AAA Fuels Technology
WBS 1.22.04 Deliverable#1: Uranium Coating-Lab Preliminary Design Report
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PURPOSE: Programmatic documentation of the basic laboratory facilities and equipment planned for the AAA Fuels Technology Uranium Coating-Lab.

SCOPE: WBS 1.22.04-TASK#2. Uranium Coating-Lab: Establish a laboratory for sintering, coating, and primary characterization (size, shape, density, metallography) of uranium-bearing TRISO coated particles. The work will progress in the following stages: (a) obtaining the necessary authorization basis, (b) facility design, (c) creation of the facility. The authorization basis will cover work with (a) depleted uranium, and (b) special campaigns with limited quantities of LEU (<20% U-235). Design work will include the early definition of the facility basis (to support authorization), design of the facility/equipment. Creation of the facility will involve hardware acquisition, installation, provision of services, and initial operation.

AUTHORIZATION BASIS: The following levels of authorization exist:

1. **NEPA:** Categorical Exclusion for Research Support for Advanced Nuclear Fuel Development (2996X): Feb.14, 2002 Letter from W. M. Blevin DOE/ORO to D. R. Allen (March 20, 2002 Approval by D. R. Allen).

2. **Facility Category**: Bldg. 4508 is a non-nuclear facility (ORNL/LPD-EP/HS-103). Anticipated quantities of depleted uranium and LEU fall within the inventory limits for this category of facility (total of 0.1 Ci, or 46kg of U-235). Low level work with radioactive materials within these limits is currently being conducted in this building.

3. **WORK CONTROL**: ORNL work control processes (e.g. ORNL-SH-P29) control installation of new equipment and facility modifications. Experimental activities must comply with all ORNL and DOE laboratory standards, and most especially chemical and radiological procedures and guidance.

LABORATORY DESCRIPTION

Bldg. 4508 Lab 242 was the site of previous uranium coating and fuel development at ORNL. Because of this, it is well configured by layout and services to support this activity. All services called for in the experimental stations are readily provided for (cooling water, electrical power, HEPA-filtered hood exhaust to a permitted stack). A basic layout of the proposed laboratory, with experimental stations identified is shown in Figure 1.

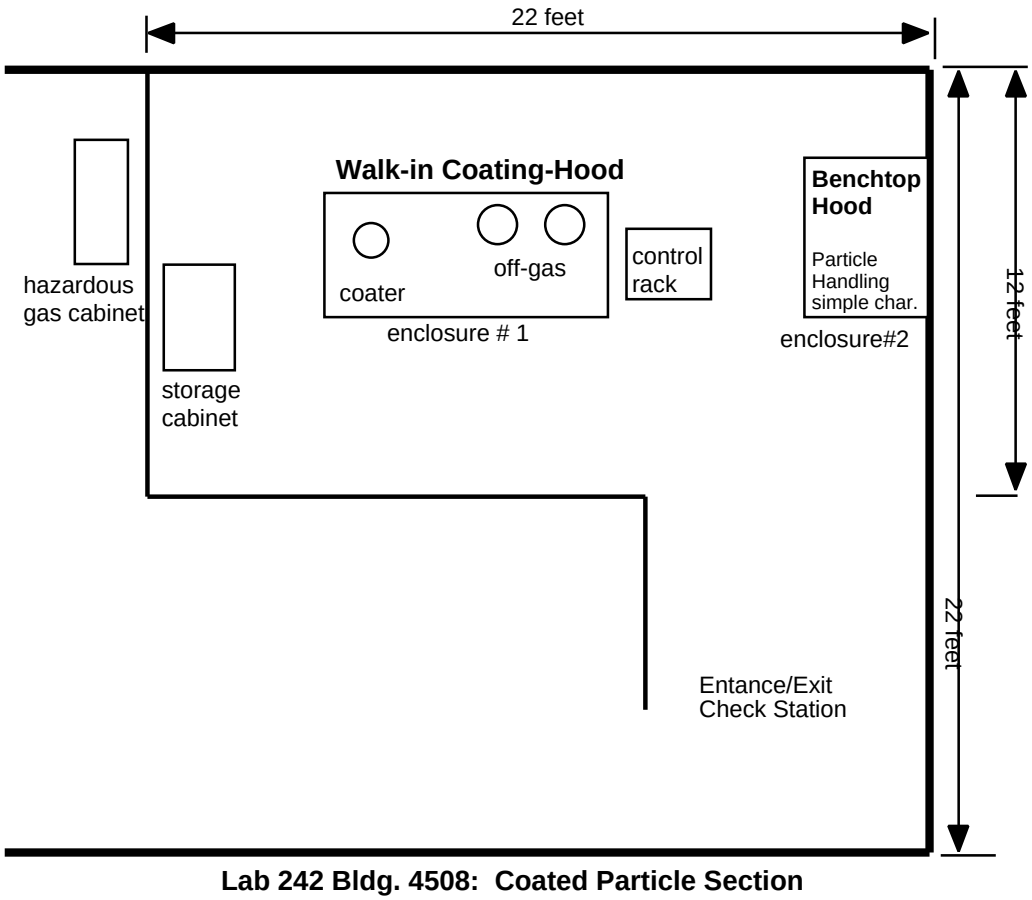

Figure 1. Proposed Uranium-Coating Laboratory Layout

The experimental stations consist of material control (receiving, shipping, and storage), sintering, coating, and characterization operations. A basic flowsheet for these operations is given in Figure 2.

