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6 ENGINEERED SAFETY FEATURES

6.1 Summary Description

The concept of Engineered Safety Features (ESFs) evolved from the defense-in-depth philosophy of multiple layers of features designed to ensure a reactor's safe operation. ESFs are designed to prevent accidents or mitigate accidents, should they occur, by controlling the release of radioactive materials resulting from the accidents to the environment. The ESFs at NBSR include the Emergency Cooling System, the Confinement Building, and the Ventilation Systems. ESFs can automatically be actuated by the protection instrumentation that monitors various parameters during the reactor's operation, or manually be actuated by the reactor operator. The principal accidents they protect against are overheating of the core should forced flow of primary coolant be unavailable, and uncontrolled release of radioactive material to the surrounding environment.

Chapter 13, Accident Analyses, shows that the NBSR Confinement Building mitigates the consequences of the most limiting accident scenario to acceptable levels. Accordingly, a more extensive containment facility is not required and, therefore, not included as part of the reactor's ESFs.

6.1.1 Emergency Cooling System

The Emergency Cooling System, shown in Figures 6.1, provides cooling for the reactor core and experiments should primary coolant be lost through leakage; for example, from a pipe rupture in the Primary Coolant System. Using conservative assumptions with no operator action, a minimum of 28 minutes of coolant flow is always available to the core from the Inner Reserve Tank (IRT) located within the Reactor Vessel during normal operation of the reactor (Appendix A).

The D_2O Emergency Cooling Tank, which is located about 37 feet (11 meters) above the top of the reactor core, acts as an overhead reservoir of emergency coolant. This tank receives a continuous flow of approximately 20 gpm (76 lpm) of primary coolant (i.e., heavy water) from the Primary Coolant Purification System. During normal operation, 3,000 gallons (11,350 liters) of heavy water in this tank is available for emergency cooling. This volume is determined by the height of the internal standpipe within the tank. Excess water normally overflows from the D_2O Emergency Cooling Tank through this standpipe into the IRT within the Reactor Vessel that has a holdup volume of approximately 800 gallons (3,000 liters). During normal operation, water from the IRT continuously drains and overflows to the reactor core. Thus, heavy water flows continually from the D_2O Emergency Cooling Tank through the IRT into the reactor core and returns to the Primary Coolant System during normal operation of the reactor.

Should a pipe break in the Primary Coolant System occur, emergency coolant would drain from the IRT to the core; the IRT being replenished from the D_2O Emergency Cooling Tank by manipulating control valves DWV-32 and DWV-33. The coolant passes over the fuel, removing decay heat, then drains out at the pipe rupture location. Heavy water can be drained from the D_2O Emergency Cooling Tank to each of the reactor inlet plenum by manipulating control valves DWV-34 and DWV-35. With this mode the coolant passes upward through the core and exits through the normal reactor outlet lines, assuming that the pipe break is on the outlet side of the vessel. It then drains out at the pipe break location. In either case, the emergency coolant flows through the Reactor Vessel and Primary Coolant System to the pipe rupture location in the Primary Coolant System, where it drains out onto the floor of the Process Room. The concrete curb and floor drains in the Process Room direct the heavy water to the Emergency Sump where it is either pumped back to the D_2O Emergency Cooling Tank or to the 14,650-gallon (55,500-liter) D_2O Storage Tank located in the Confinement Building. While the location of the pipe break governs which path is selected, supplying emergency coolant to the IRT would typically be the initial path chosen.

In severe accidents (beyond the design basis accidents), domestic light water can be added to the D_2O Emergency Cooling Tank through a spool-piece and double manual isolation valves. Light water may also be directly added to the D_2O Experimental Cooling System.

Chapter 13, Accident Analyses, shows that the Emergency Cooling System adequately protects against melting of the core and the associated release of fission products. The IRT is always full during normal operations. Should the water level in the reactor vessel fall for any reason, this tank will start draining though the two nozzles near its bottom into the emergency cooling distribution pan. This flow requires no mechanical action; it results directly from the loss of water in the reactor vessel. Initially, the flow from the IRT is 40 gpm (150 lpm), but decreases as the water level in the tank falls. The tank takes approximately 28 minutes to gravity drain, allowing time to assess the situation and determine which of the alternate flow paths to use to supply emergency coolant to the reactor core. There is sufficient heavy water in the D_2O Emergency Cooling Tank and the IRT to provide 2½ hours of cooling on a once-through basis. Furthermore, heavy water in the D_2O Storage Tank is also available, which can be pumped to the D_2O Emergency Cooling Tank when deemed necessary.

Surveillance tests ensure the proper operation of the Emergency Cooling System and its components.

6.1.2 Confinement Building

The front or east wing of the NIST Reactor Building (Building 235) consists of offices, cold laboratories, warm laboratories, shops, and other special purpose space, all of which are outside the Confinement Building. The north side of this wing has a cold basement area where various plant spaces for air-conditioning equipment, power distribution gears, demineralizing equipment, emergency power units, and storage are located. On the rear or west wing, the Confinement Building is a three-level structure, 90 feet x 90 feet (28 meter x 28 meter) in size. Both east and west wings are interconnected. The Cold Neutron Guide Hall is located on the north side of the Confinement Building in the west wing. In the Confinement Building, the thermal neutron beams are accessed on the first floor. The control room and general access to fuel elements and in-core thimbles are from the second floor. The basement or below grade level contains most of the process systems, fuel element storage pool, and radiochemical laboratories. The stack and the pump annex (or pump house) are located on the north side of the confinement area.

None of the design basis accidents discussed in Chapter 13 leads to significant overpressure within the reactor building. Thus, the Confinement Building is not required to be a steel containment vessel, but rather a structure designed to meet the more normal building design requirements. The building is designed to withstand wind, snow, and seismic loadings. Internally, it is designed for the large dead weight loading due to the reactor itself and the heavy biological radiation shields. The heavy concrete walls and floors supporting the structural loads also serve as radiation shields. Also, the building has the capability to maintain sufficient internal negative pressure to ensure in-leakage (i.e., prevent uncontrolled leakage to outside the confined area).

Figure 6.2 shows the plan view of the first floor of the NBSR Confinement Building at elevation 428 feet (130 meters). The experimental facilities that use the beam tubes and the thermal column are located on this floor, and are serviced by a 15-ton (13,600-kg) annular crane. This floor is at the same level as the main floor of the adjacent laboratories and office space. Personnel access to the Confinement Building from the adjacent building is through either of the entrances located on the building's east wall, or from an entrance through the basement. Each first floor entrance consists of two sets of double doors separated by a short passageway. A sliding steel door with inflatable gaskets is located in each passageway between the two sets of double doors. During normal operations, this sliding door is fully open. Ingress into the Confinement Building through the outer doors is controlled locally by a card reader, or remotely by the reactor operator. Egress from the building is unrestricted. In an emergency, when a Major Scram (see Chapter 7) signal seals the Confinement Building, the sliding steel doors automatically close and the gaskets automatically inflate to seal the entrances to the building, leaving authorized personnel in control of entry though these doors. The entrance from the basement operates similarly except it has one set of double doors.

During normal operation, the Confinement Building operates with a slight under-pressure. Under emergency conditions with the building sealed rapidly rising atmospheric pressure could create an abnormal pressure across the building. The structural design of the Confinement Building addresses this effect. In addition, a vacuum relief valve (i.e., ACV-12) is incorporated to prevent any detrimental pressure differential from developing across the building's walls or roof.

The reactor (including biological shielding) is about 20 feet (6 meters) in diameter and is located in the center of the first floor. The biological shield runs up to the ceiling, and supports the inner rail of the annular crane that services the area.

Figure 6.3 shows the plan view of the second floor of the Confinement Building at elevation 450.4 feet (140 meters). The top of the reactor shielding is flush with the floor, and utility and access trenches under the floor provide access to the radiation facilities that go into the core and into the reflector from the top of the reactor. This area is serviced by a 20-ton (18,000-kg) crane, which can handle heavy equipment. Two large square hatches on the floor provide access to the floor below, so that heavy equipment can be moved from one level to the other.

The Control Room is also located on the second floor and looks out over the reactor's top. All process and reactor instrumentation is located in the Control Room. Thus, the entire operation can be monitored from this single location.

Many experimental stations are located within the Confinement Building. Seven neutron-guides, maintained under vacuum for their full length, supply a number of other experiments in the adjacent Cold Neutron Guide Hall. The guides are centered on the core mid-plane and radiate from the Cold Neutron Source to the experimental stations. At the point where each guide passes through the Confinement Building's wall there are Neutron Guide Isolation Valves to seal the penetrations in an emergency, whenever a Major Scram signal seals the Confinement Building.

