Chapter 1

REACTOR DESCRIPTION

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1.1 THE FACILITY

1.1.1 The Site

The PRR-1 is located in the PNRI Compound in the campus of the University of the Philippines (U.P.) in the Diliman area of Quezon City, a part of Metropolitan Manila in the island of Luzon, the Philippines. See the following figures:

a. Fig. 1. The PRR-1 in the PNRI Compound

b. Fig. 2. The PNRI Compound in the U.P. Diliman Campus

The PNRI Compound is a 7.5-hectare fenced plot of land. The PNRI Compound is in the 100-hectare mostly-vacant northwest section of the U.P. campus that is separated from most of the academic buildings by Commonwealth Avenue, a wide highway running northeast. The PNRI Compound is bounded at the north by Central Avenue, at the west and southwest by a wooded area (the U.P. Arboretum), at the south and southeast by empty brush land up to Commonwealth Avenue (currently undergoing development into a Science and Technology Park), and at the east by another fenced compound occupied by the Engineering Research and Development Center of the Philippine National Oil Corporation.

Aside from the PRR-1, the PNRI Compound contains three large buildings: the Atomic Research Center Building, the Co-60 Multipurpose Irradiation Facility and the PNRI Administrative and Training Building. There are also numerous small buildings housing laboratories and various workshops. The southwest corner of the compound is fenced apart and contains the Radioactive Waste Management Facility of the PNRI.

1.1.2 The Reactor Building

The Reactor Building is made of reinforced concrete, with a central cylindrical structure topped by an approximately-ellipsoidal dome and two attached wings. The space enclosed by the central cylindrical structure is called the Reactor Bay and contains the Reactor Pool. The two wings are called the East Wing and the West Wing.

See the following drawings:

a. Fig. 3. The Basement-Floor Plan of the Reactor Building

b. Fig. 4. The First-Floor Plan of the Reactor Building

c. Fig. 5. The Second-Floor Plan of the Reactor Building

d. Fig. 6. The ESE-WNW Vertical Section of the Reactor Building

e. Fig. 7. The NNE-SSW Vertical Section of the Reactor Building

The Atomic Research Center (ARC) Building is built as a detached semicircular arc around the Reactor Building but is not considered part of the reactor facility. However, the basement and first floors of the ARC Building are connected by covered hallways to the Reactor Building.

The reactor's cooling tower and small auxiliary structures are located in the northeast space between the Reactor Building and the ARC Building

1.1.2.1 Reactor Bay

The Reactor Bay has an internal diameter of 20.7 m (68 ft), has walls 0.46 m (1.5 ft) thick, and rises 29.8 m (97.8 ft) from its floor to the top of the dome. The floor of the Reactor Bay is 3.8 m (12.3 ft) below ground level. A polar crane spanning the full width of the building is mounted on a circular rail 14.0 m (45.8 ft) above the floor. The Reactor Bay has a truck entrance door, which opens into a tunnel that slopes up to ground level. There are personnel doors into the Reactor Bay from the East and West Wings, and a small hatch into the West Wing.

1.1.2.1.1 Reactor Bay Location Codes

The following codes will be used to refer to locations and items in the Reactor Bay. (The prefix RB means Reactor Bay.) Refer to Figures 3 to 7.

RB-1 Floor.

RB-2 Alcove for sliding truck entrance door.

RB-3 Truck Entrance Ramp.

RB-4 Fuel Storage Tank. This tank is a free-standing cylindrical tank made of stainless steel, 4.9 m (16 ft) high and containing up to 51.1 m^3 (13,500 gal) of demineralized water. The tank was intended to be a temporary storage location for irradiated nuclear fuel elements and other radioactive material that were removed from the Reactor Pool while the pool liner was being repaired in the 1990s. The spent fuel were all shipped out in 1999, but the fuel from the TRIGA core and the other radioactive material are still in the tank. There is a demineralizer attached to the Fuel Storage Tank.

RB-4a Large Portable Demineralizer (beside RB-4).

RB-4b Small Portable Demineralizer (beside RB-4).

RB-4c Co-60 Source (in lead cask inside RB-4).

RB-4d TRIGA Fuel Elements (inside RB-4).

RB-4e Cf-252 Neutron Sources (inside RB-4).

RB-4f Sb-Be Neutron Source (inside RB-4).

RB-4g Pu-Be Neutron Source (inside RB-4).

RB-4h Neutron Source Holder (inside RB-4).

RB-4i Old Regulating Rod (inside RB-4).

RB-4j Various Storage Racks and Tanks (inside RB-4).

RB-5 Stairway. This stairway connects the Reactor Bay floor to the Control Room, East Wing second floor.

RB-6 Stairway. This stairway connects the Reactor Bay floor to the West Wing first floor.

RB-7 Interior surfaces of the wall and dome of the Reactor Bay.

RB-8 Storage Holes. These holes, set horizontally into the wall of the Reactor Bay, were used for storage of the beam tube plugs and some irradiated material.

RB-9 Air-Conditioning Ducts.

RB-10 Polar Crane.

RB-11 Co-60 Source. This source is inside a shipping cask on the floor of the Reactor Bay.

RB-12 Seed Neutron Irradiation Facility (SNIF). The SNIF is stored on the floor of the Reactor Bay.

RB-13 Various Fuel Storage Racks. These racks, which originally held spent fuel, were removed from inside the Reactor Pool and stored on the Reactor Bay floor.

RB-14 Various Shielded Containers. These containers are stored on the floor of the Reactor Bay. At least one of them contains radioactive material.

1.1.2.2 East Wing

The East Wing, including underground spaces, occupies almost two quadrants outside the Reactor Bay, to about 11 m (36 ft) beyond the wall of the Reactor Bay. The East Wing has three floors, two above ground level and one below. The East Wing houses the reactor control room and ventilation equipment in the second floor; a laboratory room and a mechanical/electrical equipment room in the first floor; and another laboratory room, an equipment room, tank rooms and various utility rooms in the basement floor.

The East Wing rises about 8.1 m (26.5 ft) above ground level, with most of its basement floor at the same level as the floor of the Reactor Bay. The basement floor in the tank rooms is 1.4 m (4.7 ft) below the floor of the Reactor Bay.

The East Wing has five doors into the Reactor Bay, one in the control room in the second floor, one each in the laboratory and isotope rooms in the basement floor, and two in the equipment room in the basement floor. The East Wing connects to the ARC Building through a hallway at the first floor level and another hallway directly underneath at basement level. Aside from the connections through the ARC Building, the East Wing has two doors to the outside, one at the first floor and another at the second floor opening to the roof deck.

The locations in the East Wing are described below. (The prefixes have the following meanings: E0 - basement floor; E1 - first floor; E2 - second floor.) Refer to Figures 3 to 7.

1.1.2.2.1 Basement Floor Location Codes

E0-1 N-16 Decay Tank Room. Contains the N-16 decay tank.

E0-1a N-16 Decay Tank. This 11.4 m^3 (3,000 gal) tankwas used to delay primary coolant as it flows from the reactor core, reducing the radiation level around the rest of the primary coolant equipment during operation. The tank is carbon steel with a chemical-resistant phenolic coating.

E0-2 Drain Storage Tank Room. Contains the drain storage tank.

E0-2a Drain Storage Tank. This 37.8 m^3 (10,000 gal) tank was meant to temporarily store waste water before being discharged. The tank is carbon steel with a chemical-resistant phenolic coating. Nevertheless, the tank rusted out and was replaced with a stainless-steel tank in the 1990s. The new tank has never been used.

E0-3 Retention Tank Room. Contains the retention tank and a transfer pump.

E0-3a Retention Tank. This 56.8 m^3 (15,000 gal) tank was used to hold water from the Reactor Pool when the pool water level was lowered. The tank is carbon steel with a chemical-resistant phenolic coating and is still full of ex-pool water at present.

E0-3b Transfer Pump.

E0-4 Suspect Tank Room. Contains the suspect tank and a small transfer pump.

E0-4a Suspect Tank. This 1.9 m^3 (500 gal) tank was meant to hold liquids that are suspected to contain radioactivity. The tank is carbon steel with a chemical-resistant phenolic coating. This tank was used mainly during regeneration of the ion-exchange resin of the clean-up demineralizer.

E0-4b Transfer Pump.

E0-5 Hot Resin Tank Room. Contains the 1.9 m^3 (500 gal) tank meant to store ion-exchange resin that has been discharged from the clean-up demineralizer. The tank is carbon steel with a chemical-resistant phenolic coating.

E0-6 Process Equipment Room. Contains the reactor's heat exchanger, primary pump, make-up softener and demineralizer, clean-up demineralizer, clean-up pump and the sump pit.

E0-7 Sump Pit. All the floor drains in the Reactor Bay and in the East Wing laboratories discharge into the Sump Pit.

E0-7a Sump Pump. This submerged pump in the Sump Pit moved waste water into the drain storage tank or directly into external discharge piping.

E0-8 A shielded alcove in the Process Equipment Room containing the clean-up demineralizer.

E0-8a Clean-Up Demineralizer. The clean-up demineralizer has a discharge connection through the wall to the hot resin tank in room E0-5.

E0-9 Storage Room.

E0-10 Office.

E0-11 Storage Room.

E0-9, E0-10 and E0-11 were used by radiation protection personnel. The storage rooms were used for equipment and supplies, not for radioactive materials.

E0-12 Toilet.

E0-13 Toilet.

The sanitary drains of E0-12 and E0-13 discharge into a septic tank outside the Reactor Building.

E0-14 Stairwell. This stairwell connects the basement, first and second floors of the East Wing.

E0-15 Change Room for Isotopes Laboratory Room (E0-17).

E0-16 Hallway. This hallway connects various rooms in the basement of the East Wing, and also connects to the basement of the ARC Building through an underground corridor. The hallway has a door to the Reactor Bay at one end. The stairwell to the first and second floors of the East Wing opens into this hallway.

E0-17 Isotopes Laboratory Room. Radiochemical processing of targets irradiated in the reactor was done in this room. The room also contains one of the two terminals of the reactor's pneumatic irradiation system. The room was decontaminated in the early 1990s and new equipment (a hot cell for the production of I-131) was installed, which was never used because the reactor never resumed operation.

E0-18 Counting Room. A shielded alcove of the Isotopes Laboratory Room, meant to house counting equipment.

E0-19 Vertical Shaft. Originally meant to contain an elevator (lift) to the first and second floors. The elevator was never installed, and the shaft was closed off.

E0-20 Isotopes Storage Room. This room contains vaults for the storage of radioactive material.

1.1.2.2.2 First Floor Location Codes

E1-1 Mechanical/Electrical Equipment Room. This room contains the switchgear of the building's electrical power supply, the chiller of the building's air-conditioning system, a compressor for the building's compressed-air supply, and a booster pump for the building's water supply.

E1-2 Hallway. This hallway connects the various rooms in the first floor of the East Wing. The stairwell to the basement and second floors opens into this passageway.

E1-3 Office. This room was used by laboratory personnel. This room was later used for storage only.

