C-AD

Radiation Safety Committee

Issued: September 24, 2014

Minutes of RSC Subcommittee of September 11, 2014

Subject: Design of a Soil Cap for Booster E7 Proton Scrapping

Present: D. Beavis, E.T. Lessard, C. Gardner, K. Yip, C. Schaefer, H. Kahnhauser, D. Paquette, A. Etkin, R. Karol, B. van Kuik, C. Theisen, J. Tuozzolo, and J. Sandberg

The committee met to discuss how soil activation should be estimated for C-AD operations and then to apply those methods to determine the size of the soil cap at E7 for vertical scraping of the polarized proton beam.

A description of possible improvements[1] to the SBMS guidance[2] for soil activation had been distributed before the meeting. The first hour of the meeting had an animated discussion on how the calculations should be done and what is correct or incorrect in the exhibit in the SBMS for accelerator safety. The discussion was terminated by a fire drill. It was clear that no consensus was going to be established. Therefore, the RSC Chairman will send his recommendations on the SBMS guidance to the subject matter expert for consideration.

It was recommended that existing data from the U.S. geologic surveys on Long Island and the NRC studies of the Shoreham site be examined to see if a suitable range of soil compositions can be determined from existing data. **(ATS-Nov. 1 ,2014-CAD-Schaefer& Beavis) This is closed per note added below.**

Note added after the meeting:
After the meeting D. Paquette and the RSC Chair had several meeting and discussions regarding the soil composition at BNL. The notes that support the method that Photon Sciences (PS) personnel used to calculate the soil composition were reviewed. The composition was derived from using measured trace metals within BNL soil and adding the to SO_2 for the balance of materials. This was deemed a reasonable approach to determining the soil composition. In

[1] D. Beavis, "Soil Activation and the BNL Subject Area", Sept. 9, 2014; http://www.c-ad.bnl.gov/esfd/RSC/Memos/Soil_9_09_14.pdf
[2] SBMS Subject Area on Accelerator Safety; https://sbms.bnl.gov/sbmsearch/subjarea/40/40_Exh9.cfm?ExhibitID=6375

addition, the Geological Survey for the site[3] was used to compare the the above analysis. It provides good agreement but cannot produce the small trace elements that was included in the PS. The only item missing from the PS analysis is the moisture content.

D. Paquette was able to find additional documentation on the porosity[4] of the soil and the moisture concentration[5]. The porosity is 30% and the moisture content is 10% by volume.

Based on the information gathered after the meeting the RSC Chair recommends that the soil composition used by P.K. Job and W.R. Casey be used with an adjustment for water content at 10% by volume and a wet density[6] of 1.8 gm/cc. For most analyses the composition can be simplified. The hydrogen content[7] is important for shielding calculation of the neutrons.

If the examination of existing data does not yield appropriate soil compositions than a series of samples should be taken and sent for analysis. **(ATS-Dec. 15, 1014-CAD-Schaefer& Beavis) This is closed as per note added above.**

The discussion moved to the determination of the E7 cap size. Information was provided in a draft memo[8] by D. Beavis and in a memo by K. Yip[9]. K. Yip also provided[10] some numbers for the beam striking upstream of the E7 dipole at the beam pipe tapered section at the quadrupole.

The soil sample located 60 cm downstream of the E7 dipole suggests that the potential ^{22}Na leachate concentration 10cm from the tunnel side wall for future operations would range from 1740 pCi/l (old method) to 6340 pCi/l (proposed method) depending on how it is calculated. The BNL action limit is 100 pCi/l. To meet the BNL ^{22}Na action limit a soil cap is needed and must extend to a distance to reduce the leachate concentration by a factor of 17 to 65 based on the removable soil sample data. A simple estimate using only the attenuation length for neutrons suggests[11] that the cap must extend 170-250 cm beyond the vertical projection of the tunnel wall for ^{22}Na at the peak of the distribution. It is typical to apply a 10 degree angle from the shield surface to the production volume to account for possible horizontal shifting of the percolating water.

---

[3] Geological Survey Bulletin 1156-B, "Physical properties and Mineralogy of Selected Samples of the Sediments from the Vinicity of the Brookhaven National Laboratory, Long Island, New York, 1963.
[4] Geological Survey bulletin 1156-C, "Hydrology of Brookhaven national Laboratory and Vicinity Suffolk County New York", 1968.
[5] Geological Survey bulletin 1156-E, "A Hydrologic Analysis of Poluted Liquid-Waste Releases Brookhaven National Laboratory, Suffolk County New York", 1966.