The Confinement Building has a volume of approximately 600,000 ft^3 (19,300 m^3) and was designed and constructed to ensure a minimum air leakage. The Ventilation Systems allow the Confinement Building's atmosphere to be maintained at a slight under-pressure compared to external atmosphere pressure under both normal and emergency conditions, assuring that any leakage is into the Confinement Building rather than out. All ventilation ductwork that penetrates the reactor building has automatically sealing closure valves or dampers.

The building's tightness specifications are monitored by two different methods. The first method involves the measurement of the relaxation time from test differential pressure conditions (simulating an overpressure and under-pressure conditions), the value of which is over 64 minutes. The second method involves the measurement of the flow rate resulting from the same overpressure or under-pressure conditions, at less than 24 cfm per inch (0.27 $meter^3$ per minute per cm) of water differential pressure across the wall. During pre-operational testing (NBSR 9A and NBSR 9B), it was demonstrated that the Confinement Building satisfied both acceptance criteria. However, during plant operations the latter method is normally used as part of the surveillance tests to verify the building's tightness condition.

Surveillance tests ensure that the building tightness system and its components (i.e., door and penetration seals and gaskets) in the Confinement Building operate properly, and also that the leakage rate remains within acceptable limits.

6.1.3 Ventilation Systems

Figure 6.4 shows the ventilation systems within the Confinement Building for both normal and emergency conditions.

The intake air-supply for the normal ventilation system includes both fresh air from outside and recirculated air within the building, while for the emergency ventilation system the air interior to the Confinement Building is recirculated after being appropriately filtered. There are separate recirculation fans for the three main levels in the Confinement Building. All effluent air, which is exhausted from the Confinement Building, is monitored for radioactivity. Each of the effluent pathways have filter banks which are monitored for particulate activity; air samples are withdrawn for counting of gaseous activity; and a monitor measures activity in the stack at the point of release to the environment. In the event high radiation levels are detected, the normal ventilation system will be shutdown, all building closure devices will be sealed, and the emergency ventilation system will be activated.

Under normal conditions, the Confinement Building is air conditioned except for the process equipment area of the reactor basement, which is separately heated and ventilated, as shown in the simplified flow diagram in Figure 6.5. Fresh air is brought into the building and is supplied separately to both the air conditioning system and the basement heating and ventilating system. The Normal Air-Conditioning Fresh Air System is a conventional heating and cooling system and supplies conditioned air to the first and second floors, and to the basement laboratories. The first and second floor systems circulate a mixture of fresh and recirculated air, while the basement system uses fresh air only without recirculation. The Basement Heating And Ventilating System maintains the process equipment area temperature by heating the fresh air and mixing it with recirculated air within the basement during winter and ventilating with once-through fresh air only in the summer.

Three separate exhaust systems operate during normal operation of the reactor, as shown in the simplified flow diagram in Figure 6.6. The Normal Exhaust System takes air from those areas supplied by conditioned air and combines with the exhaust air from fume hoods. The Reactor Basement Exhaust System draws air from the process equipment area. Finally, the Irradiated Air Exhaust System takes air from potentially contaminated areas. Air from each of these systems passes through similarly designed HEPA type filtering systems. The air is then released through the stack after being appropriately diluted and monitored for an acceptable level of radioactivity.

The locations of the exhaust ductwork ports are chosen to control air flow within the building's experimental areas. Most air from the first and second floor areas exhausts at the center of the experimental area through ducts embedded in the reactor's biological shield, thereby controlling contamination levels within the building, since potential sources of contamination are closest to the reactor.

Under emergency conditions, the air interior to the Confinement Building can be recirculated after being filtered through a system consisting of both a HEPA and a charcoal filtering system. In the event the inside air warrants cooling and humidity control, the normal air conditioning system could be used to condition the inside air as appropriate during an emergency. In addition, the emergency exhaust system is designed to draw air at such a rate from the building that a pressure differential can be established across the building structure to assure that any leakage is into the building rather than out regardless of likely outside pressure variations due to wind or barometer changes. It consists of two redundant subsystems; each could draw air from Normal Exhaust System ductwork. Air exhausted from the building in each subsystem passes through a filtering system consisting of both HEPA and charcoal filters before releasing through the stack.

6.2 Detailed Description

6.2.1 Emergency Cooling System

The Emergency Cooling System is a key ESF included in the design of the NBSR (see Figure 6.1). The objective of the Emergency Cooling System, should primary coolant be lost through a pipe rupture in the Primary Coolant System, is to provide an adequate amount of primary coolant to the:

- Reactor core to prevent melting of fuel elements, and
- Experimental facilities at the NBSR, as necessary.

6.2.1.1 Description of Components

6.2.1.1.1 D_2O Emergency Cooling Tank

The D_2O Emergency Cooling Tank is an aluminum cylindrical reservoir with a dimension of 20 feet (6 meters) long and 4½ feet (1.5 meter) in diameter. It has a capacity of 3,300 gallons (12,500 liters) but normally contains only 3,000 gallons (11,350 liters). It is equipped with three internal standpipes; one that overflows at 3,150 gallons (11,900 liters) to prevent overfilling, a second to hold up a volume of 3,000 gallons (11,350 liters), and a third at the 2,000-gallon (7,600-liter) level. Although the 2,000-gallon (7,600-liter) standpipe allows up to 1,000 gallons (3,800 liters) of D_2O for emergency cooling to experiments, its isolation valves are gagged shut to reserve the normal full volume of the D_2O Emergency Cooling Tank for the core cooling. The Helium Sweep Gas System sweeps this tank to remove any decomposed gases.

6.2.1.1.2 Inner Reserve Tank

Figure 6.7 shows a vertical cross section of the Reactor Vessel. The Inner Reserve Tank (IRT), as shown in Figure 6.8, is located within the Reactor Vessel above the core's upper grid plate. It is made of concentric cylinders of approximately 6 feet 10 inches (210 cm) tall and 4 feet (120 cm) in diameter. The construction material is aluminum with inner walls ¼ inch (0.64 cm) and outer walls $^{3}/_{8}$-inch (0.95-cm) nominal thickness, and 1-inch (2.5-cm) thick top and bottom. There are five 5-inch (13-cm) diameter vertical thimble port penetrations, five top vent holes which go to the reactor vessel, one 5-inch (13-cm) diameter penetration for the reactor vessel overflow pipe, one 2½ inch (6.5 cm) diameter D_2O inlet penetration, one 2½ inch (6.5 cm) helium inlet penetration, and four guide holes. Two $^{23}/_{32}$-inch (1.8-cm) I.D. nozzles, which penetrate the inner cylindrical wall, drain the 800 gallons (3,000 liters) of D_2O, directing the flow into the emergency cooling distribution pan, as shown in Figures 6.9 and 6.10.

The mounting brackets of the upper grid plate support the IRT. Its four legs, each resting on one bracket, are bolted in place by one bolt passing through each leg into the mounting bracket.

6.2.1.1.3 D_2O Holdup Pan

Should there be a major rupture of the sub-pile room piping that would drain the reactor vessel, D_2O would be held up in two places within the reactor vessel itself, as shown in Figure 6.7. As discussed above, an annular shaped IRT located in the top reflector can only be drained through two non-isolable pipes at the bottom of the tank. These pipes feed an emergency cooling distribution pan, which directs water to the top of each of the thirty fuel elements. Water from the IRT flows through nozzles into distribution piping arranged on the upper grid. Holes in the distribution piping are located near each element's position and the cooling water flows through these holes. In addition, there is a D_2O Holdup Pan (see Figure 6.11) that extends upward from below the lower grid plate to above the lower fueled portions of the elements. Water can only be drained from this pan through the fuel element seats in the lower grid plate. The end fittings of the fuel elements and any other tubes inserted into the lower grid plate are conical to minimize leakage of water down through the fuel element seats. The D_2O Holdup Pan keeps the lower core submerged in heavy water and also collects any of the heavy water from the IRT which splashes over the top of the distribution pan or runs down the outside of the fuel elements.

6.2.1.1.4 Pumps

The Emergency Sump Pump is driven by a single speed, 480 Vac, 60 Hz, three-phase motor rated at 3 hp and 1750 rpm. The pump is powered from Emergency Power MCC B-6. This pump is required to be in operational condition during normal operation of the reactor. Primary coolant collected in the Emergency Sump (Sump Pit #4 in Figure 6.1) is pumped to the D_2O Emergency Cooling Tank as the coolant level rises due to leakage or pipe break in the Primary Coolant System.