E1-4 Foyer. This room was originally the reception room to the Reactor Building. The reception area was later moved to the lobby at the first floor of the ARC Building. A hallway connects E1-4 to the first floor lobby of the ARC Building.

E1-5 Stairwell. This stairwell connects the first and second floors of the East Wing. This stairwell was originally meant to be used only by visitors. E0-14 is an adjacent but separate stairwell for reactor and laboratory personnel.

E1-6 General-Purpose Laboratory. This room was originally used for general laboratory work and some radioactivity counting. In the 1980s, the room was partitioned into an office space and a space for the terminus and counting electronics of a Delayed Neutron Activation Analysis system that was installed in the reactor. The DNAA system had an automated pneumatic system for irradiating samples and transporting them to the counter. The remains of the DNAA system is still in the room. The room also has a terminus for the reactor's original pneumatic irradiation system.

E1-7 Vertical Shaft. Continuation of E0-19 in the basement floor. Also closed off.

1.1.2.2.3 Second Floor Location Codes

E2-1 Ventilation Equipment Room. This room was originally an open deck containing the blowers for the ventilation system of the Reactor Building. The original ventilation system was removed and replaced with an air-conditioning system in the 1990s. Most of the roof deck was then enclosed and roofed to hold the emergency exhaust system of the Reactor Building. The unenclosed part of the deck contains the cooling tower of the Reactor Building's air-conditioning system.

E2-2 Visitor's Gallery. This room was originally meant as a viewing room into the Reactor Bay, with glass windows looking into the Reactor Bay and into the control room. The room has its own entrance and stairwell (E1-5), separate from the reactor personnel's entrance and stairwell. The room was later merged with the control room and converted into office space for reactor operations personnel.

E2-3 Control Room. This room contains the operator console and instrumentation cabinets of the reactor. It has a door and a glass window into the Reactor Bay.

E2-4 Toilet. The sanitary and floor drains of this toilet discharge into a septic tank outside the Reactor Building.

E2-5 Storage Room. This is actually the upper portion of the abandoned vertical shaft E1-7 in the first floor. Unlike the similar spaces in the basement and first floor, this room was provided with a concrete floor and was used for storage of control-room supplies.

1.1.2.3 West Wing

The West Wing occupies almost a quadrant and extends to about 13.9 m (45.5 ft) beyond the wall of the Reactor Bay. The West Wing is of the same height as the East Wing, and also has three floors, two above ground level and one below. The second floor houses laboratory and office rooms, and the basement floor is used for storage. The first floor was originally intended to be a large laboratory for radioisotope processing, but the necessary equipment were never installed and the first floor was used only for storage of non-radioactive materials (except for a special room set aside for fresh nuclear fuel). The first floor still has two rooms shielded with heavy concrete that were to be the hot cells.

The West Wing has one personnel door opening into the Reactor Bay, and one room extending into the Reactor Bay with a ceiling hatch originally meant for irradiated targets headed for the hot cells. The West Wing has two doors leading to the outside.

The locations in the West Wing are described below. (The prefixes have the following meanings: W0 - basement floor; W1 - first floor; W2 - second floor.) Refer to Figures 3 to 7.

1.1.2.3.1 Basement Floor Location Codes

W0-1 Storage Room. This was originally just a single room, but was later partitioned into several storage areas. Spare mechanical and electrical equipment for the reactor were stored here. The PNRI property and procurement unit also stored office and laboratory supplies for the whole institute here.

W0-2 Stairwell. This stairwell connects the basement and first floors of the West Wing.

1.1.2.3.2 First Floor Location Codes

W1-1 Transfer Room. This room is actually inside the Reactor Bay, but enclosed by the Reactor Pool concrete. The room has a ceiling hatch that opens into the platform around the top of the Reactor Pool. Irradiated material was intended to be transferred to the West Wing though this room. The room was never used for this purpose, and was only used to store fresh and near-fresh nuclear fuel.

W1-2 Transfer Corridor. Heavy doors on wheels at the back of the hot cells (W1-4 and W1-5) were supposed to open into this corridor, through which the radioactive materials to be processed can enter the hot cells. The doors were never installed.

W1-3 Decontamination Room. Never used as such; used only for storage.

W1-4 Hot Cell 1. Never used as such; used only for storage.

W1-5 Hot Cell 2. Never used as such; used only for storage.

W1-6 Stairwell. This stairwell connects the first and second floors of the West Wing. There is also a door to the Reactor Bay. A door connecting this stairwell to the outside was opened in the 1980s.

W1-7 Operating Room. This room was intended to contain the operator ends of manipulators installed in the hot cells, and would have had lead-glass windows looking into the hot cells. The equipment were never installed, and this room was used only as a hallway. This room originally opened overhead directly into the second floor, but a ceiling was installed in the 1980s.

W1-8 Decontamination and Service Area. Never used as such; used only for storage.

W1-9 and W1-10 were supposed to be the women's change and locker rooms:

W1-9 Women's Contaminated Room. Never used as such; used only for storage.

W1-10 Women's Clean Room. Never used as such; used only for storage.

W1-11 and W1-12 were supposed to be the men's change and locker rooms:

W1-11 Men's Contaminated Room. Never used as such; used only for storage.

W1-12 Men's Clean Room. Never used as such; used only for storage.

W1-13 Storage Room.

1.1.2.3.3 Second Floor Location Codes

W2-1 Ventilation Equipment Room. This room originally contained blowers for the ventilation system of the West Wing, which was separate from the reactor's ventilation system. The ventilation equipment was removed in the 1980s, when this room was converted into office space for regulatory personnel. This room also contains hatches into rooms W1-4 and W1-5 in the first floor below.

W2-2 to W2-5 Offices and laboratories. These rooms were used as offices and laboratories by reactor, research and regulatory personnel. Some radiation counting and light use of radioactive material were done in these rooms.

W2-6 Hallway. This hallway connects the various rooms in the second floor of the West Wing. The stairwell to the first floor (W1-6) connects to one end of this hallway.

W2-7 Women's Toilet.

W2-8 Men's Toilet.

The sanitary drains of W2-7 and W2-8 discharge into a septic tank outside the Reactor Building.

W2-9 Storage Room.

1.1.2.4 Reactor Pool

The Reactor Pool is a monolithic free-standing reinforced-concrete structure sitting on the Reactor Bay floor. The Reactor Pool was designed to hold about 200 m^3 (7000 ft^3) of water, with the waterline about 8.5 m (27.9 ft) above the floor. The pool water and concrete serve as the reactor's biological shield. The Reactor Pool is shown in the drawings of the Reactor Building (Figures 3 to 7) and in cut-away view in Figure 8.

1.1.2.4.1 Pool Sections

The Reactor Pool has three sections: the high-power section, the intermediate section and the low-power section. The intermediate and low-power sections are connected to the high-power section in that sequence going from east to west. The sections are open to each other down to their bottoms.

The high-power section is circular with an internal diameter of 2.6 m (8.6 ft) and a depth of 9.5 m (31 ft), and is concentric with the Reactor Bay. The intermediate section is rectangular, with internal dimensions of 1.6 m (5.2 ft) by 2.4 m (8.0 ft), and is 8.7 m (28.4 ft) deep. The low-power section is almost square, with internal dimensions of 2.6 m (8.5 ft) by 2.4 m (8.0 ft), and is also 8.7 m (28.4 ft) deep.

The reactor core is suspended inside the Reactor Pool, and can be moved to any of the pool sections. The reactor's primary cooling system has 8-inch pipe stubs in the Reactor Pool that connect when the core is in the high-power section; in that location, the availability of forced cooling allows the reactor to be operated at its maximum power, hence the name of the pool section. There is no provision for forced cooling in any of the other two sections, but the reactor can still be operated up to about 100 kilowatts using natural convection cooling in either section. In practice, the core was operated in the high-power section most of the time, occasionally in the low-power section, and never in the intermediate section. The intermediate section was used for storage of spent fuel.

1.1.2.4.2 Pool Stages

The Reactor Pool rises from the floor of the Reactor Bay in four stages. The first to third sections are approximately octagonal in outline around the high-power and intermediate sections but changes to a rectangular outline around the low-power section, while the fourth stage is completely rectangular enclosing all three sections. The first stage is 4.2 m (13.9 ft) high and is about 3 m (10 ft) thick around the high-power and intermediate sections, and 2.3 m (7.5 ft) thick around the low-power section. The second stage stands 1.1 m (3.8 ft) above the first stage and is about 2.1 m (6.8 ft) thick around the high-power and intermediate sections and 0.9 m (3 ft) thick around the low-power section. The third stage stands 1.1 m (3.8 ft) above the second stage and is about 1.3 m (4.3 ft) thick around the high-power and intermediate sections and 0.6 m (1.8 ft) thick around the low-power section. The fourth stage stands 2.4 m (7.9 ft) above the third stage and is at least 0.6 m (1.8 ft) thick all around. The top of the pool is 8.9 m (29.3 ft) above the floor of the Reactor Bay and is at the level of the second floor of the East Wing of the Reactor Building.

1.1.2.4.3 Pool Penetrations

There are several penetrations in the Reactor Pool for irradiation facilities. All the penetrations are at the elevation of the reactor core, which is centered at 0.89 m (2.9 ft) above the floor of the Reactor Bay.

The thermal column fills an opening about 1.8 m (5.9 ft) square through the east face of the high-power section's octagonal outline (directly opposite where the intermediate section is connected). The thermal column has an aluminum casing that juts into the pool's high-power section, touching the reactor core. The external end of the thermal column is closed with a wheeled concrete and steel door that is 0.6 m (2 ft) thick.

There are six radial beam port penetrations at reactor core level, one through each of the north, northwest, northeast, south, southwest and southeast faces of the high-power section. The north and south beam ports are 8-inch aluminum tubes, and all the others are 6-inch aluminum tubes. The tubes are flanged where they leave the pool concrete. Aluminum extensions were bolted on to the tubes to extend them to the core at the center of the high-power section. These extensions were removed in the 1990s during the repair of the pool liner. All of the beam ports have an internal shutter and removable end plugs for radiation shielding.

There is a 0.6 m (2 ft) square window in the Reactor Pool concrete at core level at the west end of the low-power section. Only the pool liner covers this opening. The window opens into the dry gamma room, a shielded irradiation facility 2.4 m (7.8 ft) deep by 3.4 m (11 ft) wide by 2.4 m (8 ft) high. The reactor core can be moved flush against the window. The core (when shut down) was originally intended as the gamma irradiation source, but a rack of Co-60 pencils was actually exclusively used for irradiation. The dry gamma room has a concrete and steel door 0.9 m (3 ft) thick.

1.1.2.4.4 Pool Liner

The inside of the Reactor Pool is completely lined with welded aluminum plates 6 mm (0.25 inch) thick. The liner was installed after the pool concrete was poured. The liner was welded on a framework of aluminum I-beams bolted to the pool concrete. The 150 mm (6 inch) gap between the liner and the concrete was filled with grout as the liner was assembled from the bottom up.

