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DECONTAMINATION AND DECOMMISSIONING OF THE JANUS REACTOR AT THE ARGONNE NATIONAL LABORATORY-EAST SITE

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ABSTRACT

Argonne National Laboratory has begun the decontamination and decommissioning (D&D) of the JANUS Reactor Facility. The project is managed by the Technology Development Division's D&D Program personnel. D&D procedures are performed by sub-contractor personnel. Specific activities involving the removal, size reduction, and packaging of radioactive components and facilities are discussed.

I. INTRODUCTION

The JANUS reactor at Argonne National Laboratory - East (ANL-E) is located in Building 202. The reactor, named JANUS after the two-faced Roman god, was used to study the effects of both high and low doses of fission neutrons in animals. The facility operated from August 1963 to March 1992. The 200 kW reactor was located below ground level and had radiation rooms at each of its two faces. The High Dose Room was capable of specimen exposures at a dose rate of 100 rads per minute. The Low Dose Room dose rates could range up to 50 rads per week. The Low Dose Room was never utilized for experiments. A pneumatic pressure tube allowed small biological samples to be irradiated within the reactor tank. The reactor tank was four feet in diameter and seven feet high and was fabricated from T-6 aluminum. The reactor was light water moderated - cooled and fueled with enriched uranium. A graphite layer was used to reflect neutrons back into the reactor. Nuclear fuel was removed from the reactor and shipped off-site in March 1993. See attached Figures 1, 2, and 3 for layout and cross sectional views of the JANUS Reactor Facility.

Residual radioactivity is present in the reactor vessel from neutron activation. Radioactivity levels inside the reactor tank have been measured to 400 mrem/hr.

Some reactor structural components and shielding structures associated with the facility are activated. Process systems and components that contained primary coolant are contaminated. Storage tanks are also contaminated. Mixed waste is present as activated lead shielding. However, beryllium start-up sources and cadmium control rods have been removed. All floors have been surveyed and found not to be contaminated. Approximately 100 tons of lead will be removed and recycled for other uses at Argonne National Laboratory.

During fiscal year (FY) 1996, environmental assessments and safety analysis were prepared to document how the decontamination and decommissioning (D&D) will take place. Characterization Plans, D&D Plans, and Procedures and Procurement Documents were also completed. Once these documents were approved, a D&D subcontractor was selected in November, 1996.

This paper will highlight the completion of the field activities required to complete the D&D of the JANUS reactor from the beginning of the project to May 1, 1997.

II. JANUS REACTOR D&D ACTIVITIES

The D&D activities began in November, 1995 and are scheduled for completion in August, 1997. These activities were divided into the six major areas discussed below.

A. Project Preparations and Characterization

1. Project Preparations. In November of 1995 preparations for the commencement of the JANUS Reactor Facility D&D were started. These activities consisted of preparing a facility characterization plan, a detailed cost and schedule plan, application for Illinois Environmental Protection Agency Air Discharge Permit,

Environmental Assessment of the D&D activities, and preparation of required plans and procedures for upcoming hands on work.

2. Facility Characterization. During January and February of 1996, ANL-E performed a radiological and hazardous materials characterization of the JANUS Reactor Facility. This characterization was used for the preparation of the project specific Health and Safety Plan, Audible Safety Analysis, and application for required air discharge permits. The characterization identified fifteen radioisotopes (predominantly Co-60, Eu-152, and Eu-154), 20 areas containing asbestos, 7 items coated with lead based paint, and approximately 200,000 pounds of lead brick and block. Since the start of D&D activities in January of 1997, an additional 4 radioisotopes have been identified as well as the additional hazardous materials mercury and cadmium. The additional radionuclides were primarily a result of installed instrument check sources and low energy beta emitters in steel and graphite which posed no additional impact on worker or public safety. Radioactive waste characterizations were updated to include the new nuclides as part of the waste matrix isotopic for disposal purposes. The cadmium was discovered in thin sheet form and was transferred to another ANL-E division which had a need for the metal. The mercury was in the form of sealed mercury switches and pressure gages which were transferred to the ANL-E waste management group for proper disposition.