The Sump Pump to Hot Waste is driven by a single speed, 480 Vac, 60 Hz, three-phase motor rated at 1 hp. The pump is powered from the Emergency Power MCC A-5. This pump would be normally used to pump the accumulated liquid waste collected in the sump.

The Reactor Operator remotely controls both of these pumps from the Main Control Panel in the Control Room.

6.2.1.1.5 Control Valves

The Reactor Operator controls all valves discussed in this section from the Main Control Panel in the Control Room. All valves are normally fully closed. Their electrical power comes from the Instrument Power Bus located in the Main Control Panel.

Emergency Cooling to IRT Valves DWV-32 and DWV-33 are redundant 1½ inch (4cm) pneumatic-operated diaphragm valves that control the flow of emergency coolant to the IRT.

Emergency Cooling to Plenums Valves DWV-34 and DWV-35 are redundant 1½ inch (4cm) pneumatic-operated diaphragm valves that control the flow of emergency coolant to the Inner and the Outer Plenums.

D_2O Experimental Emergency Cooling Valves DWV-29 and DWV-30 are redundant 1½ inch (4cm) pneumatic-operated diaphragm valves that regulate the flow of emergency coolant to the D_2O Experimental Cooling System.

Sump Pit to D_2O Emergency Cooling Tank Valve DWV-20 is a 1½ inch (4cm) pneumatic-operated diaphragm valve that controls the flow of heavy water from the Emergency Sump to the D_2O Emergency Cooling Tank.

Sump Pit to D_2O Storage Tank Valve DWV-21 is a 1½ inch (4cm) pneumatic-operated diaphragm valve that controls the flow of heavy water from the Emergency Sump to the D_2O Storage Tank.

D_2O Emergency Cooling Tank Drain Valve DWV-13 is a 3-inch (7.6-cm) pneumatic-operated diaphragm valve that controls the flow of heavy water from the D_2O Emergency Cooling Tank to the D_2O Storage Tank.

D_2O can be returned to the D_2O Emergency Cooling Tank from the D_2O Storage Tank through a 2 inch (5cm) valve, DWV-40, and from the sump through 1½ inch (4cm) valve, DWV-20 and 2 inch (5cm) valve, DWV-40.

The design requirements for the piping and valves are the same as those specified for the Primary Coolant System discussed in Chapter 5, Reactor Coolant Systems.

6.2.1.1.6 Instrumentation

Instrumentation is provided to sense the D_2O Emergency Cooling Tank's water level, emergency cooling water flow to the reactor core, sump level, and the discharge pressure of the emergency cooling sump pump.

Emergency Cooling Tank Level Indicator Alarm Channel LIA-2 measures the level of the emergency coolant in the D_2O Emergency Cooling Tank. Level Transmitter, LT-2, sends a signal to Level Indicator, LI-2, and Level Alarm, LA-2, which is proportional to the level of emergency coolant in the D_2O Emergency Cooling Tank. The alarm unit alerts the Reactor Operator to a low level condition in the tank. The channel's range is 0-60 inches (0-152 cm).

6.2.1.2 Technical Specifications

6.2.1.2.1 Technical Specification 3.5, Reactor Emergency Cooling System

This Technical Specification applies to the availability of the Emergency Cooling System. Its objective is to ensure an adequate supply of emergency coolant. The reactor is not to be operated unless the Emergency Cooling System is operable and a source of makeup water to the D_2O Emergency Cooling Tank is available. Should core coolant be lost, the Emergency Cooling

System provides adequate protection against melting of the reactor core and associated release of fission products. Thus, the operability of this system is a prerequisite to operating the reactor.

The Emergency Cooling System employs one emergency sump pump to return spilled coolant to the overhead storage tank. Because only one pump is used, it must remain operational during the operation of the reactor. Sufficient D_2O is available in the D_2O Emergency Cooling Tank and the IRT to provide 2½ hours of cooling on a once-through basis. If the sump pump fails and the supply of heavy water in the D_2O Emergency Cooling Tank is exhausted, domestic water or a suitable alternate would be used to furnish water for once-through cooling. The water makeup capacity must be in excess of 25 gpm (95 lpm), which was calculated as adequate to prevent fuel damage.

6.2.1.2.2 Technical Specification 4.4, Reactor Emergency Cooling System

This Technical Specification applies to the Emergency Cooling System; its objective is to ensure the system operates properly. The control valves in the Emergency Cooling System are required to be exercised quarterly, the starting function of the Emergency Sump Pump is required to be checked quarterly, and the operability of the pump is required to be tested annually; the light-water injection valves are required to be exercised semiannually. The proper operation and the continued reliability of the Emergency Cooling System must be ensured. Because the equipment in this system is not used normally during reactor operation, its operability must be verified periodically. The frequencies are chosen so that deterioration or wear would not be expected to be an important consideration. Moreover, the frequency should be sufficient to ensure that the pumps and valves will not fail because of extended periods of standby. Possible failure resulting from corrosion buildup or other slow-acting effects should become apparent with these surveillance schedules. The control and injection valves specified are those leading to or from the D_2O Emergency Cooling Tank.

6.2.2 Confinement Building

The objectives of the Confinement Building and its associated Heating, Ventilation and Air Conditioning (HVAC) systems are to prevent the uncontrolled release of radioactivity to the surrounding environment. The Confinement Building provides protection from any radiological release to the environment resulting from a reactor accident, the principal ones being fuel damage and primary coolant leakage.

The Confinement Building is designed to contain radioactive material released in an accident so that it can be exhausted in a controlled manner through an Emergency Exhaust System that filters out the radioactive materials before releasing the confinement air to the environment. The leakage from the building is limited to a leak rate of 24 cfm per inch (0.27 meter^3 per minute per cm) of pressure differential across the confinement barriers. Any release of radioactive material inside the Confinement Building is detected in the normal ventilation system by redundant instrumentation, which initiates closure of the building. A sliding steel door at each of the three entrances to the Confinement Building closes automatically and seals with inflatable gaskets.

These doors are automatically shut whenever a major scram signal is initiated. This signal goes to the door scram relays (DSRs). These relays start electric motors that close the doors. These motors are powered from electrical buses A-5 and B-6, the diesel-backed buses. The doors themselves have limit switches on them that stop the door travel when fully closed or open. Signals from these limit switches are sent to the DSRs, which cut the power to the electric motors. There is also a manual override switch on the outside confinement side near each door that will reopen the doors. The operators use this manual override, if necessary, for evacuation of personnel left inside the confinement after the doors are closed. It should be noted that if the major scram signal remains active, when this manual override button is released, these doors would automatically re-close. When the limit switch signals closure of each door, a signal is sent to the solenoids that inflate the seal on each door from the compressed air system. The door would not automatically reopen on clearing of the major scram signal. In order to reopen the doors and deflate the seals, the major scram signal has to be removed and the manual override used to return the doors to their open position.

These doors are on tracks. The rubber seal is only on the closing face of each door. Therefore, the balancing of confinement HVAC must be done to offset any potential leakages around the track surfaces. The two compressors that provide air to the seals are powered from the diesel-backed buses. There are no air accumulators on the inflatable confinement door seals.

All normal ventilation ducts are sealed shut by automatically operating valves, thus isolating the building from the outside. The Emergency Exhaust System starts automatically and draws the buildings atmosphere down to a negative pressure so that any leakage is into the building. At the same time, a large internal clean-up system of 5,000 cfm (142 meter^3 per minute) capacity (i.e., Emergency Recirculation System) can be activated to circulate air within the building through filters to clean it up and minimize the release of radioactive iodine to the internal environment.

6.2.2.1 Confinement Building Leakage Rate

6.2.2.1.1 Design Leakage Rate

Confinement, as opposed to containment, is a concept suitable to the situation wherein the worst hypothetical reactor incident results in negligible overpressure, as is the case for the NBSR. Here, the design concept is to confine or retain radioactive gases so that they can be filtered and passed up the stack at a reasonably low rate for subsequent atmospheric dispersion. The tighter the building, the lower is the airflow rate through the filter and up the stack.

6.2.2.1.2 Leakage Rate Tests

The Confinement Building components that isolate the building are shut and checked sealed. A test blower and associated equipment are used to achieve building pressures of +6.0 and -2.0 inches (+16 and -5 cm) of H_2O. Leakage flow rates across the confinement barrier are observed and shown to be less than 24 cfm per inch (0.27 meter^3 per minute per cm).

6.2.2.1.3 Inspection of Penetrations

Independent of leakage rate tests, building penetrations that may affect the confinement's integrity are inspected and tested for tightness. Door or other opening seals and gaskets are periodically inspected for their sealing integrity.