Originally, the liner was not successfully welded to the thermal column casing because of accessibility problems with the joints. The joints were packed with epoxy to make them watertight. A leak in an epoxied joint caused the shutdown of the reactor in 1988, about 25 years after the liner was constructed. The liner was repaired in the 1990s by cleaning out and modifying the epoxied joints to allow full re-welding. While the repair was being performed, corrosion was discovered in many places in the pool liner. To delay the eventual penetration of the corrosion, the thickness of the pool liner was doubled in 1997 by welding another set of 6-mm aluminum plates over all of the pool liner below about 3.6 m (12 ft) below the top of the Reactor Pool.

1.1.2.4.5 Piping Embedded in the Pool

Pipes embedded in the concrete of the Reactor Pool carry the primary cooling water, air for the ventilation of irradiation facilities (thermal column, beam tubes and dry gamma room), and capsules of the pneumatic irradiation facility. There are also embedded conduits for instrumentation and electrical power cables.

1.1.2.4.6 Pool Platform

The pool platform is a walkway around the upper part of the Reactor Pool, at the same level as the second floor of the East Wing, and connecting to the Control Room (E2-3). The western end of the pool platform is also the ceiling of room W1-1 of the West Wing. The Pool Platform is surrounded by safety railing. Trays for reactor instrumentation and power cables run under the pool platform, as well as the piping for the pneumatic irradiation system.

1.1.2.4.7 Bridge, Suspension Frame and Core Box

The top of the Reactor Pool is spanned by a steel bridge, at the center of which is attached an aluminum framework that supported the reactor core box under water. See Figures 9, 10 and 11. The bridge is mounted on rails, allowing the bridge to be moved to any of the pool sections, carrying the core box with it. The core box contained the reactor's fuel elements, reflector elements, control elements, start-up neutron source, irradiation baskets and two vertical irradiation tubes. (Except for the control elements and baskets, all these contents of the core box have been removed.) The drive motors of the control elements are mounted on the bridge. The framework also supports ducting that carried the primary coolant around the core and connected with the pipe stubs in the high-power section of the Reactor Pool.

1.1.2.4.8 Reactor Pool Location Codes

The following codes will be used to refer to locations and items in the Reactor Pool. (The prefix RP means Reactor Pool.) Refer to Figures 3 to 7.

- RP-1 Interior of High-Power Section
- RP-2 Interior of Intermediate Section
- RP-3 Interior of Low-Power Section
- RP-4 Dry Gamma Room
- RP-5 Thermal Column
- RP-6 Beam Tubes
- RP-6a Beam Tube Plugs.
- RP-7 Exterior Surfaces of the Pool
- RP-8 Pool Platform
- RP-8a Irradiation Capsule Stringers. These irradiated parts are stored behind lead shielding at the west end of the pool platform.
- RP-8b DNAA Irradiation End. This item was removed from the reactor core and placed in a rack at the north side of the pool platform.
- RP-8c Spare Neutron Detector. This item may have been installed in the core box for a short time. It is stored in a rack at the north side of the pool platform.
- RP-8d Various Fuel Handling Tools. These items are stored in racks at the south side of the pool platform.
- RP-9 Bridge and Core Suspension Frame
- RP-10 Core Box
- RP-10a Control Elements (Blades and Rods). These items are still installed in the core box but are easily removable.
- RP-10b Irradiation Baskets. A few irradiation baskets are still in the core box.
- RP-10c Neutron Detectors. Some neutron detectors are installed inside the corner posts of the core suspension frame, and some are installed in irradiation baskets in the core box.

1.1.2.5 Reactor Grounds

There are a few auxiliary structures in the grounds northwest of the Reactor Building that are considered part of the PRR-1. See Figure 1.

1.1.2.5.1 Hallways to ARC Building

The basements and first floors of the Reactor Building East Wing and the ARC Building are connected by separate enclosed hallways, one atop the other. The hallways run west-to-east and are each about 3.2 m wide.

1.1.2.5.2 Reactor Office

The office of the reactor personnel is a single-floor concrete building adjoining the north side of the first-floor hallway to the ARC Building. The area of the building is about 6.1 m by 16.8 m. This building was constructed in the 1980s.

1.1.2.5.3 Large Powerhouse

The reactor's 500 kW diesel generator is in a detached concrete powerhouse on the north side of the reactor's office building. The single room of the powerhouse has an area of about 4 m by 6 m. This powerhouse and diesel generator were added to the reactor in the 1990s.

1.1.2.5.4 Small Powerhouse

A 10 kW diesel generator and an Uninterruptible Power Supply (UPS) for the reactor's control and instrumentation system are installed in a small concrete powerhouse a few meters north of the large powerhouse. The area of the building is about 3.6 m by 6.6 m. This powerhouse and diesel generator were added to the reactor in the 1980s.

1.1.2.5.5 Diesel Fuel Tank

Diesel fuel for the reactor's generators is stored in a steel tank in a concrete pit close to and north of the powerhouses. The pit is covered with a concrete slab and is 3.5 m in diameter and 3.5 meters deep. The tank in the pit that can hold up to about 11,000 liters (3,000 gal) of diesel fuel. This fuel tank was constructed in the 1990s.

1.1.2.5.6 Cooling Tower

The reactor's cooling tower sits on a concrete pad 5.8 m (19 ft) square, about 7.5 m (24 ft) north of the Reactor Bay wall. Pipes run in trenches from the underground equipment room E0-6 to the cooling tower. The pipes carry secondary cooling water between the cooling tower and the reactor's heat exchanger. The pumps of the secondary cooling system are installed outdoors, in a pit beside the cooling tower.

The cooling tower was originally installed in 1963 but has been rebuilt twice. The original tower had a concrete basin and wooden fill The first rebuild in the 1970s replaced the wooden fill. The second rebuild during the 1980s replaced the cooling tower entirely with a new one with a steel basin and PVC fill.

1.1.2.5.7 Utility House

A small concrete shed stands beside the cooling tower, originally intended to house a softener for water in the secondary cooling system. The softener was later found unnecessary and was never installed. The structure was then used as a general utility building.

1.1.2.5.8 Raw Water Tank

An above-ground cylindrical concrete tank that can hold up to 56.8 m^3 (15,000 gal) of water is located near the utility house and diesel fuel tank. The tank holds the reactor's reserve of unprocessed water. The raw water tank was constructed in the 1980s.

1.1.2.5.9 Underground Waste Water Discharge Piping

Waste water from the reactor, excluding sanitary waste, is discharged through a single underground concrete pipe running from the basement of the East Wing to the western boundary of the PNRI Compound. The pipe runs under the pump pit at the side of the cooling tower and under the truck entrance ramp, where it is accessible through manholes and vertical shafts.

The original pipe run from the second manhole to the site boundary collapsed and was blocked during the 1980s. A new underground pipe run was dug at that time, and the old pipe run was abandoned.

1.1.2.5.10 Underground Septic Tanks

The toilets in the East Wing and the West Wing are connected to buried septic tanks, whose digested liquid effluents are diffused to the subsoil by perforated overflow pipes.

1.1.2.5.11 Reactor Grounds Location Codes

The following codes will be used to refer to locations in the grounds around the Reactor Building. (The prefix RG means Reactor Grounds.)

RG-1 Earth, Subsoil and Rock

RG-2 Underground Waste Water Pipes

RG-3 Septic Tanks

RG-4 Basement-Level Hallway to ARC Building

RG-5 First-Floor Hallway to ARC Building

RG-6 Reactor Office

RG-7 Large Powerhouse

RG-8 Small Powerhouse

RG-9 Diesel Fuel Tank

RG-10 Raw Water Tank

RG-11 Cooling Tower

RG-12 Utility House

1.1.3 The Reactor Systems and Equipment

Reactor operation was supported by several mechanical/electrical systems that are described below. Some of these will remain operational to support the decommissioning of the PRR-1.

1.1.3.1 Irradiation Facilities

1.1.3.1.1 Thermal Column

The thermal column is a graphite-filled horizontal cavity in the high-power section of the reactor pool that provided neutrons in the thermal range. The penetration has been described previously. The thermal column abuts the east face of the core box, being separated from the latter by a water-cooled lead gamma shield.

1.1.3.1.2 Beam Ports

The beam ports are air-filled aluminum tubes, described previously, that provided neutrons which were primarily above the thermal range. Three beam ports were fed by the north face of the core box, and three by the south face. The three northern beam ports were used to irradiate capsules that were manually inserted in the tubes. Two of the southern beam ports were connected to neutron spectrometers, and one was connected to a time-of-flight experiment rig. These rigs were dismantled in the 1990s when the fuel storage tank (RB-4) was constructed in the Reactor Bay.

1.1.3.1.3 Pneumatic Tubes

The pneumatic tubes are air-filled aluminum tubes that rapidly transported 1-1/2-inch-diameter, 6-inch long polyethylene capsules (“rabbits”) to near the reactor core. There were two tubes, one terminating at the north face of the core box and one at the south face. The other ends of the tubes, where the capsules were inserted and retrieved, were at the laboratories in the East Wing, one at location E0-17 and another at location E1-6. The turbo-compressor powering the facility was located at the mechanical/electrical equipment room (E1-1). The pneumatic irradiation facility was deactivated and partially dismantled in the 1990s.

1.1.3.1.4 Dry Pipes

The dry pipes were two 2-inch-diameter air-filled vertical aluminum tubes inserted in the core box, in the grid but outside the fuel element array. The tubes were bent and offset to prevent radiation streaming. Small aluminum capsules containing target material were manually lowered down the dry pipes in stringers for irradiation. The dry pipes were removed when the reactor core was defueled.

1.1.3.1.5 DNAA System

A delayed-neutron activation analysis (DNAA) system was installed in the 1970s to analyze geological samples for uranium content. The system used compressed air to drive small 1/2-inch-diameter polyethylene capsules containing the samples to an irradiation tube vertically inserted in the core box. After irradiation, a capsule was driven to a counting system in location E1-6 in the East Wing that detected the delayed fission neutrons produced by uranium in the sample. Plastic tubing was used to transport the capsules between the irradiation and counting locations. The system was automated and accepted a number of capsules loaded in a magazine. The DNAA system was dismantled in the 1990s, although there are still remains of the system in location E1-6.

1.1.3.1.6 Seed Neutron Irradiation Facility

The Seed Neutron Irradiation Facility (SNIF) was provided by the IAEA in the late 1960s, primarily for the fast-neutron irradiation of seeds. The SNIF was basically a barrel-shaped gamma and thermal-neutron shield, with a diameter of about 43 cm (17 inches) and a height of about 40 cm (15.75 inches), with a central cavity to accommodate the irradiation target. The SNIF was floor-mounted on a pedestal at the low-power section of the Reactor Pool. The core box was moved alongside when the SNIF was to be used. The SNIF was removed from the pool in the course of pool liner repair in the 1990s.

1.1.3.1.7 Dry Gamma Room

The Dry Gamma Room has been described previously as a penetration in the Reactor Pool. This was a Co-60 gamma irradiation facility that shared the Reactor Pool but was utilized independently of the reactor.