[6] W.R Casey et. al., Sand as a Side Shield for 30 GeV Protons Stopping in the Brookhaven AGS", NIM **55** (1967), 253-268.
[7] Typically an 8% by atomic composition has been used in Monte Carlo applications.
[8] D. Beavis, "Soil Activation at Booster E7", Sept. 24, 2014
[9] K. Yip, " Monte Carlo Simulation Related to Soil Activation at Booster E7", Aug. 14, 2014; http://www.c-ad.bnl.gov/esfd/RSC/Memos/E7%20Cap.pdf
[10] K. Yip to D. Beavis e-mail, Sept. 10, 2014.
[11] An attenuation length of 60cm is used for the neutrons, which was extracted from MCNPX simulations at 800 MeV.

The BNL tritium action limit is 1000 pCi/l and the drinking water standard is 20,000 pCi/l. The production ratio of tritium to ^{22}Na was given in the old guidance as 0.075/0.02 or 3.75. All the produced tritium is considered leachable. Accounting for the difference in half-lives the tritium concentration based on calculations suggested in footnote 1 would be 18,000 pCi/liter. The old method would use a shorter column height but a larger tritium to ^{22}Na ratio resulting in essentially the same tritium concentration in the leachate. The new BNL action limit for ^{22}Na was established using the old technique of estimating concentration so that the size of the soil cap would be established by ^{3}H (and ^{22}Na simultaneously).

The remaining discussion on the cap size is not reproduced in these minutes. After the meeting the Chair continued to examine potential differences between the azimuthally symmetric model and the more exact model. Problems were found in both models and understood. The azimuthally symmetric model was corrected of any errors and then used in conjunction with the model of K. Yip to determine the cap size.

The RSC Chair decided[12] that the leaching model parameters that he understands as more correct than the SMBS exhibit should be used. These were used in the determination of the cap size. They make the cap larger than if the old analysis was used. The details can be found in footnote 8.

Additional soil samples and water samples will be placed in the booster tunnel for monitoring.
(ATS-Booster-Nov. 1, 2014-VanEsendelft&Beavis)

It was noted that it is most likely that tarps and other temporary caps will be used for run15. The time is expected to be too short to get a cap installed by a contractor especially with NSRL operating the Booster with beam.

C. Gardner noted that the B6 beam dump has a vertical aperture[13] that had been forgotten about. It may cause an unacceptable vertical loss to ions but may be useful. Beam tests will be conducted while NSRL is operating to determine if the aperture can be used for protons while ions are also needed. It is hoped that this could negate the need for vertical scraping at E7.

It was also noted after the meeting that there may be a risk to the solid state amplifiers for the RF cavity at E6. This issue is being considered by department managers.

A small subgroup will work on the final dimensions of the soil cap at E7 if needed. This will include the 10 degree angle using contour maps.
(ATS-Nov. 1, 2014-Phillips-Beavis-booster)

During the discussion it was noted that calculations for the soil samples are about a factor of five too high. The only systematic effect known is that typically an isolated soil container is not used in the analysis. A simple analysis will be conducted to determine if this create an artificially high

[12] If any RSC members are unhappy with this decision they can request another meeting. They would be expected to provide numerical calculations to support changing this decision.
[13] C.J. Gardner, " The new Booster Dump and Dump Bumps", March 2001; http://public.bnl.gov/docs/cad/Documents/The%20New%20Booster%20Dump%20and%20Dump%20Bumps.pdf

comparison of the Monte Carlo calculations to the measured soil activity for ^{22}Na in removable containers. A "recent" paper[14] from SLAC has sodium activation estimates a factor of two larger than the measurements. There may a common issue with sodium cross sections or neutron spectra for these type of calculations.

CC:

RSC minutes file
RSC
Attendees
M. VanEssendelft
T. Blydenburgh
D. Passarello

[14] James C. Liu and Sayed H. Rokni, "Analytic method in Estimating the induced Radioactivity in Soil around High-Energy Accelerators", RP Note 2000-07 (Oct. 27, 2000).