6.2.2.2 Building Services and Utilities

The NIST Plant Division supplies and maintains necessary services for the NBSR facility including water, pressurized air, electricity, steam, chilled water, and drains. In addition to the Compressed Air System, backup air compressors are available within the building.

6.2.2.3 Technical Specifications

6.2.2.3.1 Technical Specification 3.1, Confinement System

This Technical Specification applies to the operating status of the Confinement Building. The objective is to ensure the confinement's integrity when required, namely,

- Whenever the reactor is operating,
- When changes of components or equipment within the confines of the thermal shield, other than rod drop tests or movements of experiments, are being made which could affect reactivity, or
- When irradiated fuel is being moved.

In addition, no maintenance that causes a breach in confinement can be undertaken unless the reactor has been shut down for a period equal to or greater than one hour for each megawatt of operating power level. The Confinement Building is a major engineering safeguard, serving as the final physical barrier to mitigate the release of radioactive particles and gasses to the environment following accidents (Chapter 13, Accident Analyses).

The confinement's integrity is stringently defined to ensure that the Confinement Building will perform in accordance with its design basis. Piping penetrations and conduits that are open to the inside of the building become an extension of confinement and must be sealed on the exterior of the Confinement Building to prevent leakage outwards. All other piping penetrations that do not have automatic closure devices must be sealed within the confinement by devices that can withstand the confinement test pressure of 6.0 inches (15 cm) of H_2O overpressure, or 2.0 inch (5cm) of H_2O vacuum, within specified leakage limits. The maximum allowable leakage rate for the Confinement Building is 24 cfm per inch (0.27 meter^3 per minute per cm) of water differential pressure across the wall.

The Confinement Building is sealed automatically upon an indication of high activity within. All automatically operated valves and doors that affect this sealing must either be operable or already sealed. Although tests showed that the Confinement Building can continue to operate with one or more of these closures failed, its margin of effectiveness is reduced. Tests of the Confinement Building demonstrated that even if one of the automatically closing personnel doors fails to operate properly, the confinement's design capability is met provided that one set of the building's vestibule doors are closed (FSAR, NBSR-9, Supplement A, Response No. 5, p.1-18, October 1966, and Supplement B, Response No.6, p.1-10, December 1966). By specifying that these doors remain closed except when they are being used or attended, a backup to the normal confinement closure is provided. If the closure is placed in its closed or sealed condition, then operability of the automatic closure devices is not required.

The reactor building's truck door does not have automatic closure devices and must be in the closed position to ensure the confinement's integrity. Tests have verified that the Confinement Building could continue to operate properly, although at a reduced efficiency, if the truck door's seal were to fail. However, it will not operate properly if the truck door itself is open. Changes in the core, involving operations such as handling irradiated fuel or repairing the control rods, affect the reactivity and status of the core. Confinement integrity is required whenever these changes are made.

Confinement integrity is not required whenever the reactor is shut down and experiments are being inserted or removed. The reactor is normally shut down by a substantial reactivity margin. Experiments are inserted and removed one at a time; hence, the total change in reactivity in any single operation will be limited to the specified maximum worth of 0.5% $\Delta\rho$. Even postulating the sequential movement of all experiments (including "fixed" experiments), the maximum potential reactivity insertion would not exceed the 2.6% $\Delta\rho$, which is the worth of all experiments permitted in the reactor at any one time. Under this circumstance, the shutdown margin still would be substantial. Even when the reactor is shut down, irradiated fuel, which contains significant fission product inventories, poses a potential risk should its cladding be violated when it is not otherwise contained (e.g., during transit or during sawing of the aluminum end pieces). Whenever irradiated fuel is contained within a closed system, such as the reactor vessel, the transfer lock of the refueling system, or the sealed shipping cask, these act as a secondary barrier to the release of fission products; therefore, confinement integrity is not required. In carrying out any maintenance that prevents the normal rapid closing of the confinement, all possibilities of releasing fission products from the fuel must be precluded. For this reason, no such maintenance is permitted unless the reactor has been shut down for a specified length of time.

6.2.2.3.2 Technical Specification 4.1, Confinement System

This Technical Specification applies to the Confinement Building. Its objective is to ensure the continued reliability of the Confinement Building. A quarterly test of the operability of the confinement's closure system is required, as well as an integrated leakage test of the Confinement Building at least annually. Any additions, modifications, or maintenance to the Confinement Building or its penetrations must be tested to verify that the building can maintain its required leak tightness. The confinement closure system is initiated either by a signal from the Confinement Building's exhaust radiation detectors or manually by the major scram button. To ensure complete surveillance, the system's operability is verified using these same devices to initiate the test. In addition, both the trip features and the ability of the radiation detectors to respond to ionizing radiation are checked.

A pre-operational test program was conducted to measure the representative leakage characteristics at differential pressure values of +7.5 inch (19cm) of H_2O and -2.5-inch (-6.35cm) of H_2O (FSAR, NBSR-9, Section 3.7.2, p. 3-16, April 1966). These specified test pressures and vacuums are acceptable because past tests showed that leakage rates are linear with applied pressures and vacuums (FSAR, NBSR-9, Supplement A, Response No. 5, p.1-18, October 1966, and Supplement B, Response No.6, p.1-10, December 1966). Changes in the building or its penetrations must be verified to withstand specified test pressures; therefore, tests must be made before the building can be considered operable.

6.2.3 Ventilation Systems

6.2.3.1 Ventilation System Under Normal Conditions

Inside the Confinement Building, the exhaust air is monitored for radioactivity and appropriately filtered before the exhaust air releases through the stack to the outside environment. The recirculation air also is filtered and monitored for radioactivity during its normal operation. This provides indications of the proper operation of the diverse systems within the Confinement Building, since these systems are designed not to release any radioactivity within the confinement.

6.2.3.1.1 Normal Ventilation Systems

Under normal reactor operations, the Confinement Building is air-conditioned with fresh and recirculated air, except for the Process Room area in the reactor basement, which is separately heated and ventilated with fresh air only, as shown in Figure 6.5. Thus, the two systems supplying conditioned air during normal operation are: the Normal Air-Conditioning (AC) Fresh Air System and the Basement Heating and Ventilating (H&V) System.

Fresh air is brought into the mezzanine equipment area through louvers in an areaway in the south wall of the Confinement Building. The Normal Air-Conditioning Fresh Air System draws 13,680 cfm (400 meter^3 per minute) of fresh air from the intake via ACV-1 and the Basement Heating And Ventilating System draws 16,500 cfm (470 meter^3 per minute) of fresh air during summer and 2,500 cfm (70 meter^3 per minute) during winter via ACV-2. Both automatic closure valves ACV-1 and ACV-2 that regulate the amount of fresh air drawn into the building seal the louvers for the fresh air intakes in the event of a high radiation level within the confinement. The incoming air is filtered by filter F-2 in the former system and by filter F-11 in the later system before discharging to the normal ventilation systems.

The first system, Normal Air-Conditioning Fresh Air System, is a conventional heating and cooling system and supplies conditioned air to the first and second floors, and the basement laboratories. Fresh air at a flow rate of 13,680 cfm (390 meter^3 per minute) is drawn by the supply fan, SF-2, in the AC Fresh Air System. Of this flow, fresh air at 5,670 cfm (160 meter^3 per minute) flow rate is branched to supply two independent AC systems for the first and second floors and the remaining 8,010 cfm (230 meter^3 per minute) is supplied to another independent

AC system for the basement laboratories. In the First Floor AC System, supply fan SF-3 draws 2,350 cfm (65 meter^3 per minute) of fresh air and 21,150 cfm (600 meter^3 per minute) of recirculated air from the first floor area. Thus, after passing through the filter F-3 the system supplies a total of 23,500 cfm (665 meter^3 per minute) conditioned air to the first floor. A relief valve, ACV-12, is connected to this supply line from the fresh air intake louvers in order to prevent excessive under-pressure relative to outside static atmospheric pressure.

In the Second Floor AC System, supply fan SF-1 draws 3,320 cfm (95 meter^3 per minute) of fresh air and 17,405 cfm (495 meter^3 per minute) of recirculated air from the second floor area. Thus, after passing through filter F-1 the system supplies a total of 20,725 cfm (590 meter^3 per minute) conditioned air to various zones on the second floor, including the control room and parts storage room. In the Basement Laboratory AC System, the supply fan SF-12 draws the remaining 8,010 cfm (230 meter^3 per minute) of fresh air. No recirculated air is mixed with this fresh air supply. After passing through filter F-12 the system supplies conditioned air to various basement laboratories, pool area, and the counting room.