1.1.3.2 Reactor Cooling System

The reactor was cooled by water in a system that delivered reactor heat to a heat exchanger. The primary coolant loop pumped water through the reactor core, passing hot water through a 3,000-gallon N-16 delay tank, through the 75-hp primary pump, through the tube side of the heat exchanger, and back to the reactor core as cooled water. The N-16 delay tank is in room E0-1 while the primary pump and heat exchanger are in room E0-6 of the East Wing. The all-aluminum primary piping within those rooms are accessible in bolted-together sections that can be taken apart. However, the piping from those rooms to the Reactor Pool are embedded in concrete under the floor of the Reactor Bay and in the concrete of the Reactor Pool. The primary coolant within the pool is guided but not completely isolated from the pool water by flow channels built into the suspension frame supporting the reactor core.

The hot water in the secondary coolant loop was routed from the shell side of the heat exchanger to the top of the cooling tower, sprayed down to the cooling tower basin, collected from the basin by two 40-hp pumps, and returned to the shell side of the heat exchanger as cooled water. The all-aluminum secondary loop piping are accessible in bolted-together sections.

The current reactor cooling system was installed in the 1980s during TRIGA conversion. The original heat exchanger, pumps and exposed piping were replaced, but the N-16 delay tank and all of the embedded piping were retained.

1.1.3.3 Water Supply and Purification System

The reactor's water is supplied by the city's water mains, except for a few years during the 1960s when the reactor used deep ground water pumped up to a water tower. (The water tower still exists, no longer directly connected to the reactor. It is now used as an emergency supply for the entire PNRI compound.) Reserve raw water is stored close to the Reactor Building in a tank (RG-10). A booster pump is installed in room E1-1 for those times when the city water pressure is not adequate.

Make-up water that was to be added to the reactor pool was purified using a softener column and a mixed-bed ion-exchange demineralizer column in room E0-6. The make-up purification system handled only incoming raw water, never pool water. The purity of the pool water was maintained by a separate clean-up demineralizer column in location E0-8. Both of these purification systems are the original equipment installed in the 1960s.

The water in the secondary coolant loop was not treated, except for the addition of a biocide to control the growth of algae. The purity of untreated city water was considered sufficient for use in the secondary coolant loop.

1.1.3.4 Air Conditioning and Ventilation System

The Reactor Bay and East Wing were originally ventilated by blowers that provided 2.5 air changes per hour. The air was not conditioned and was often hot and humid in the tropical environment. Uncontaminated air was discharged at the level of the second floor of the East Wing, while air from the irradiation facilities was filtered and discharged at the top of the dome. During an emergency, the normal ventilation system was shut down and a separate blower discharged air at the top of the dome through a filter, supposedly keeping the interior of the building at a negative air pressure and preventing radioactive contamination from escaping. However, in practice the air leakage through the ducting of the normal ventilation system did not allow much negative pressure to build up inside the Reactor Bay.

The original ventilation system was removed during the 1990s. Discarding the old ventilation ducts and sealing the wall penetrations allowed a single blower to maintain negative pressure inside the Reactor Bay at all times, not just during an emergency. A new separate ventilation system was installed for the isotopes laboratory E0-17 in the East Wing. A large air-conditioning system was installed to control the humidity and lower the temperature in the Reactor Bay, although it was not fully tested before the reactor was shut down.

The West Wing had a ventilation system that was separate from that of the East Wing and Reactor Bay. This ventilation system also did not supply conditioned air. The West Wing ventilation system was removed in the 1980s, by which time all the rooms in the West Wing that were in use as offices or laboratories had individual room air-conditioners.

1.1.3.5 Control and Instrumentation System

The central node of the reactor's control and instrumentation system is in E2-3, the control room. From there, cables run under pool platform RP-8 to cable towers, and then to the bridge RP-9. The control rod drive motors are on the bridge. Cables for instrumentation run from the bridge down the suspension frame to the core.

Many other control and instrumentation cables are installed in electrical conduits that terminate in the control room. These cables are for the reactor's radiation monitoring system, process control system, motor control system, fire alarm system, door monitoring system, public-address system, and warning lights and alarms.

The control and instrumentation system has been shut down since the 1988 and is probably mostly non-functional by this time.

1.1.3.6 Electrical Power Supply System

The reactor's electrical power is supplied by the city's electrical utility company, although the reactor has generators capable of supplying its entire operational load for back-up. Electrical power is carried by high-voltage cables from the utility company that enter a power room at the basement of the ARC Building. That room contains a large step-down transformer that converts the power to three-phase 220 V, 60 Hz. Until the 1990s, the entire PNRI Compound was supplied with power from this single source. The PNRI Administrative and Training Building is now supplied with 220 V power directly by the utility company, but the Reactor Building is still supplied with power from the ARC Building transformer. Electrical power enters the Reactor Building in room E1-1.

The reactor has a 500 kW diesel generator (RG-7) with an 11,000-liter fuel tank (RG-9). This generator was installed in the 1990s and was not much used until the reactor was shut down. However, it is still functional.

The reactor also has a 10 kW diesel generator and UPS (RG-8) that is connected only to the control and instrumentation system. This emergency electrical supply system was installed in the 1980s. This system can supply essential power even if the city power and the large generator both fail. However, the UPS has become non-functional in the years after the reactor was shut down.

1.1.3.7 Polar Crane

The polar crane in the Reactor Bay has a rated lifting capacity of 9 metric tons. However, its mechanical parts date back to the 1960s, and it has never been used to lift more than 5 tons in recent years. The crane was refurbished in the 1990s, and is still functional.

1.1.4 Facility Operating History

1.1.4.1 Authorized Activities

1.1.4.1.1 Reactor Operation

The PRR-1 first attained criticality on 26 August 1963 and was first operated at 1 MW on 26 October 1964. The reactor was then operated regularly, usually at 1 MW for a few hours a day until

30 March 1977, accumulating a total burn-up as of that date of 570 MWd. Problems with aging instrumentation caused the reactor to be operated at no more than 500 kW from then to 14 July 1980, increasing the total burn-up to 604 MWd. The instrumentation was replaced, but problems with the reactor building's ventilation system caused the reactor power to be reduced further to 100 kW until 24 October 1984. The total burn-up had reached only 617 MWd by that date. The reactor was then shut down for conversion to a TRIGA-type reactor.

The reactor originally had 30 plate-type fuel elements in the core in 1963, each containing 134 g of U-235 at an enrichment of 20%. The reactor was partially refueled several times during the 1970s and early 1980s, eventually replacing 10 of the original fuel elements with similar fuel elements containing 137 g each of U-235 at 93% enrichment, and another 10 with fuel elements containing 155 g each of U-235 at 93% enrichment. The core size was reduced to 26 fuel elements, with 6 of the original fuel elements still in service in 1984.

All of the irradiated plate-type fuel elements were eventually shipped back to the U.S.A. on 14 March 1999.

1.1.4.1.2 TRIGA Conversion

The cooling system, instrumentation system and electrical power supply system were reconstructed with new components during 1984-1987. The original plate-type fuel elements were replaced with 115 rod-type TRIGA elements, housed in 30 shrouded 4-rod clusters that approximated the external dimensions of the plate-type fuel elements in order to fit into the original grid. (Five rod positions were occupied by control rods or irradiation tubes.) Other components of the reactor were not replaced or rebuilt at the time, although it was planned to repair or upgrade some aging components (primarily the ventilation system) before the reactor would be put back into regular operation.

The PRR-1 was successfully tested as a TRIGA reactor during 9 to 30 March 1988. First criticality with the TRIGA core was achieved on 11 March 1988. Testing was completed with a five-hour run at 3 MW on 28 March 1988.

The PRR-1 never resumed regular operation. The pool liner leak that begun its unplanned shutdown appeared on 18 April 1988.

1.1.4.1.3 Gamma Irradiation

Gamma irradiation was done in the dry gamma room independently of the reactor using a 20 kCi (as of May 1970) Co-60 source. The source was placed in the storage tank (RB-4) in the Reactor Bay in the 1990s in the course of pool liner repair. There is another 19 kCi (as of September 1978) Co-60 source in a lead cask stored in the Reactor Bay.

1.1.4.1.4 Radionuclide Processing

Targets irradiated in the reactor were processed in the isotopes laboratory room (E0-17) for the production of radionuclides. The radionuclides that were routinely produced were in small amounts and generally were short-lived. These included Br-82, Cr-51, Co-58, Co-60, Cu-64, Au-198, I-128, Ir-191, Mn-56, Ni-65, P-32, Na-24 and S-35.

Most of the processing was moved out of the Reactor Building into a separate building in the 1970s. The isotopes laboratory room was gutted and decontaminated in the 1990s and a new hot cell for I-131 was installed. The new equipment has never been used except for some testing.

1.1.4.2 License or Authorization History

The PNRI, the owner/operator of the PRR-1, is also the national nuclear regulatory body of the Philippines. Philippine law has been interpreted by the PNRI as exempting its own facilities from the formal licenses required of other nuclear facilities in the Philippines. The PRR-1 was never issued an official license during its operational lifetime from 1963 to 1988, but its operation was always subject to review and approval by a Reactor Safety Committee. The head of the PNRI regulatory division traditionally was also the chairman of the Reactor Safety Committee.

In 2004, the PNRI decided to implement a formal internal licensing process for its own facilities, called an "authorization" process to differentiate it from the licensing imposed on externally-owned facilities. The PNRI's regulatory division was given formal authority over the PNRI's facilities, which will be subject to the same regulations imposed on external facilities. The PNRI facilities were required to obtain official authorizations from the regulatory division in order to continue operating. The PRR-1 was already shut down at time, but was required to obtain authorization for the possession of the remaining radioactive materials in the facility, and future decommissioning activities will also be subject to the authorization process.

1.1.4.3 Spills and Occurrences Affecting Decommissioning

There is no known major spill or other major release of radioactivity during the operational life of the reactor. There may have been minor unrecorded spills (e.g., of activated ion-exchange resin or fluids while regenerating the reactor's demineralizer, or small mishaps in the laboratories).

The pool liner leak in 1988 released water continuously until the pool was completely dewatered in 1992, but fortunately there had never been a fuel cladding failure in the PRR-1 and the water did not carry a significant amount of contamination. However, the water did completely saturate the concrete under the liner, and could have diffused activation products deeper than their places of formation.

1.1.4.4 Previous Decommissioning Activities

During TRIGA conversion in the 1980s, all of the components of the reactor cooling system except the pipes embedded in concrete were removed and replaced. The instrumentation system, including the control element drives and the neutron detectors, was also completely replaced.

Also in relation to TRIGA conversion, the old equipment in the isotopes laboratory room (E0-17) in the basement floor of the East Wing was removed and the room was decontaminated, in preparation for the installation of a new hot cell for the production of I-131. The new hot cell was installed and tested, but never used for production because the reactor was shut down.

