Technical Basis for NSLS Trans-uranic Quantity Limits

A growing number of experimental proposals utilizing trans-uranic (TRU) radionuclides have been received by NSLS in recent years. As TRU use increases, it is important to establish a formal structure for NSLS safety requirements for this type of work to ensure a consistent approach and to minimize potential risk. A set of TRU Safety Requirements is described in Section 6.2. The purpose of this document is to provide a technical basis for TRU quantity limit of 100 μCi per sample for work done at the NSLS.

Background

Trans-uranics such as Np-237, Pu-239, and Am-241 are all long radiological half-life alpha emitters which if inhaled or ingested selectively deposit in bone with long biological half-life. As a result, the permissible intake for humans for these materials is extremely low. In addition, these materials are regarded by many community members as among the most dangerous materials known. Because of these issues, it is very important that TRU materials be handled in a manner that prevents release to the environment or uptake by humans.

Benchmarks

Depending on the form and quantity, TRUs are typically handled in fully enclosed structures with triple containment barriers to prevent releases to the environment. At least 2 synchrotron light sources (i.e. SSRL, ESRF) have provided such facilities for beam lines. In addition to the containment structures, inventory limits have also been established to limit the degree of hazard created by the materials. ESRF has established a quantity limit of 5 mCi of TRU. SSRL has established a mass limit which is variable depending upon the form of the material. For Pu metal the limit is 640 mg which is equivalent to 38 mCi. For Pu solution, SSRL has established a limit of 5 mCi for Pu. It is proposed that the NSLS limits be considerably smaller than the ESRF/SSRL limits because of the lack of containment structures around the experimental apparatus.

Another useful benchmark are the criteria established by the DOE for characterizing nuclear facilities. For TRUs of interest to the NSLS, a level of about 500 mCi would result in a nuclear facility classification as defined in DOE Standard 1027. The requirements for a nuclear facility are very strenuous - it should be clear that the NSLS does not want to use TRU in quantities anywhere near these values.

As a starting point, it is proposed to use 100 μCi as the quantity limit for TRUs per sample. 100 μCi is 2% of the current limit at ESRF for work done in its glove box containment structure, and 0.02% of the nuclear facility threshold.

Radiological Consequence of Release

For Pu samples assumed to be metal and non-volatile, a release fraction of 0.001 is used as recommended by DOE 1027. This suggests that there is a release potential of 0.1 μCi, assuming a quantity of 100 μCi initially.

- If we assume that a user ingests 0.1 μCi through accidental contact with this amount, the resulting committed effective dose equivalent is 500 mRem.
- If we assume that 0.1 μCi is released into a hutch and uniformly mixes in a 10 m^3 volume, a five minute exposure produces a dose of 500 mrem.
- If we assume that 0.1 μCi is released into the experimental hall and uniformly mixes in a volume of 25,000 m^3, a five minute exposure produces a dose of 0.2 mrem.
- If we assume that 0.1 μCi is released in a plume that is transported under stable weather conditions, a person 30 m away during the passage of the plume would experience a dose of 1.9 mrem.

These dose commitments are acceptable consequences for an accident with small probability - it is proposed to use 100 μCi per sample as the quantity limit at NSLS.

Programmatic Consequences of Release

This technical basis document does not specifically address the programmatic consequences of a TRU release in a hutch. Contamination resulting from a leak would need to be cleaned up to very low levels. Clean-up in a facility as complicated as the NSLS could be very difficult. 0.1 μCi uniformly distributed would contaminate 100 m^2 above the clean-up value of 20 disintegrations/minute per 100 cm^2. Costs of such a clean-up could be 10s of thousands of dollars and machine downtime could be several weeks.