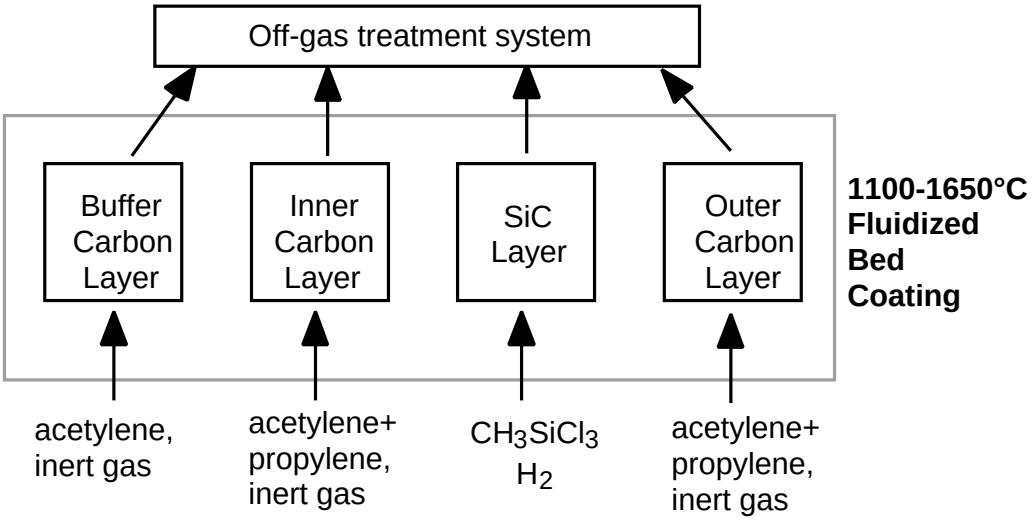

Figure 2. Basic Flowsheet for Coating-Lab Operations

In most cases all of these functions will exist in Lab 242, but in a few special cases support will come from existing capability elsewhere at ORNL. A description of each experimental station follows.

MATERIAL CONTROL STATION

Means for assay (primarily weight), packaging, and storage are provided for. All open handling of uranium is done in ventilated enclosure#2 with appropriate zoning.

SINTERING STATION

Densification and conversion to UO_2 of low-temperature dried kernels (i.e. gel-microspheres) at temperatures up to 1600°C is planned for ventilated enclosure#1. High-purity bottled gases will supply the atmosphere for the sintering operation. Sintering batch sizes can be as large as practical.

COATING STATION

Ventilated enclosure#1 will be used for the coating operations. The primary element of a particle-coating laboratory is the coating furnace accompanied by a power supply, temperature controls and measurement instrumentation (including an optical pyrometer), gas and vapor distribution systems, and scrubbers and traps for the exhaust gasses. A large cooling water supply is also required to cool the exterior elements of the furnace. All of these services are readily available in lab 242.

The objective of this task is to coat small batches (< 100 g) of particles thus small resistively heated furnaces, initially designed for the HTGR program, will be used.

Existing coating furnaces will be used to begin operations. The furnaces utilize a conical gas distributor up to ~ 50 mm in diameter, which is more than adequate to coat the aforementioned quantities of kernels.

The presence of flammable and hazardous gasses and uranium-containing materials necessitates the use of an enclosure or hood. A large hood with adequate workspace will be used to allow for loading and unloading of the furnace, for furnace maintenance, and for housing much of the necessary gas and vapor handling equipment. The floor of the hood will be covered with a stainless steel pan with a lip to contain any loose particles or inadvertent liquid spill. The SiC precursor, MTS (CH_3SiCl_3), is a liquid the vapor of which must be transported to the furnace. The MTS supply and/or vaporizer must also be kept in the hood with the furnace. Exhaust gasses are to be filtered or scrubbed to remove certain reaction products such as carbon soot and HCl. The scrubbers or traps are typically fabricated from cylindrical glass columns, with units for the given furnaces being approximately 15 cm in diameter by 60 cm in length and must also be located in the hood with the furnace. Excess hydrogen or unreacted hydrocarbon gasses will be burned before entering the hood exhaust system to prevent possible accumulation of flammable gasses in the ventilation system.

CHARACTERIZATION OPERATIONS

Quality control (QC) tests on the dimensions and structure of the coating layers will be carried out to assure the coating processes are properly conducted. Particles at various stages will be tabled and screened to remove non-spherical particles and microspheres outside the desired diameter range. Simple microscopy will be employed to examine coating integrity and overall quality and microstructure will be examined employing metallographic techniques. A portion of the analysis will be conducted in a tabletop fume hood with adequate space and working area. The internal working surfaces of the hood will be covered with stainless steel to minimize trapped/permanent contamination. The QC and characterization activities described above cover only the most basic functions. This area is under development, and more extensive efforts will be defined for FY03 and will likely involve some separate laboratory space.

OPERATING MODES:

The vast majority of operations will be with depleted uranium in an exploratory mode. A separate set of operational controls (inventory, material balance) will apply to operations with enriched materials. A separate set of Quality Assurance requirements will apply to operations supporting the production of irradiation test specimens.

POTENTIAL FOR EXPANDED SCOPE:

This report focuses on FY2002 scope, but certain points should be made about the ability to support additional activities. Adequate services and space exist in Lab 242 to support larger coating operations and additional fuel fabrication activities (compacting). We note particularly the large ventilation capacity of the Bldg.4508 complex. The present facility classification and inventory limits are adequate for laboratory development purposes.