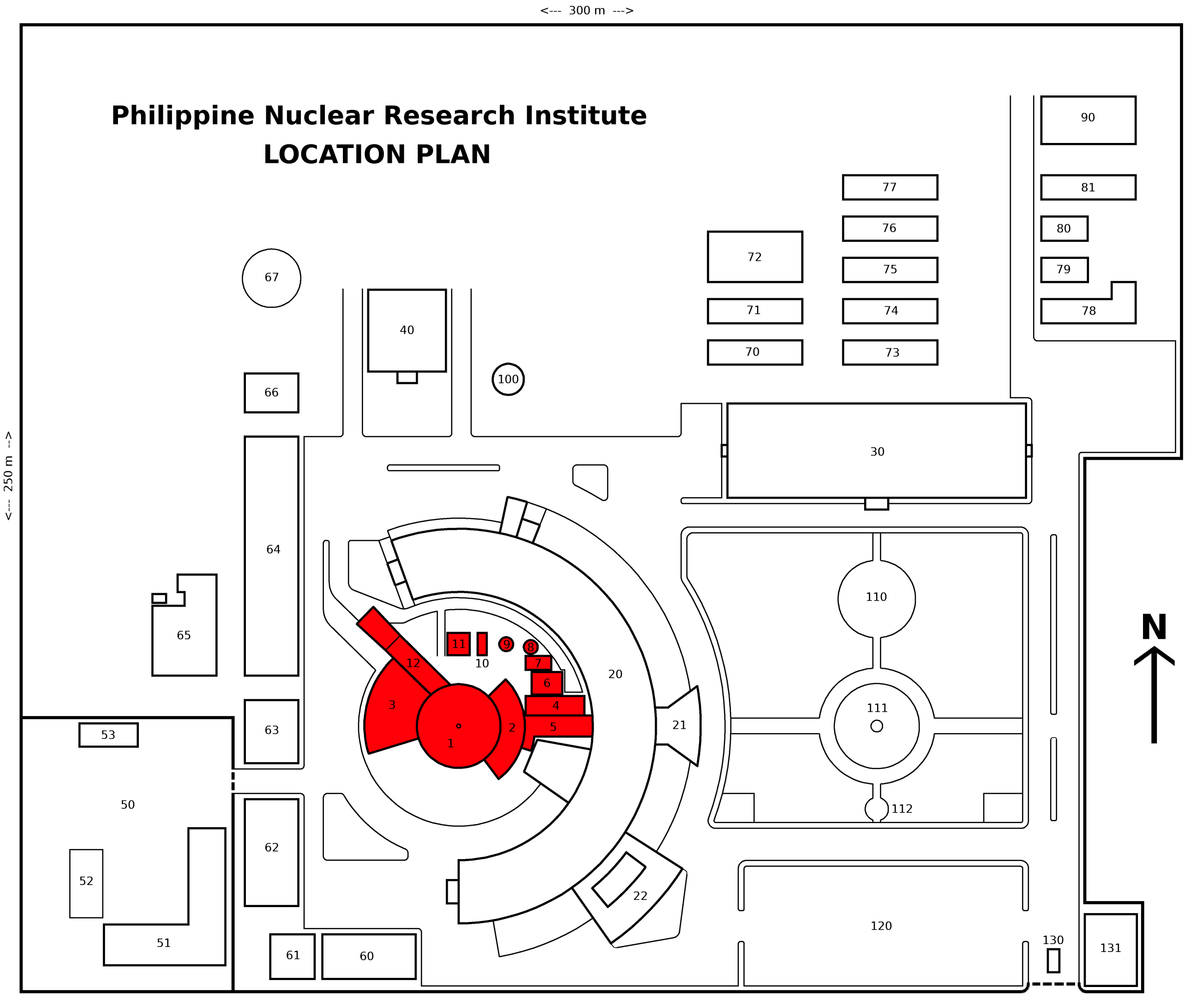
Also in the 1980s, the old buried waste water discharge piping became blocked and was abandoned. A new buried pipe run was installed.

The reactor pool was dewatered and decontaminated during the 1990s in the course of repairing the pool liner leak. A new layer of aluminum plates was welded over the old liner in the bottom half of the Reactor Pool.

At about the same time as the pool liner was being repaired, the rusted-out drain storage tank (E0-2) in the basement floor of the East Wing was dismantled and replaced with a new tank. The new tank has never been used.

All of the reactor's spent plate-type fuel elements were shipped out of the site in 1999. The TRIGA fuel elements remain in the fuel storage tank (RB-4) in the Reactor Bay.

FIGURES



LEGEND:

PRR-1:
1 Reactor Building Dome
2 Reactor Building East Wing
3 Reactor Building West Wing
4 Office
5 Hallway to ARC Building
6 Large Powerhouse
7 Small Powerhouse
8 Diesel Fuel Tank
9 Water Tank
10 Utility House
11 Cooling Tower
12 Truck Entrance

20 Atomic Research Center Building
21 Entrance Canopy
22 Poolside

30 Administrative and Training Building

40 Co-60 Multipurpose Irradiation Facility

50 Radioactive Waste Management Facility
51 Waste Processing Building
52 Waste Storage Trenches
53 Utility House

60 Irradiation Services Lab
61 Warehouse
62 Industrial Applications Lab
63 Radiography Facility
64 Machine Shop
65 Nuclear Materials Lab
66 Carpentry Workshop
67 Gamma Garden

70 Agriculture Lab 1
71 Agriculture Lab 2
72 Greenhouse
73 Biomedical Lab 1
74 Biomedical Lab 2
75 Entomology Lab
76 Seed Processing Lab
77 Animal House
78 Health Physics Lab
79 Tritium Lab
80 Environmental Lab
81 Cytogenetics Lab

