. Here a failure occurs when the difference between the existing shielding and the required shielding is less than -0.5 efd. I found that the first failure occurred in the Transverse sheet at station 157, where the MTA experiment hall shielding is just 10.2 equivalent feet of dirt. This location fails at an intensity above 5.62E11 protons per pulse, or 3.03E16 protons per hour.

I conclude that since the Longitudinal and Transverse sheets fail at a higher intensity than the Labs and Pens sheet, the ASE limiting intensity should become 2.11E16 protons per hour.

Worksheets reflecting this intensity are attached [2].

**References**

1. Jason M. St. John, *Shielding Assessment Document for the MeV Test Area at the Fermilab Linac Endstation,* 24 August 2020.

2. William S. Higgins and Michael Vincent, file "MTA ISA Spreadsheets for ASE 08-25-2020.xslx," 25 August 2020.