B. Contractor Mobilization by AFFTREX, LTD

1. Contract Award. Tasks to be completed in this area included finalizing contract documents, submitting performance bonds, and providing plans and procedures for review and approval by ANL-E. Upon approval of the required documentation a Pre-Construction Safety Meeting was held at Argonne on December 13, 1996. This meeting provided the opportunity for AFFTREX, LTD management personnel to meet with representatives from the various groups at ANL who would be involved with the D&D operations. Personnel from Industrial Hygiene, Safety Engineering, Fire Protection, and Building Maintenance reviewed the requirements for notifications, permits, and inspections. Health Physics discussed their oversight role with the contractor. The Building manager reviewed requirements and procedures related to occupancy, parking, emergency response, and shelter assignments. Security personnel stated the procedures for site access, site deliveries of materials and equipment, and traffic regulations. Plant Facilities and Services requirements and assistance available were also discussed. Contract change order procedures were explained by the Procurement Official.

2. Mobilization. AFFTREX, LTD personnel arrived at ANL-E on January 6, 1997 and completed two weeks of on-site training activities. All contractor personnel were required to complete ANL-E Contractor Orientation, Building 202/JANUS Facility Orientation, ANL-E Radiation Worker II, OSHA 40-hour Hazardous Waste Site Operations, ANL-E Radioactive Waste Generator training, and the ANL-E course on Lead Hazards and Control. In addition, all personnel who would perform health physics related functions were required to be DOE qualified as a Radiation Control Technician.

C. Biological Preparation Rooms and Dose Rooms

1. Electrical Equipment. Tasks to be completed in this area included the identification and isolation of electrical components to be removed from the biological preparation rooms as well as the high and low dose rooms. This included pump motors, blowers, and control consoles. Lock-out/tag-out was performed by ANL-E Building Maintenance and then by AFFTREX and ANL-E project personnel. All wiring associated with electrical components was removed, along with any conduit or cable trays that were no longer needed. Excess equipment such as file cabinets, tool boxes, spare parts, and test equipment were also removed from the area, surveyed for contamination and released as scrap or recycle.

2. Storage Tubes. Two 6" diameter 12' deep storage tubes located in the high bay were opened and decontaminated for free release.

3. Lead Shielding and Borated Wallboard. The lead shielding from the High Dose and Low Dose rooms was removed and surveyed for release for recycle to the ANL-E Lead Bank. This lead will be shipped off-site and smelted into shield blocks for the Advanced Photon Source (APS) at ANL-E. As of May 1, 1997 over 201,000 pounds (91,254 kg) of lead has been removed and released for recycle from the project.

Significant difficulties were encountered during lead removal operations in the High Dose Room. The lead on the walls of the room was constructed of chevron shaped lead bricks that were 4 inches high, 4 inches wide, and 24 inches long. It was believed that the bricks were surface welded to a depth of 1/4 inch. However, during lead wall removal operations we found that the gap between the bricks had been filled with molten lead, effectively fusing all the bricks together as well as to 1 inch thick lead strips behind the joints. The lead strip was bolted to the wall. Tests of various cutting methods were conducted to identify a safe, cost efficient method to remove the wall lead. Electric chisels merely pushed the lead around and were easily wedged. A router produced good results to a depth of 1/2 inch where melting of the lead caused binding. A circular saw fitted with a non-ferrous metal cutting blade produced good results, but could only cut to a depth of about 3 1/2 inches. The saw cut the lead wall in progressive cuts (at 1/2 inch depth per cut) at a rate of about one brick every two minutes. An electric chain saw was tried next, and to everyone's surprise worked the best of all. Cutting rate was about one brick every 90 seconds at the full 4" depth, in addition the electric chain saw could get into the corners where the circular saw could not. Although the nylon drive gear in the chain saw required several replacements during the lead removal operations, the chain never needed sharpening. A combination of the circular saw and the electric chain saw were used to remove the 320 lead wall bricks (47,000 lbs.).

After the lead was removed from the walls, floor, and ceiling of the High Dose Room, 4 layers of 1" thick borated hardboard panels were next removed from the walls and floors. The high dose room activated concrete ceiling was then demolished and packaged as low level waste.