90 Motor Pool

100 Water Tower

110 Bronze Sculpture
111 Flagpole
112 Gen. Medina Memorial

120 Parking Lot

130 Guard House
131 Guard Barracks

Fig. 1. The PRR-1 in the PNRI Compound

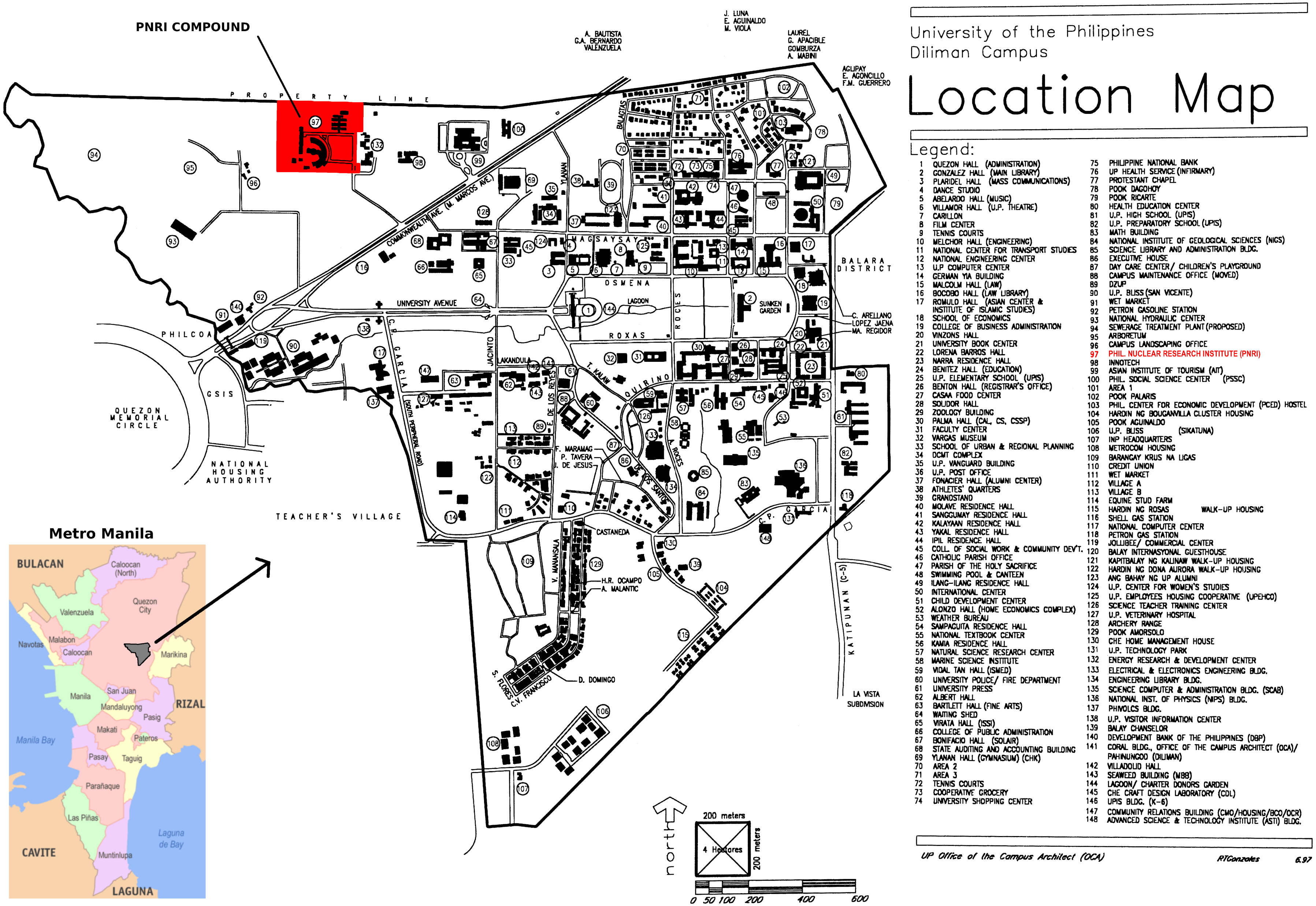


Fig. 2. The PNRI Compound in the U.P. Diliman Campus

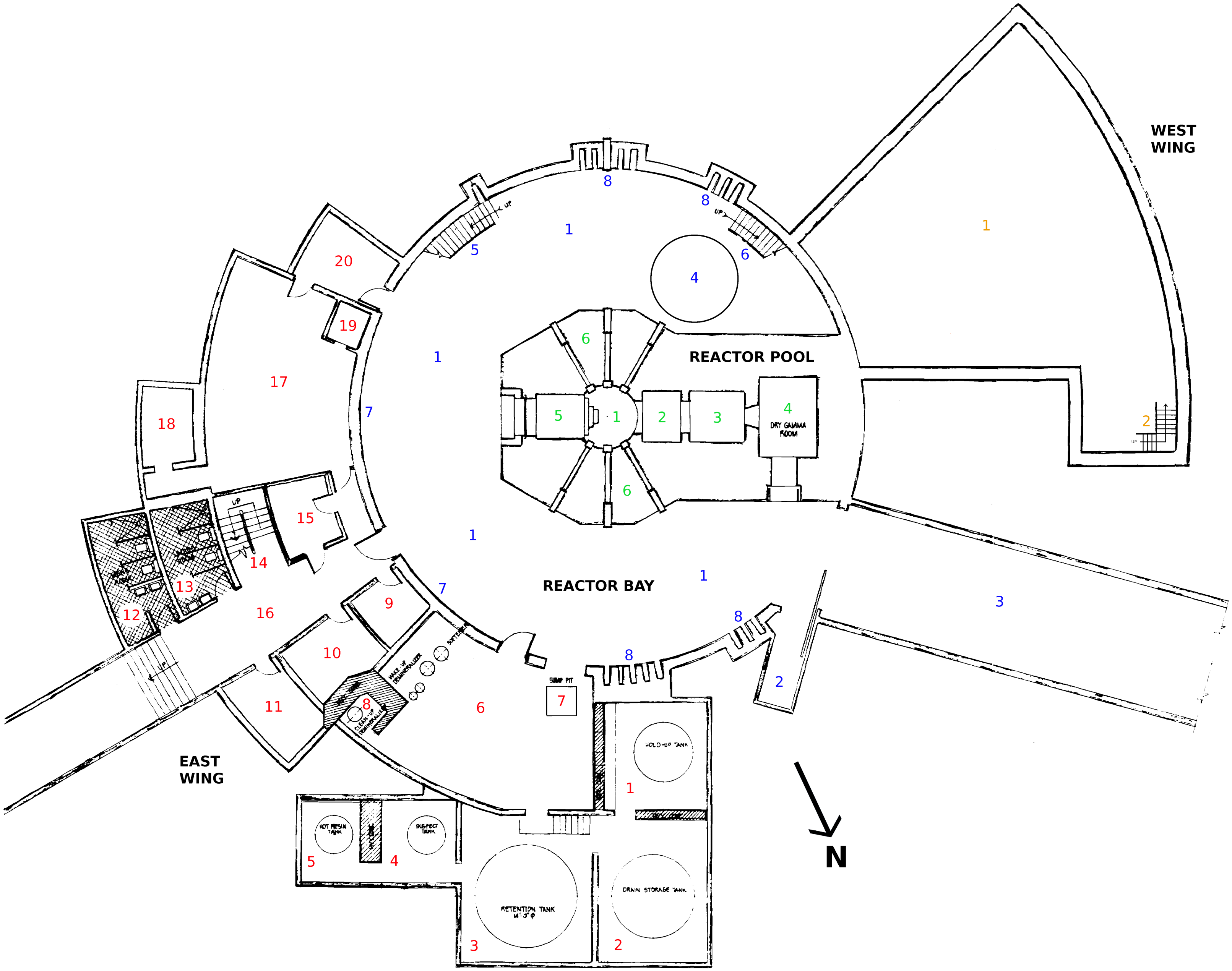


Fig. 3. The Basement-Floor Plan of the Reactor Building