In the second system, Basement Heating And Ventilating System, supply fan SF-11 circulates air at a rate of 16,500 cfm (470 meter^3 per minute) to the basement process equipment area after passing through the filter F-11. During summer months 16,500 cfm (470 meter^3 per minute) of once-through fresh air is supplied by this system, while during winter months 2,500 cfm (70 meter^3 per minute) of fresh air combined with 14,000 cfm (400 meter^3 per minute) of recirculated air are heated before supplying to the basement equipment area.

It should be noted that during an emergency situation both the normal ventilation systems are shut down. The supply fan SF-19, if operated, supplies recirculated air at a rate of 1,000 cfm (30 meter^3 per minute) to various process equipment areas in the basement and uses the ducting of the Basement H&V System (see Sec. 6.2.3.2.1).

6.2.3.1.2 Normal Exhaust Systems

As shown in Figure 6.6, the exhaust systems for the Confinement Building during normal reactor operation consist of the following three systems: the Reactor Basement Exhaust System, the Normal Exhaust System, and the Irradiated Air Exhaust System. The Reactor Basement Exhaust System includes exhaust fan EF-27, which draws 16,500 cfm (470 meter^3 per minute) air from the process equipment areas and 240 cfm (7 meter^3 per minute) from the elevator machine room and passes it through two banks of HEPA filtering systems F-59 and F-60. A holdup chamber follows the exhaust fan. Its volume is chosen to give time for the automatic closure valve ACV-3 to operate after a building closure signal, before any air entering the chamber at the start of the signal can leave. This time is calculated in accordance with the maximum exhaust rate when no recirculation is taking place. An adjustable louver, located at the exhaust of the fan, allows adjustment of the basement's static pressure relative to the first floor reactor area and, therefore, to the outside static pressure. During winter months 14,000 cfm (400 meter^3 per minute) of this exhaust air is recirculated through the Basement H&V System. Thus, exhaust air at a rate of 16,740 cfm (475 meter^3 per minute) during summer or 2,740 cfm (80 meter^3 per minute) during winter is sent to the dilution chamber at the base of the stack. After diluting with fresh air, the exhaust fan EF-2 releases this air to the atmosphere via the stack.

The Normal Exhaust System, with its exhaust fan EF-3, takes 7,290 cfm (200 meter^3 per minute) air from those areas supplied by the air-conditioned system, namely the first and second floors, storage pool area, counting room, and radiological laboratory room. A damper on the fan automatically adjusts the rate to maintain a pressure of -0.10 inches (-0.25 cm) of water in the building relative to that in the high-bay area on the first floor. Filters F-22 and F-23 clean all effluent air driven by EF-3. The exhaust of EF-3 combines with 5,500 cfm (155 meter^3 per minute) from fume hoods in the radiological laboratories driven by exhaust fan EF-23, which is similarly filtered as those from EF-3. Thus, 12,790 cfm (360 meter^3 per minute) of air in the Normal Exhaust System passes through a holdup chamber, the volume of which allows time for valve ACV-7 to automatically close. The exhaust air is sent to the dilution chamber at the base of the stack for release to the atmosphere by EF-2.

In addition to the Normal Exhaust System, there is a supplemental system called the Irradiated Air Exhaust System with its exhaust fan EF-4. It takes 650 cfm (18 meter^3 per minute) air into the biological shield at all beam-port openings to the reactor and, consequently, is the system most likely to be handling contaminated air. It is designed to ensure that all leakage of air is into the beam ports rather than out. Any potentially irradiated air is directly exhausted rather than being recirculated. All irradiated air passes through a separate set of filters F-24 and F-25 identical to those in the Normal Exhaust System. A holdup chamber follows Exhaust Fan EF-4 giving the duct-sealing valve ACV-6, adequate time to close to prevent exhausting contaminated air. Finally, this air is sent to the dilution chamber similar to other two normal exhaust systems for release to the atmosphere by EF-2, which is designed to handle exhaust air at a rate of 30,000 cfm (850 meter^3 per minute).

6.2.3.2 Ventilation System Under Accident Conditions

Radioactivity is monitored in all air exhausted from the Confinement Building. Each of the filter banks is monitored for particulate activity; air samples are withdrawn for counting gaseous activity; and a monitor measures activity in the stack. If high radiation levels are detected, the normal ventilation systems are shutdown, all closure devices will operate to seal the building, and the Emergency Exhaust System is automatically activated. The Emergency Recirculation System can be activated manually, if needed. Figure 6.6 shows the emergency ventilation systems consisting of both the Emergency Recirculation System and the Emergency Exhaust System.

6.2.3.2.1 Emergency Recirculation System

During emergency operation, the reactor building's internal air is recirculated and filtered by a separate system, known as the Emergency Recirculation System. This system is normally off, and can be operated from the Control Room or the Emergency Control Station. Air at a flow rate of 5,000 cfm (140 meter^3 per minute), containing 2,000 cfm (60 meter^3 per minute) from the second floor, 2,000 cfm (60 meter^3 per minute) from the first floor, and 1,000 cfm (28 meter^3 per minute) from the reactor basement area controlled by ACV-11, is drawn into this system. Supply fan SF-19 draws this air after passing through the particulate filters F-19 and F-20. The air then passes through a carbon filter F-21 before releasing to the building's three levels at the same flow rate it received. As stated earlier, the ducting of the normal Reactor Basement Exhaust System is used to recirculate air in the process room area.

The filtering system consists of a HEPA filtering system before the fan and an activated charcoal filter bank after the fan. This system removes particulate and gaseous activity, such as iodine, with an approximate two-hour time-constant for once-through cleaning. The process room isolation valve ACV-11 is only operated if SF-19 is running. ACV-11 will operate automatically with SF-19 when the fan is selected to the process room position at a Control Room switch. ACV-11 also can be operated with its own switch at the Emergency Control Station if it is desired to operate SF-19.

6.2.3.2.2 Emergency Exhaust System

The Emergency Exhaust System is designed to draw air from the building at such a rate as to establish a pressure differential across the confinement barrier, assuring that any leakage is into the building rather than out, regardless of likely variations in outside pressure due to wind or barometric changes. The system has two redundant trains to give maximum assurance of its operation; it can be controlled, if necessary, from the Emergency Control Station on the B2 level outside the Confinement Building.

Each of the two redundant trains (or subsystems A and B) in the Emergency Exhaust System contains an exhaust fan and identical filters and controls. Either subsystem can draw 100 cfm (3 $meter^3$ per minute) of air from the normal exhaust system's ductwork. The two subsystems are isolated from each other by valves ACV-4, ACV-8, ACV-5, and ACV-9. These are the suction and discharge valves for Emergency Exhaust Fans EF-5 and EF-6; these valves are positioned through contacts operating in their respective fan-starter circuits. Hence, the operation of a fan places the entire subsystem in service. Since the basement does not normally exhaust to the normal exhaust system's ductwork, during emergencies 35 cfm (1 $meter^3$ per minute) of air is ventilated by manually operating ACV-10, a special connection to the basement system.

Fan motors are supplied from the AC or DC emergency buses, with each fan coupled to an AC motor and a DC motor. The DC motors are normally placed in an automatic status, and run only when AC power is not available. One AC fan motor is normally placed in an automatic condition, while the second AC fan motor is placed in standby. The standby fan motor operates only when AC power is available to its control circuit.

Upon closure of the Confinement Building, all automatic closure doors and valves shut and seal. With AC power available, both subsystems will begin expelling air from the building until a building pressure of -0.10 inch (-0.25 cm) H_2O is reached. At this pressure, the standby sub-system ceases continuous operation, while the subsystem in automatic continues operating until reaching a pressure of -0.25 inch (-0.64 cm) H_2O. The automatic fan then cycles as necessary to maintain this pressure. Should the pressure return to approximately -0.10 inch (-0.25 cm) the standby fan will start cyclical operation to assist the now continuously running automatic fan in lowering the pressure. If AC power is lost, both subsystems automatically cycle to reach an approximate pressure of -0.25 inch (-0.64 cm) H_2O. The DC motors do not have a standby feature to lessen the current load on the station battery.

Charcoal filters F-28 and F-31 and HEPA filtering systems consisting of filters F-26, F-27, F-59 in subsystem A and F-29, F-30, F-58 in subsystem B, clean all air exhausted from the building by fans EF-5 and EF-6. The charcoal filters on the suction side of the fans remove gaseous effluents, such as iodine. The absolute filter removes particulate matter, including any charcoal particulate from the upstream filters, similar to those in the Emergency Recirculation System. Since one of the two trains is in operational during an emergency, 100 cfm (3 $meter^3$ per minute) of clean air is released to the atmosphere directly through the stack.