4. Rabbit Tube Facility. A rabbit tube facility originated in the Low Dose Preparation Room and penetrated the biological shield to the reactor. The facility allowed pneumatically propelled sample containers to be inserted into the reactor for direct activation. The upper tube housed the antimony/beryllium start-up source. Prior to removing the reactor tank, the rabbit tube facility shielding, tubes, and plugs were mechanically removed and either packaged as radioactive waste or surveyed for free release and recycled as scrap.

D. Reactor and Reactor Equipment Room

1. Primary Process Systems. The work in the reactor equipment room was performed in parallel with the lead removal work in the High Dose Room. All of the primary and secondary system piping and components were removed using portable electric saws and hand tools. The primary piping was constructed of aluminum, air system piping was copper, and secondary systems were stainless steel. Most connections were bolted flanges, making disassembly quite simple. Contaminated components were packaged as low level waste; many items were able to be surveyed and released as scrap for recycle.

2. Shutter Drives. The reactor was equipped with pneumatically operated shutters which were lowered in front of the reactor face whenever personnel access was required into the High or Low Dose Rooms during reactor operation. The shutter drive mounts and shutter drives were removed early in the project to provide increased work space in the high bay area over the reactor. All of this equipment was surveyed and free released for recycle.

3. Floor Plugs. The shielded floor blocks over the reactor were removed and a HEPA ventilated containment tent was set-up over the reactor to allow the remaining primary piping to be disassembled and removed.

4. Reactor Shield Plug. The reactor lid/shield plug was removed and packaged for disposal in one piece. The plug was constructed of a stainless steel shell, filled with concrete. Penetrations for the primary coolant system, reactor helium system, and reactor refueling access port were located in the reactor shield plug. The dose rate on the bottom of the plug was 130 mR/hour.

5. Reactor Internals and Vessel. Some of the upper reactor internals were removed while the reactor was in place. However, it became obvious that removal of the remaining internals could be accomplished much faster and safer if done after the vessel was removed. (The small working area above the vessel was a permit required confined space and required personnel retrieval system(s) for workers in this area).

The reactor vessel was removed on April 25, 1997 and placed in a controlled area for size reduction and packaging as radioactive waste. Cutting and packaging operations were completed on April 30, 1997. The aluminum vessel was segmented using portable electric saws.

6. Remaining work. As of May 1, 1997 the work remaining to be accomplished in this area includes the removal of the shutters for the High Dose and Low Dose rooms, removal of the activated graphite reflector and activated concrete shielding. The reactor pedestal concrete and any activated steel supports will also be removed. All of this material will be packaged as low level waste.

E. Decontamination and Restoration

1. Glovebox. A glovebox and associated high-efficiency particulate air filter unit, exhaust ductwork, and exhaust stack were removed. The

glovebox was disconnected from it's associated duct work, relocated to a containment tent and disassembled. After disassembly the glovebox was successfully decontaminated, surveyed for free release and recycled as scrap. The associated HEPA filter unit was packaged as low level waste. The ductwork and exhaust stack were free released and recycled as scrap.

2. Control Panels. Three control panels, the reactor control panel, Low Dose Room control panel and High Dose Room control panel, were locked-out/tagged-out in preparation for removal. The panels were verified de-energized with a volt/ohm meter and wiring cut to the panels. During the first day of wire removal, two 120 volt live wires were cut that entered into the reactor control panel. All electrical isolation and removal work was stopped and an investigation was performed. The two live wires were identified as JANUS facility emergency circuits for exit lights in the reactor facility. The installation of these circuits was performed after the original installation of the control panels and was never identified on available electrical prints. The circuits were improperly routed through the reactor control panels to the exit lights. The D&D contractor revised their procedure to perform additional verifications that each wire was de-energized prior to cutting. The emergency circuits were correctly rerun through newly installed conduit. Dismantlement work was resumed, the control panels were disassembled, surveyed for free release and recycled as scrap.

3. Remaining Work. As of May 1, 1997 the following activities still need to be performed. Fill the storage tubes in the high bay with concrete, fill the storage pit in the Low Dose Room with concrete and patch openings in walls and floors as a result of ductwork and piping removal operations. These tasks will be performed upon completion of the final status and independent verification surveys.