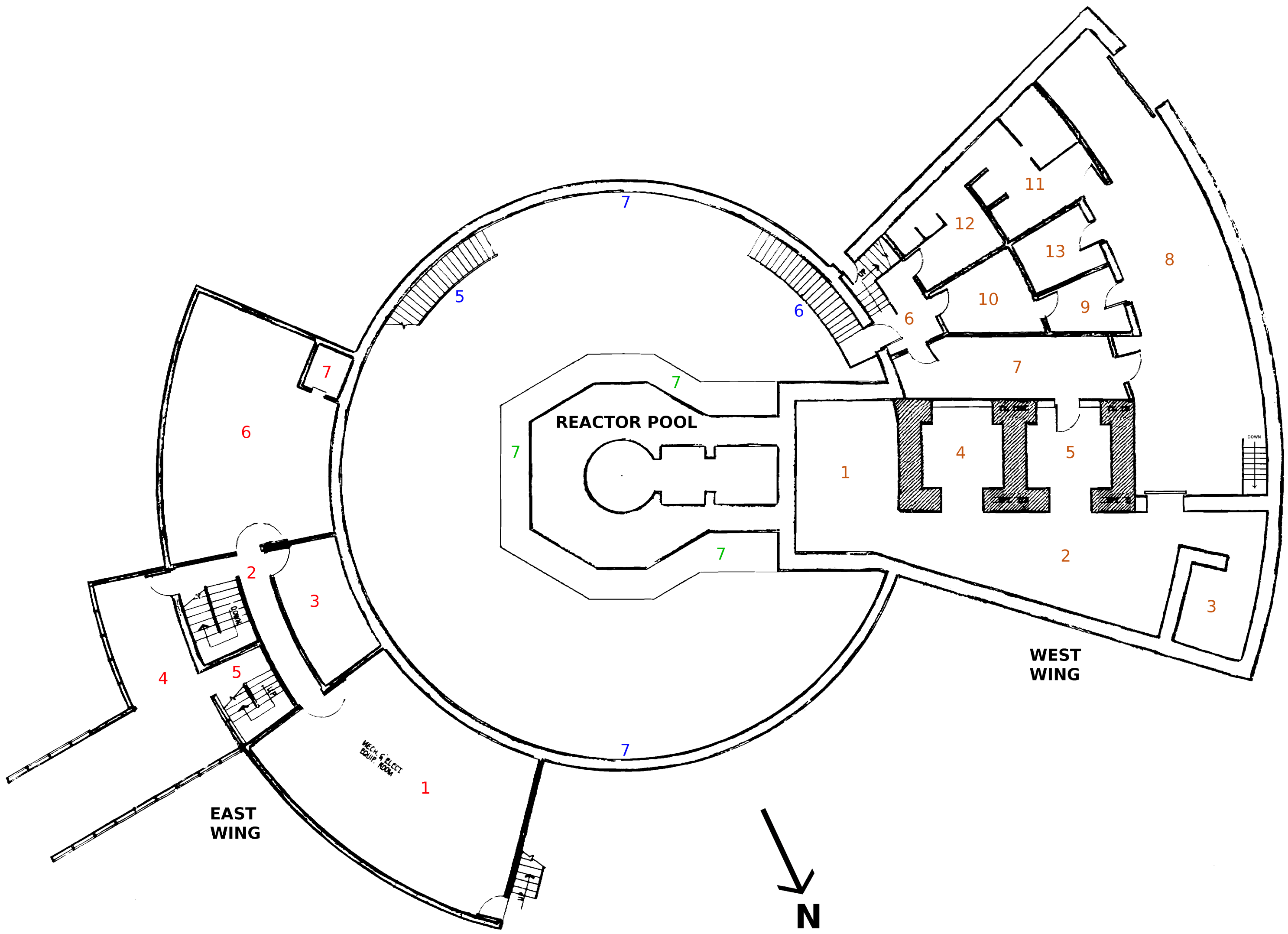


Fig. 4. The First-Floor Plan of the Reactor Building

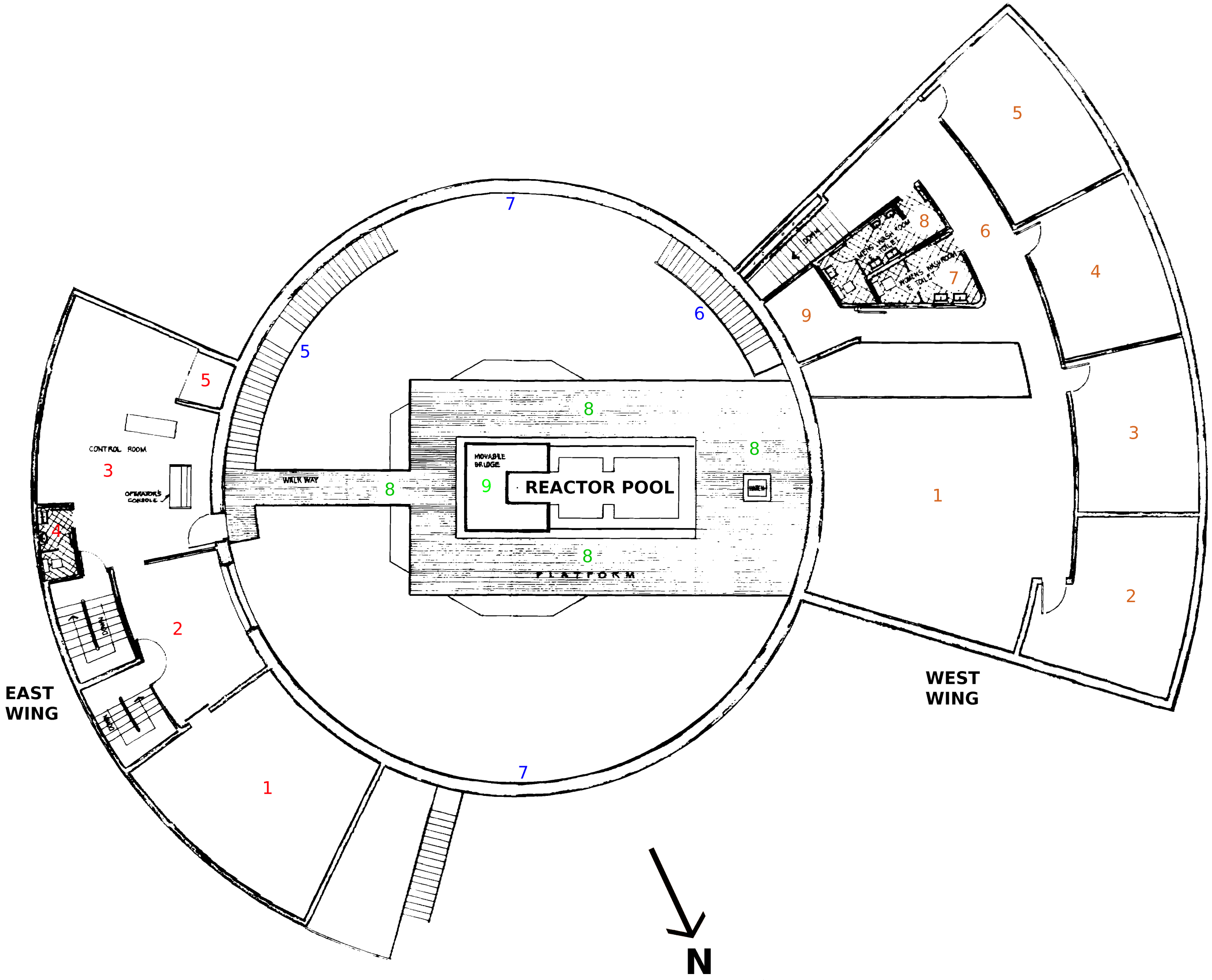


Fig. 5. The Second-Floor Plan of the Reactor Building

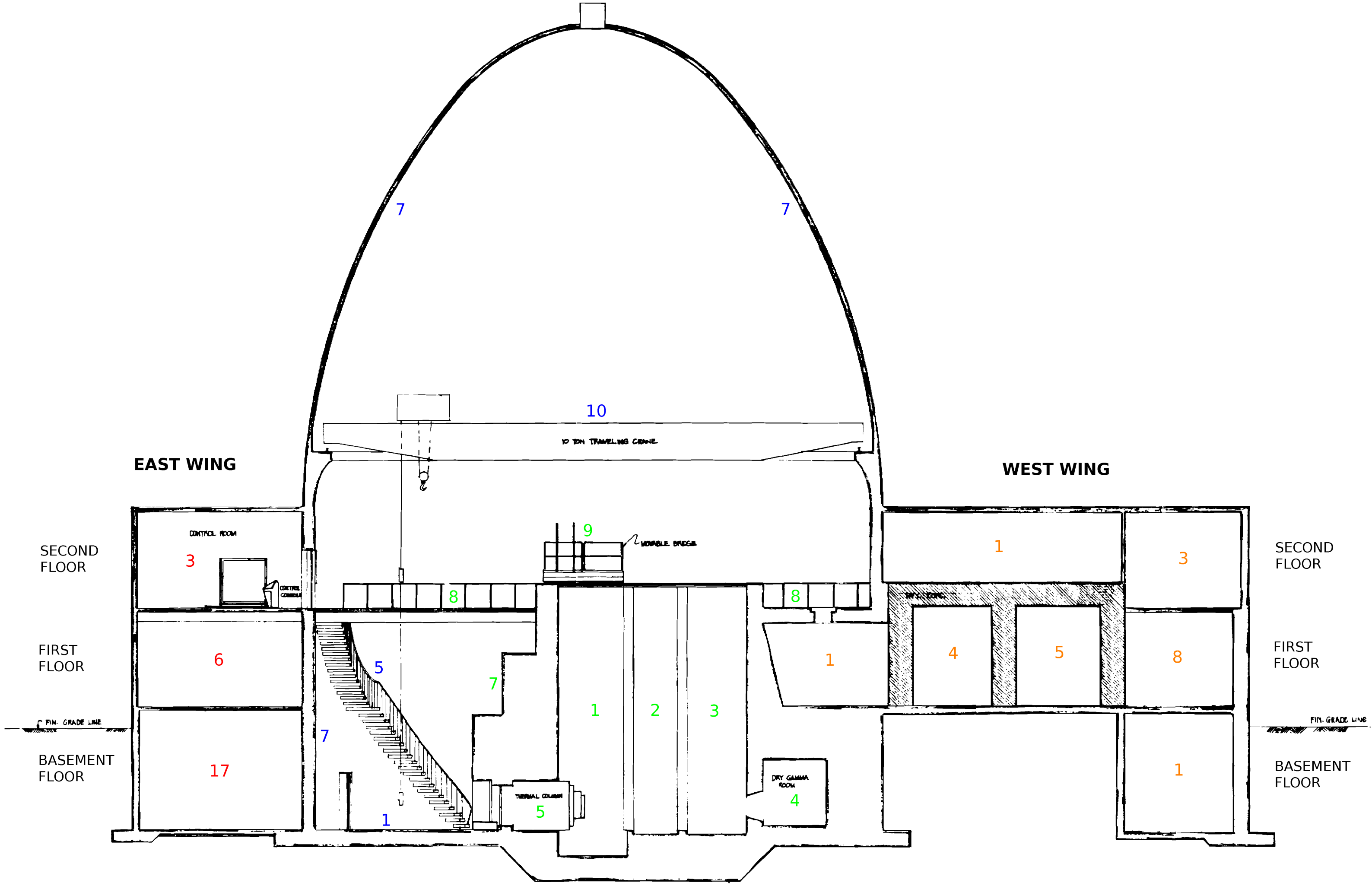


Fig. 6. The ESE-WNW Vertical Section of the Reactor Building

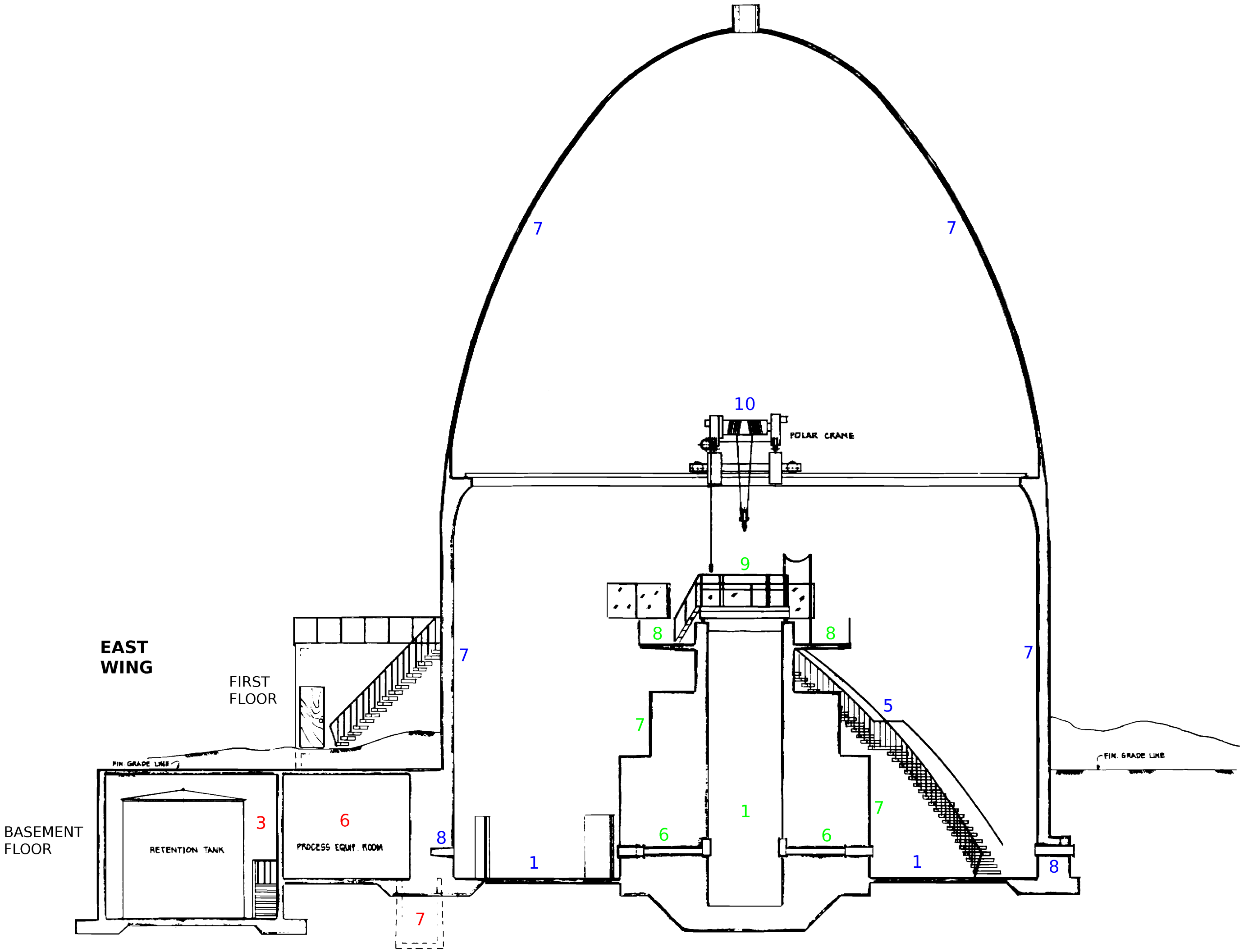