6.2.3.3 Description of Components and System Controls

6.2.3.3.1 Emergency Control Station

Even though the ventilation system under emergency conditions is fully automatic and redundant, there is an Emergency Control Station outside the Confinement Building. This control station is located in the cold laboratory basement on the front or east side of the reactor laboratory complex.

This Station has an emergency panel containing the controls for all four fans in the emergency system, namely EF-2, SF-19, EF-5, and EF-6 (including both AC and DC controls for EF-5 and EF-6), and the controls for valves ACV-10 and ACV-12 and indicators for valve positions of all valves ACV-1 through ACV-12. The building differential pressure can be monitored at this panel, and an indicator shows when exhaust air is flowing from the Emergency Exhaust System. Finally, two radiation monitors in this panel show radiation levels within the Confinement Building.

6.2.3.3.2 Confinement Building Under-pressure Protection

A vacuum relief valve, ACV-12, prevents excessive under-pressure relative to external static atmospheric pressure (see Figure 6.5).

6.2.3.3.3 Filter Description

Several types of filters are installed in the reactor building. Absolute (particulate) filters are used in all reactor building exhaust systems to prevent particulate effluent from reaching the reactor stack and being discharged. Each filter is at least 99% efficient for a particulate size of 0.3 microns. The activated charcoal filters consist of at least two banks of filters in series, each of which consists of multiple perforated members, arranged in parallel to form a bed, one-inch (2.54-cm) thick, of granular activated charcoal. The filters at the rated flow have a leakage rate of no more than 1%. The filters were designed to remove greater than 99.9% of the Iodine from air at approximately 80^{o}F (27 ^{o}C).

Each particulate-filtering system in the normal ventilation systems consists of a pre-filter followed by a HEPA filter. The filtering system in the Emergency Recirculation System is also similarly designed as the normal ventilation systems, except that a charcoal filtering system is installed after the supply fan SF-19. However, the filtering system in each train of the Emergency Exhaust System is consisting of a pre-filter and a HEPA filter before the charcoal filter, followed by a post-filter to remove any particulate left from the charcoal filter.

6.2.3.3.4 Exhaust System and Stack

All normal ventilation air that is exhausted from the Confinement Building is discharged to Fan Room, D-02, containing Dilution Exhaust Fan EF-2. Access to this room, located at the base of the exhaust stack, is via an adjacent room on the D01 level of the Pump House. This fan room serves as the suction plenum for EF-2. As shown in Figure 6.6, it receives discharge air from Normal Exhaust System fan EF-3 through ACV-7, discharge air from Irradiated Air Exhaust System fan EF-4 through ACV-6, and discharge air from Reactor Basement Exhaust System fan EF-27 through ACF-3. Dilution Exhaust Fan EF-2 discharges air directly into the base of the "A" section of the Exhaust Stack. A velocity controller keeps the discharge rate of air through the Exhaust Stack at a constant 30,000 cfm (850 meter^3 per minute) regardless of the seasonal variations in the air exhausted from the Confinement Building ventilation system. The controller accomplishes this by varying the position of automatic dampers in the Fan Room to add dilution air from the exterior of the building to the air exhausted from the Confinement Building to keep the discharge rate through the Exhaust Stack constant. Exhaust Fans, EF-5 and EF-6, discharge directly into the exhaust stack.

The principal parameter of the stack is its height. Since under normal operation, ^{41}Ar-activity is produced within the confines of air spaces in the reactor system, it was deemed necessary to elevate the point of release so that the exhaust air would be appreciably diluted via atmospheric dispersion before it entered the unrestricted area surrounding the facility. The height of approximately 100 feet (30 meters) above grade level was chosen to meet the criteria of dilution and reduced potential exposure. The stack is a dual one, one side of which exhausts the Confinement Building, while the other side exhausts the Warm Laboratories (see Figure 6.6).

6.2.3.3.5 Ventilation Fans

The operator from the Main Control Panel of the Control Room remotely controls all of the following ventilation fans discussed below.

Dilution Exhaust Fan EF-2 is driven by a single speed, 480 Vac, 60 Hz, three-phase motor, rated at 10 hp, and powered from Emergency Power MCC B-6. The controller for this fan is interlocked with the Door Scram Relays.

Normal Exhaust Fan EF-3 is driven by a single speed, 480 Vac, 60 Hz, three-phase motor, rated at 1 hp and powered from Emergency Power MCC A-5. The controller for this fan is interlocked with the Door Scram Relays and the Fan Scram Relays. The controller also supplies the power for damper ACV-7.

Irradiated Air Exhaust Fan EF-4 is driven by a single speed, 480 Vac, 60 Hz, three-phase motor, rated at one hp, and powered from Emergency Power MCC A-5. The controller for this fan is interlocked with the Fan Scram Relays. The controller supplies the power for damper ACV-6.

Two separately powered motors drive Emergency Exhaust Fan EF-5. One is a single speed, 125 VDC motor while the second, redundant motor is a single speed, 480 Vac, 60 Hz, three-phase motor. Both are rated at $^{1}/_{6}$ hp and are powered from MCC DC. The control circuitry prevents both motors from being energized simultaneously. The controller for this fan is interlocked with the Door Scram Relays and the Fan Scram Relays, and it also supplies the power for dampers ACV-4, -8 and -10.

Two separately powered motors drive Emergency Exhaust Fan EF-6. One is a single speed, 125 VDC motor while the second, redundant motor is a single speed, 480 Vac, 60 Hz, three-phase motor. Both are rated at $^{1}/_{6}$ hp and are powered from MCC DC. The control circuitry prevents both motors from being energized simultaneously. The controller for this fan is interlocked with the Door Scram Relays and the Fan Scram Relays, and it also powers dampers ACV-5 and -9.

The Hood Exhaust Fan EF-23 is driven by a single speed, 480 Vac, 60 Hz, three-phase motor, rated at 7½ hp. It is powered from Emergency Power MCC B-6. The controller for this fan is interlocked with the Door Scram Relays and the Fan Scram Relays.

Reactor Basement Recirculation Fan EF-27 is driven by a single speed, 480 Vac, 60 Hz, three-phase motor, rated at 20 hp. It is powered from Reactor MCC A-3. The controller for this fan is interlocked with the Door Scram Relays and the Fan Scram Relays, and it also powers damper ACV-3.

Recirculation Supply Fan SF-19 is driven by a single speed, 480 Vac, 60 Hz, three-phase motor, rated at 7½ hp. It is powered from Emergency Power MCC B-6.

6.2.3.4 Technical Specifications

6.2.3.4.1 Technical Specification 3.9, Ventilation System

This Technical Specification applies to the Confinement Building's Normal and Emergency Exhaust Systems. Its objective is to ensure that each system's equipment is operational. The reactor is not operated unless the Emergency Exhaust System is operable; including both fans and the absolute and charcoal filters, and the Exhaust System is capable of filtering exhaust air and discharging it above the level of the building's roof.

The potential radiation exposure to persons at the site boundary and beyond was calculated following an accidental release of fission product activity (Chapter 13). These calculations were based on the proper operation of the Emergency Exhaust System to maintain the Confinement

Building at a negative pressure, and to direct all effluents through filters and up through the Confinement Building's stack. The Emergency Exhaust System is made redundant to ensure its operation. Because of its importance, this redundancy should be available at all times so that any single failure would not preclude the system's operation when required.

The Normal Exhaust System is designed to pass effluents through high-efficiency particulate filters capable of removing particles of 0.3 microns or greater with an efficiency of at least 99% and discharging them above the level of the reactor building's roof. This system ensures that gaseous effluents are filtered and diluted before they reach personnel either onsite or offsite. The system can accomplish this function using various combinations of its installed fans and building stack.

6.2.3.4.2 Technical Specification 3.11, Radiation Monitoring System

This Technical Specification applies to those radiation monitoring systems necessary to ensure operation of the NBSR facility. Its objectives are to monitor the helium sweep gas for possible fission products, and to ensure that that releases of gaseous effluents are within acceptable limits. The reactor is not operated unless a continuous fission-products monitor is operable or samples are analyzed for fission products at least daily, and the gaseous release from the Confinement Building is below specified levels of maximum permissible concentration (MPC) for average yearly concentrations and maximum daily concentrations.