F. Final Radiological Release Surveys

1. Final Status Survey. Upon completion of all D&D work and a complete wipe down of all surfaces, a final status survey will be performed in the JANUS facility to verify that all areas meet the established free release criteria. The final survey will be performed in accordance with NUREG/CR-5849 "Manual for Conducting Radiological Surveys in Support of License Termination." The facility will be divided into affected and unaffected survey units and a reference grid system will be established. The grid system will facilitate selection of measuring/sampling locations, provide a method for referencing measurements and samples back to a specific location, and provide a convenient means for determining average activity levels. The final status survey will consist of surface scans to identify the presence of elevated direct radiation which could indicate the need for additional D&D work, direct measurements of surfaces for total activity remaining, removable contamination measurements for the presence of transferable activity, and sampling of concrete, paint, and other surfaces to determine if covered or activated materials are present. Additional special sampling protocol may be required for small penetrations, conduit and other areas that do not lend themselves to conventional survey techniques. Instrumentation shall be selected with a Minimum Detectable Activity (MDA) of 25% of the applicable release limit. All data generated from the final survey will be properly documented and reviewed for accuracy. It is estimated that the final survey will be performed in June 1997.

2. Independent Verification Survey. An independent verification survey will be performed by a separate outside contractor upon completion of the final survey. This survey will be utilized as a validation tool to confirm that the JANUS facility meets the radiological status reported as a result of the final status survey. It is estimated that the independent verification survey will be performed in July of 1997.

III. WASTE MANAGEMENT

Waste generated as a result of the JANUS Reactor D&D was separated into four categories, low level radioactive waste, mixed waste, hazardous waste and beneficial recycle or clean waste. Each waste category is further discussed below.

A. Low Level Radioactive Waste (LLW)

LLW is packaged into approved containers for disposal at the Westinghouse Hanford Company site in Hanford, Washington. This waste consists primarily of contaminated and/or activated metals, concrete, graphite, miscellaneous materials, and personnel protective equipment utilized during the D&D effort. As of May 1, 1997, 338 cubic feet of the original estimated 2,300 cubic feet of LLW had been packaged for disposal.

B. Mixed Waste

Mixed waste contains hazardous or characteristic hazardous materials contaminated or activated with radioactive materials. Special waste treatment processes are required for any mixed waste generated at ANL-E. Every attempt was made to separate these materials at the project site or forward them to ANL-E's waste management group for treatment or storage as applicable. As of May 1, 1997, approximately 50 cubic feet of the original estimated 140 cubic feet of mixed waste had been packaged for treatment. The majority of the project's mixed waste consists of activated lead which will be macro-encapsulated for disposal or slightly contaminated oil from the reactor helium system.

C. Hazardous Waste

Hazardous or characteristically hazardous materials were removed from the project site as early on as possible to prevent contamination which would require reclassification as mixed waste. If the hazardous materials could not be removed early in the project, steps were taken to prevent contamination such as wrapping asbestos and performing radioactive airborne producing operations inside of HEPA ventilated containment's to prevent cross contamination. Approximately 0.75 cubic feet of the original estimated 10 cubic feet of hazardous waste has been packaged for disposal/treatment as of May 1, 1997. In addition approximately 0.5 cubic feet of hazardous cadmium metal was transferred to another ANL-E division for experimental use.

D. Beneficial Recycle or Clean Landfill Waste

A substantial amount of material has been removed from the project site as radioactively clean. Metals, lead, and some furniture has been recycled either as scrap, the lead recycle program, or transferred to excess storage for possible reuse at the laboratory. As of May 1, 1997 a total of 27,860 pounds of miscellaneous material has been shipped for recycle or clean landfill disposal and 201,650 pounds of lead has been released to the ANL-E Lead Bank for reuse at the Advanced Photon Source.

IV. HEALTH AND SAFETY

Project health and safety took precedence over any other aspect of the project. All plans, procedures, and D&D activities were approached with personnel safety first. ANL-E performed continuous oversight of project activities as well as performing formal weekly and monthly safety inspections. A project specific Health and Safety Plan (HASP) was developed and followed for performance of D&D activities. Prior to the start of any D&D activities an Audible Safety Analysis (ASA) was written to identify and mitigate all potential job hazards. In addition to the HASP and ASA a project Radiation Protection Plan was developed to insure personnel exposure was maintained As Low As Reasonably Achievable (ALARA). Mandatory personnel experience and training requirements were established for all project personnel prior to being allowed access to the project site. As of May 1, 1997 there have been no personnel injuries or overexposures and only one reportable occurrence involving the cutting of the two live electrical wires discussed earlier.