Fig. 7. The NNE-SSW Vertical Section of the Reactor Building

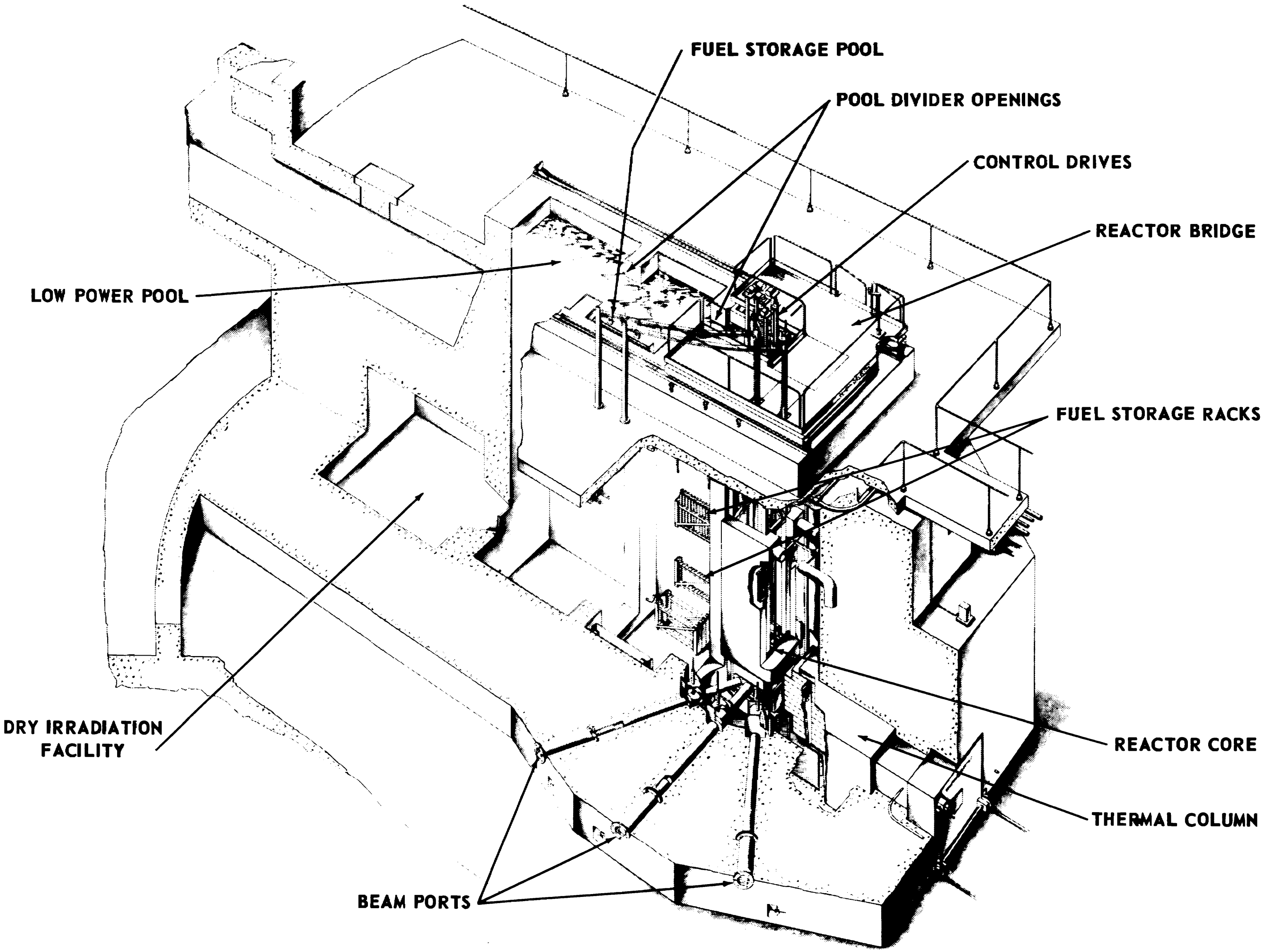


Fig. 8. A Cut-Away View of the Reactor Pool

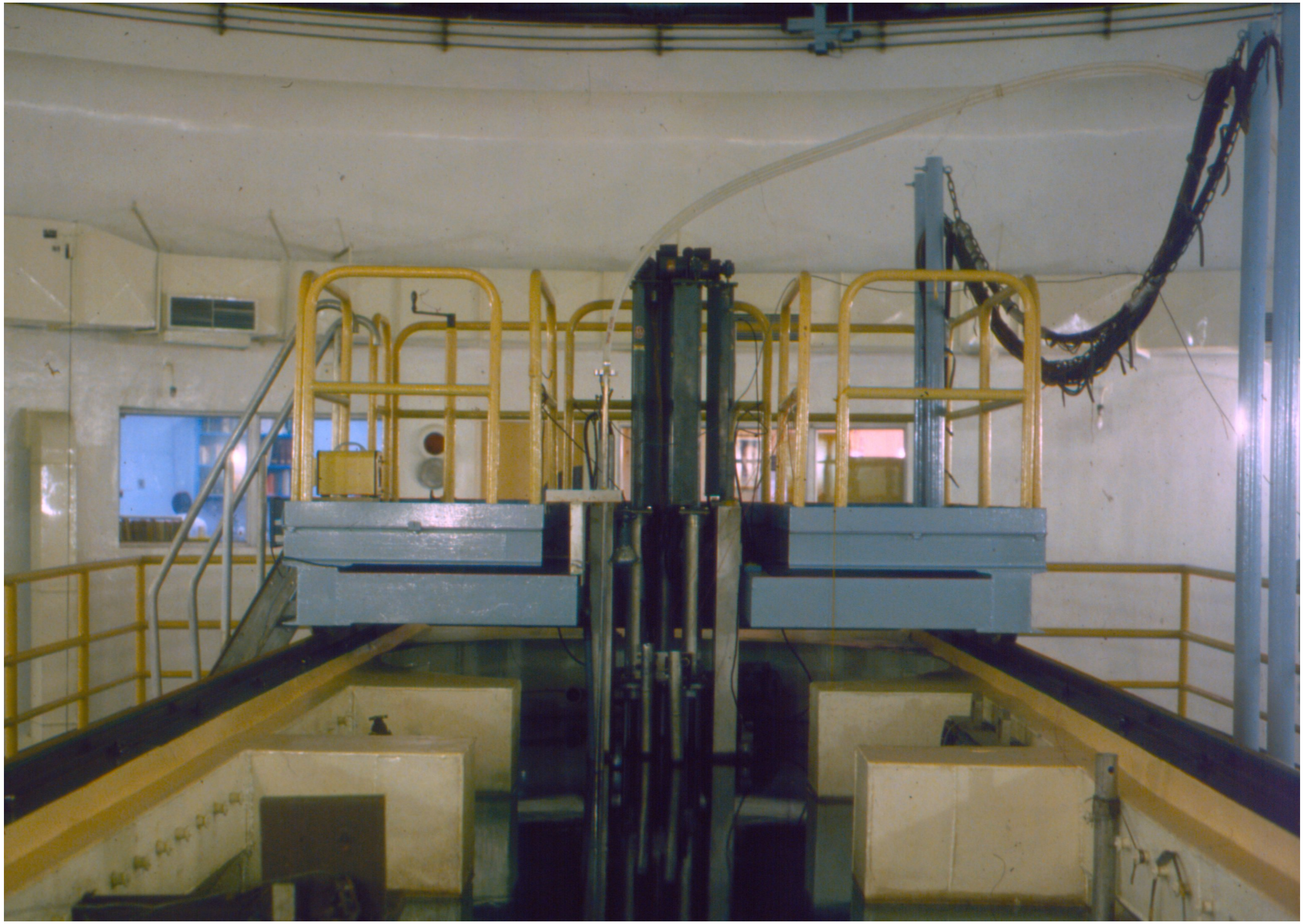


Fig. 9. The Reactor Bridge

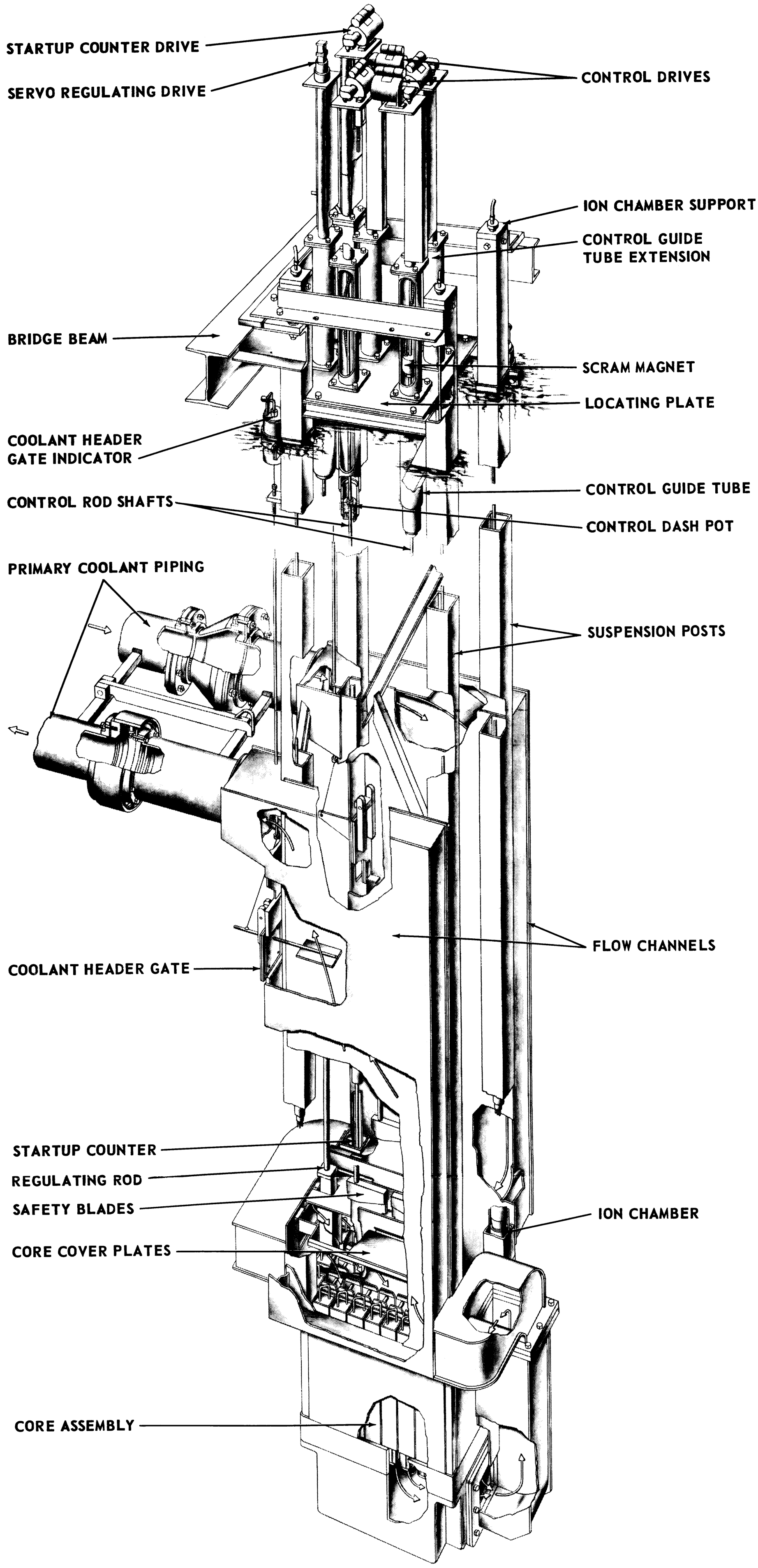


Fig. 10. A Cut-Away View of the Core Suspension Frame

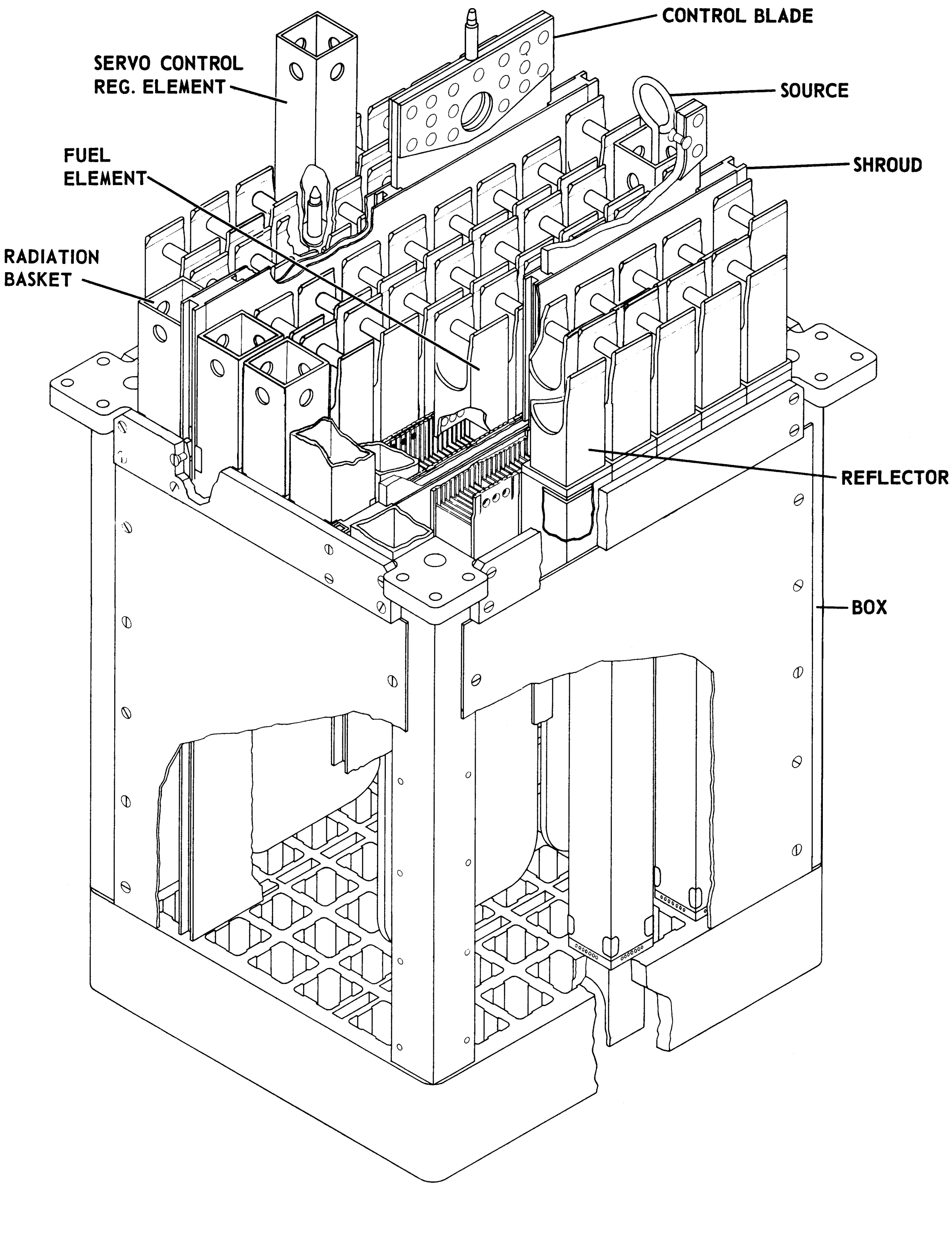


Fig. 11. A Cut-Away View of the Core Box