A fission-product monitor located in the helium sweep gas will indicate a "pin-hole" breach in the cladding, so that preventive measures can be taken quickly. Because this monitor is not redundant, whenever it is undergoing maintenance the helium sweep gas must be periodically sampled and analyzed. Daily frequency is adequate to ensure early detection of any small failures before they would be expected to grow significantly. Larger failures would occur only after an accidental reactor transient, which would be followed by a shutdown. Part of the post-incident evaluation would include sampling the helium sweep gas, so that the existence of an actual failure would be detected before continuing operation.

The concentration limits specified ensure that the 10 CFR 20 limits are not exceeded at the site boundary. Calculations have been made using standard codes to verify this fact.

6.2.3.4.3 Technical Specification 4.6, Ventilation System

The objective of this Technical Specification that applies to the Emergency Exhaust System and the Normal Exhaust System is to ensure their operability. A quarterly operability test of the Emergency Exhaust System is required. Also an operability test of the controls in the Emergency Control Station is required at least monthly. The particulate removal efficiency of the absolute filters in both the normal and the emergency exhaust systems must be tested at least biannually, while a leakage test of the charcoal absorber banks in the Emergency Exhaust System also is required at least biennially.

The emergency ventilation system depends on the proper operation of the emergency exhaust system fans, valves, and filters, which are not routinely in service. Because they are not continuously used, their failure rate as a result of wear should be low. But, since they are not being used continuously, their condition in standby shall be checked sufficiently often to ensure that they shall function properly when needed. An operability test of the active components of the emergency exhaust system shall be performed quarterly to ensure that each component shall be operable if an emergency condition should arise. The quarterly frequency is considered adequate since this system receives very little wear and since the automatic controls are backed up by manual controls.

The absolute filter efficiency shall be tested biennially. This frequency is appropriate for filters subject to continuous air flow. Because the NBSR absolute filters in the emergency exhaust system will be idle except during testing, deterioration should be much less than for filters subjected to continuous air flow where dust overloading and air breakthrough are possible after long periods of use. Therefore, a biennial testing frequency should be adequate in detecting filter deterioration.

The test requirement for the charcoal filters in the emergency exhaust system is basically a physical integrity test. It is prudent to verify that the NBSR filters are not installed or operated in such a way as to be damaged or bypassed. Therefore, an aerosol in-place leakage test shall be required biennially to detect leakage paths resulting from charcoal settling and deterioration of the filter seals. Experience has shown that the use of an aerosol gas to be an acceptable means for determining the leakage characteristics of charcoal filter installation.

6.2.3.4.4 Technical Specification 4.9, Environmental Monitoring Program

This Technical Specification applies to the environmental monitoring program. Its objective is to determine the environmental levels of radioactivity near the facility. An environmental monitoring program includes as a minimum the quarterly analysis of samples from area streams, vegetation or soil, and air monitoring.

Consistent with the study made by the U.S. Geological Survey, a periodic sampling program of area wells and streams has been conducted since November 1962 (SAR, NBSR 9, Chapter 2). To ensure more complete sampling of the area surrounding the NBSR, this program was expanded to include area vegetation and soil samples (grass samples are collected during the growing season, April through September and soil samples during the non-growing season, October through March).

Based on a database search of wells currently permitted by Montgomery County (Montgomery County, 2003), there is currently only one potable well within a one-mile radius of the site. Therefore, there are no major users of groundwater within a one (1) mile radius of the reactor site. As WSSC supplies more water for this area and development continues, there are no anticipated future uses of groundwater within a one (1) mile radius of the site. Ground water is sampled when found to be available and accessible. Sampling of area streams and /or surface water, however, is continuing and shall be required.

Thermoluminescent dosimeters or other devices also are placed around the perimeter of the NBSR site to monitor direct radiation. The continuation of this environmental monitoring program will verify that the operation of the NBSR presents no significant risk to the public health and safety. Since 1969 when the NBSR began routine power operation, the environmental monitoring program revealed nothing of significance thereby confirming that operation of the NBSR has had little or no effect on the environment. The quarterly frequency is considered adequate to detect any long-term changes in the activity levels in the vicinity of the NBSR. Shorter term changes would require a significant release which would be detected by the exhaust system radiation monitors.

A report published in March 2003 (URS, 2003), supports the findings of previous studies conducted on the hydrology and geology of the NIST site and vicinity. No significant changes in the hydrogeologic systems or ground water use were identified. This report further verifies the assumptions and techniques developed in 1962.

6.3 References

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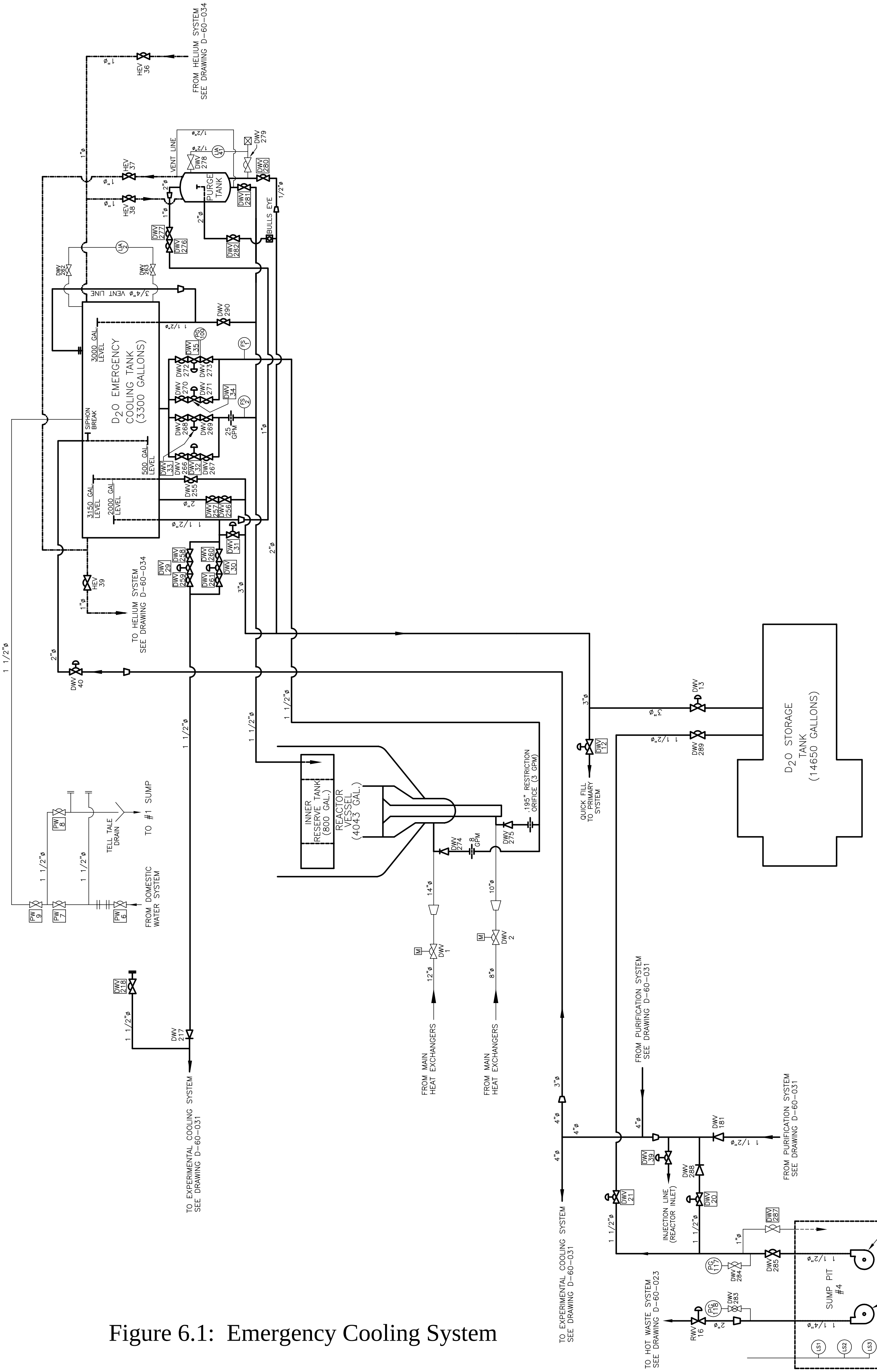