V. CONCLUSIONS

As of May 1, 1997 the project was 3% ahead of schedule and 8% under cost. This performance has been attributed to excellent preplanning, subcontractor response to identified manpower shortages early in the project, and incorporation of lessons learned from previous D&D projects.

At the completion of all field work and radiological surveys, documents will be submitted to the DOE to obtain the approval for the unrestricted release of the remaining structures.

Total Estimated Cost at Completion (TEC) is $2,004,000.00.

ACKNOWLEDGMENTS

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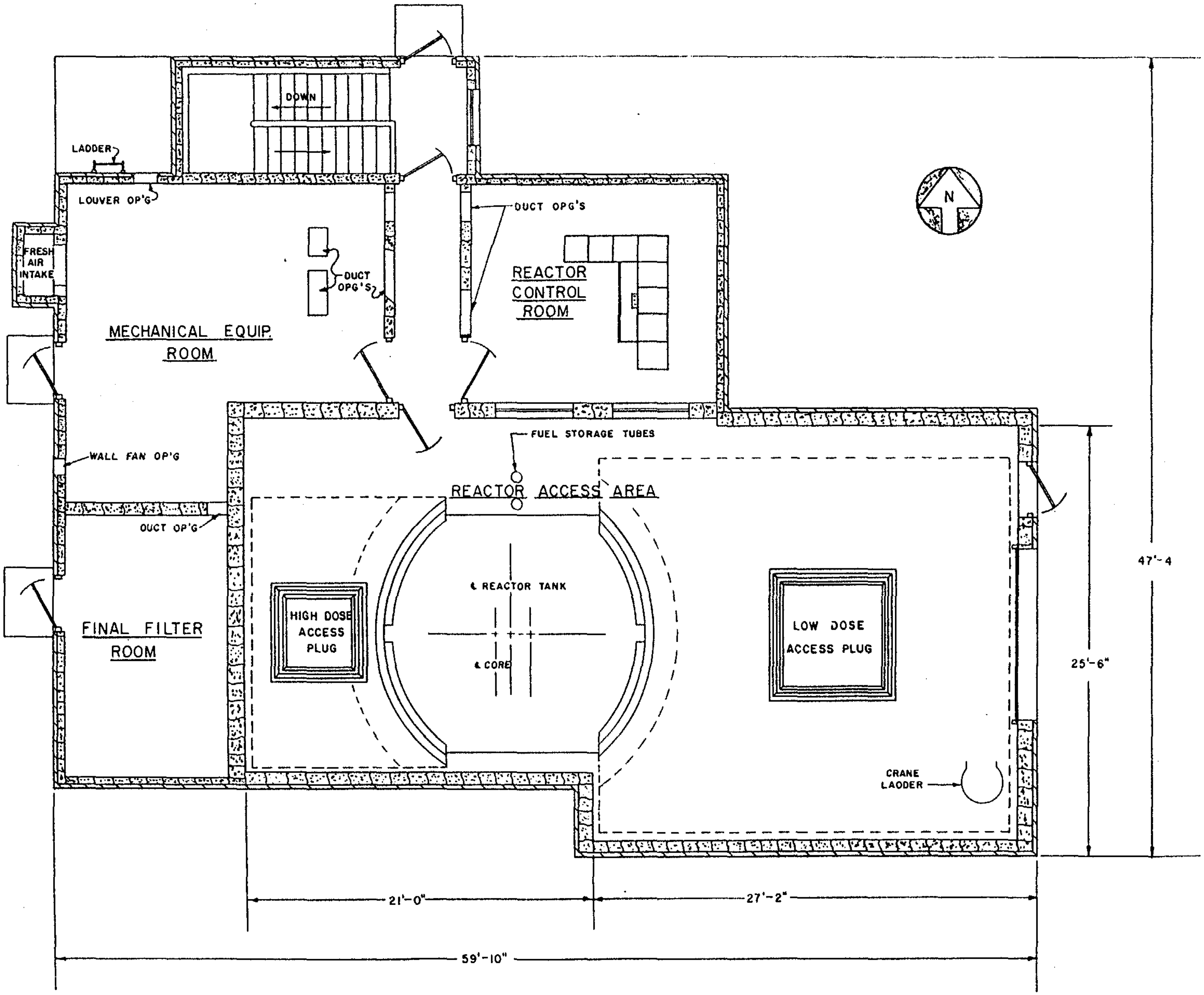

Figure 1. Main Floor Layout of JANUS Reactor Facility.

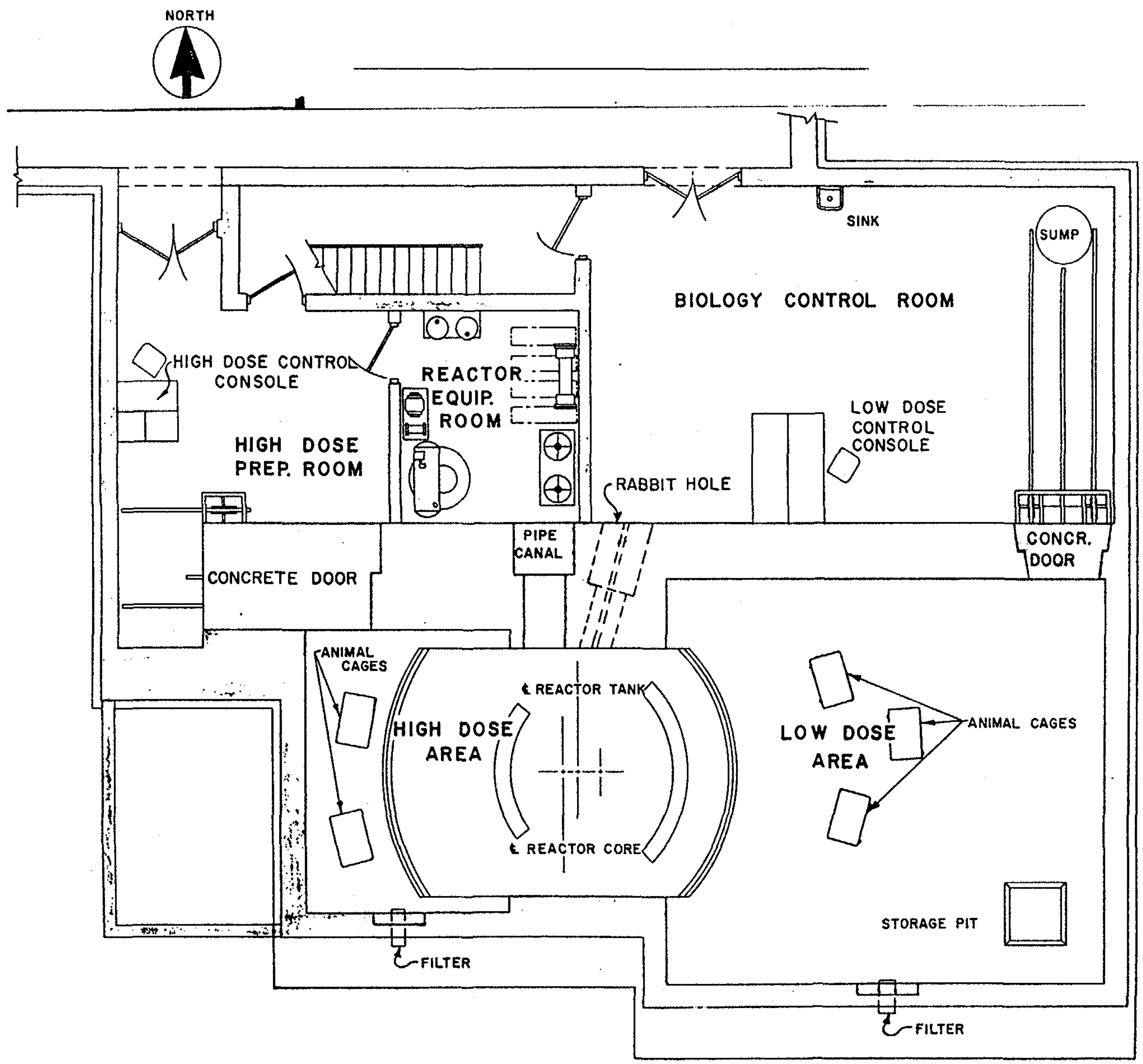

Figure 2. Sub Floor (Basement) of JANUS Reactor Facility.

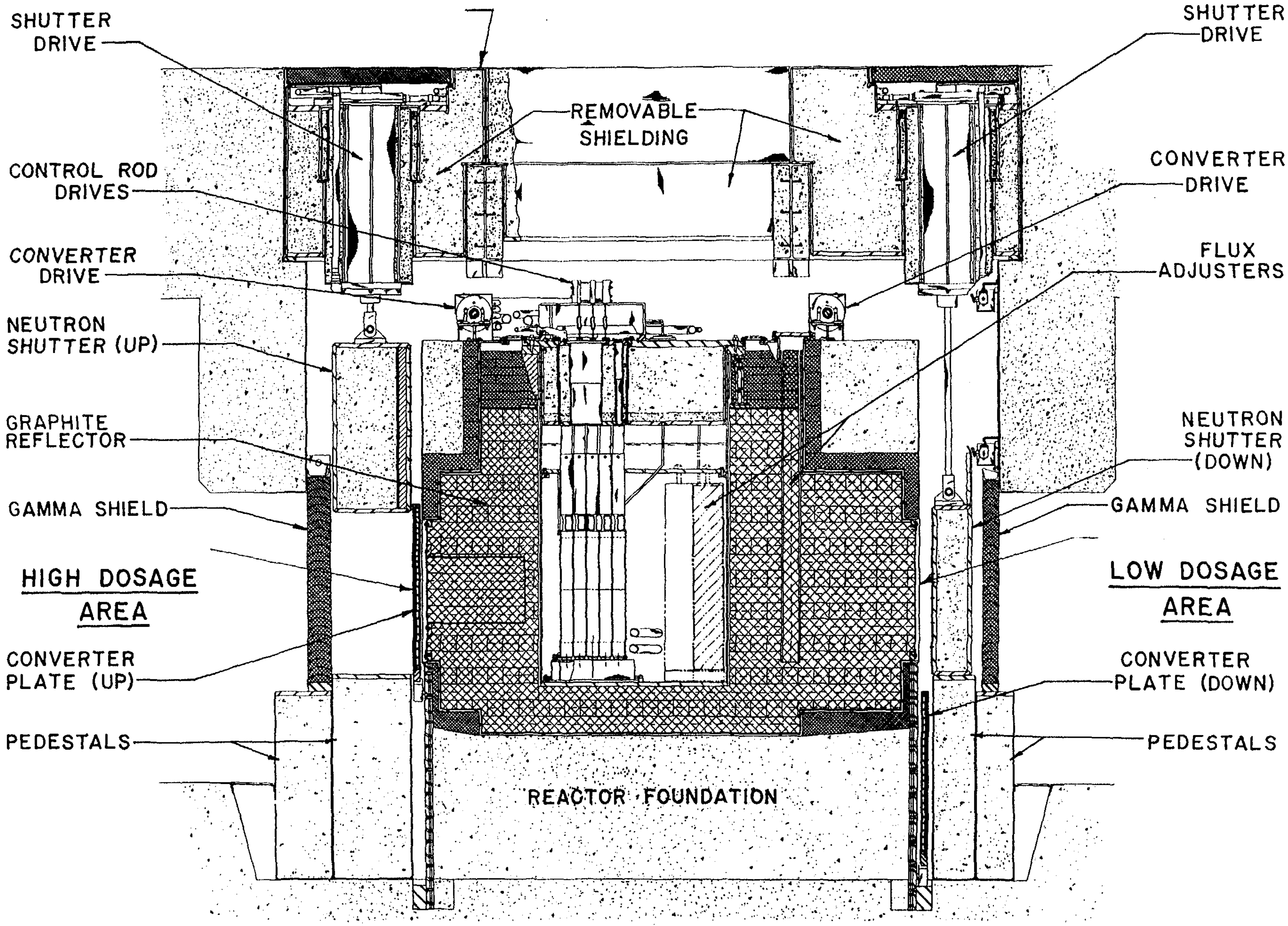

Figure 3. Cross Section of JANUS Reactor.