Figure 6.1: Emergency Cooling System

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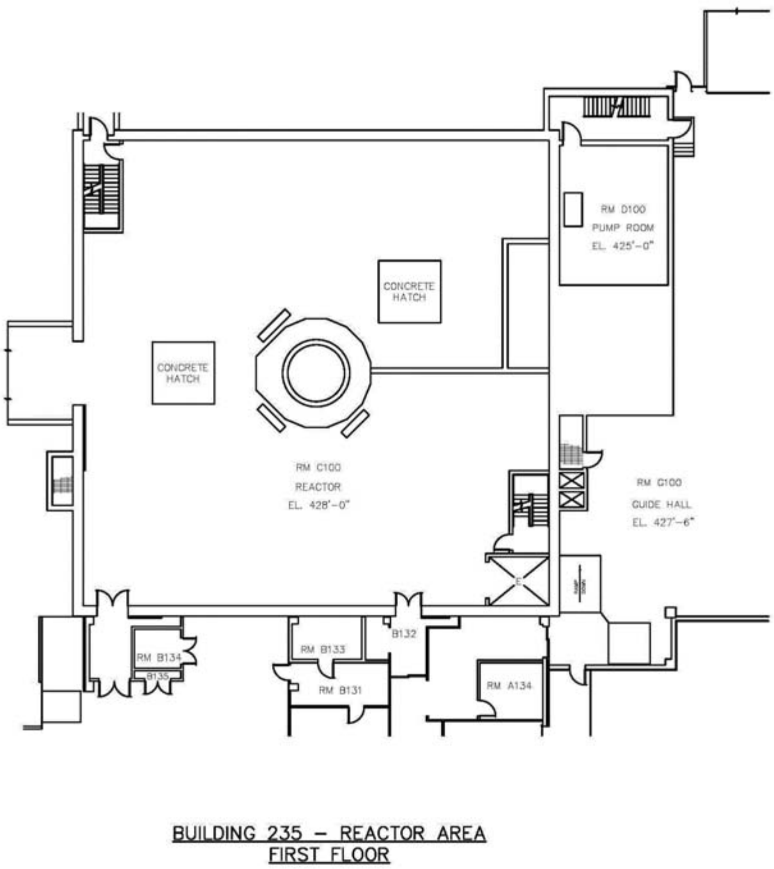

Figure 6.2: Confinement Building – First Floor at Elevation – 428 ft

⇨ N

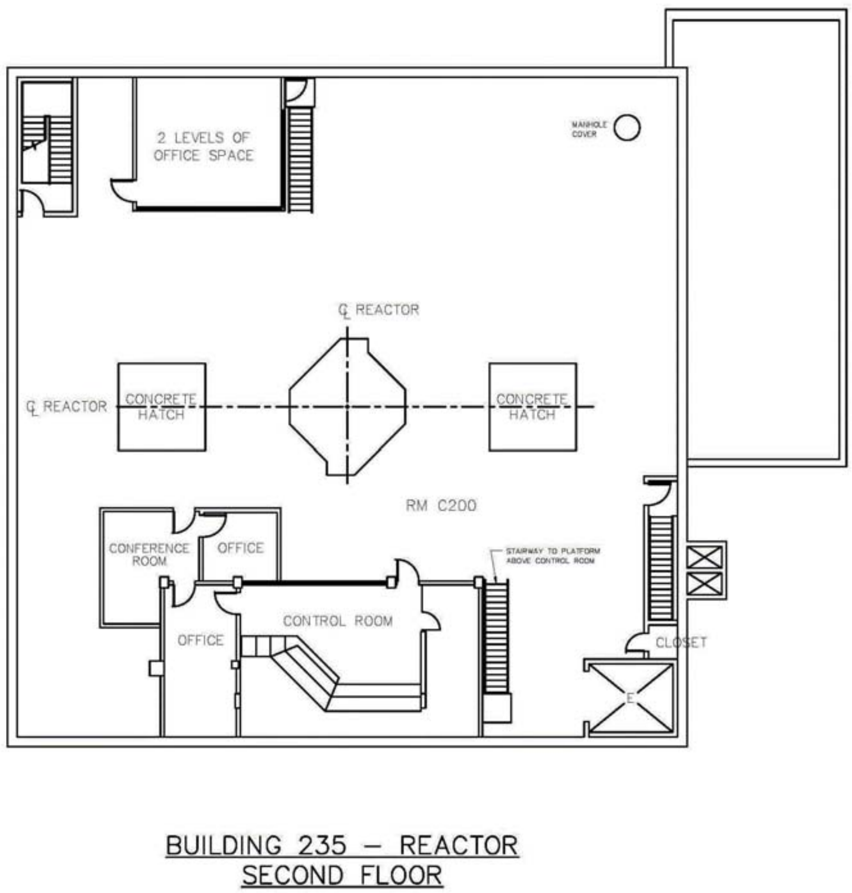

Figure 6.3: Confinement Bldg – Second Floor at Elevation – 450.4 ft.

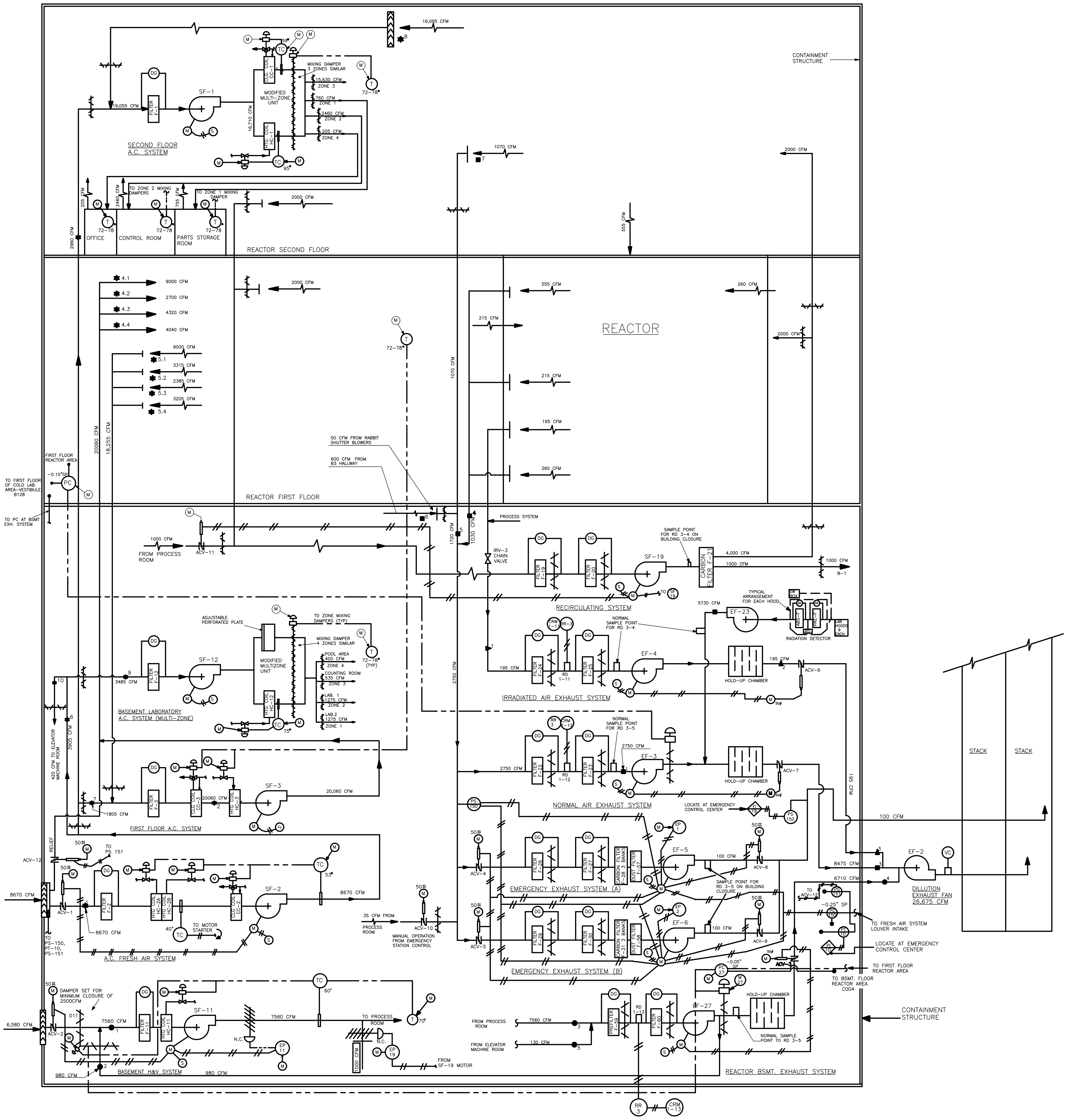

Figure 6.4: Confinement Building Ventilation for Normal and Emergency Conditions

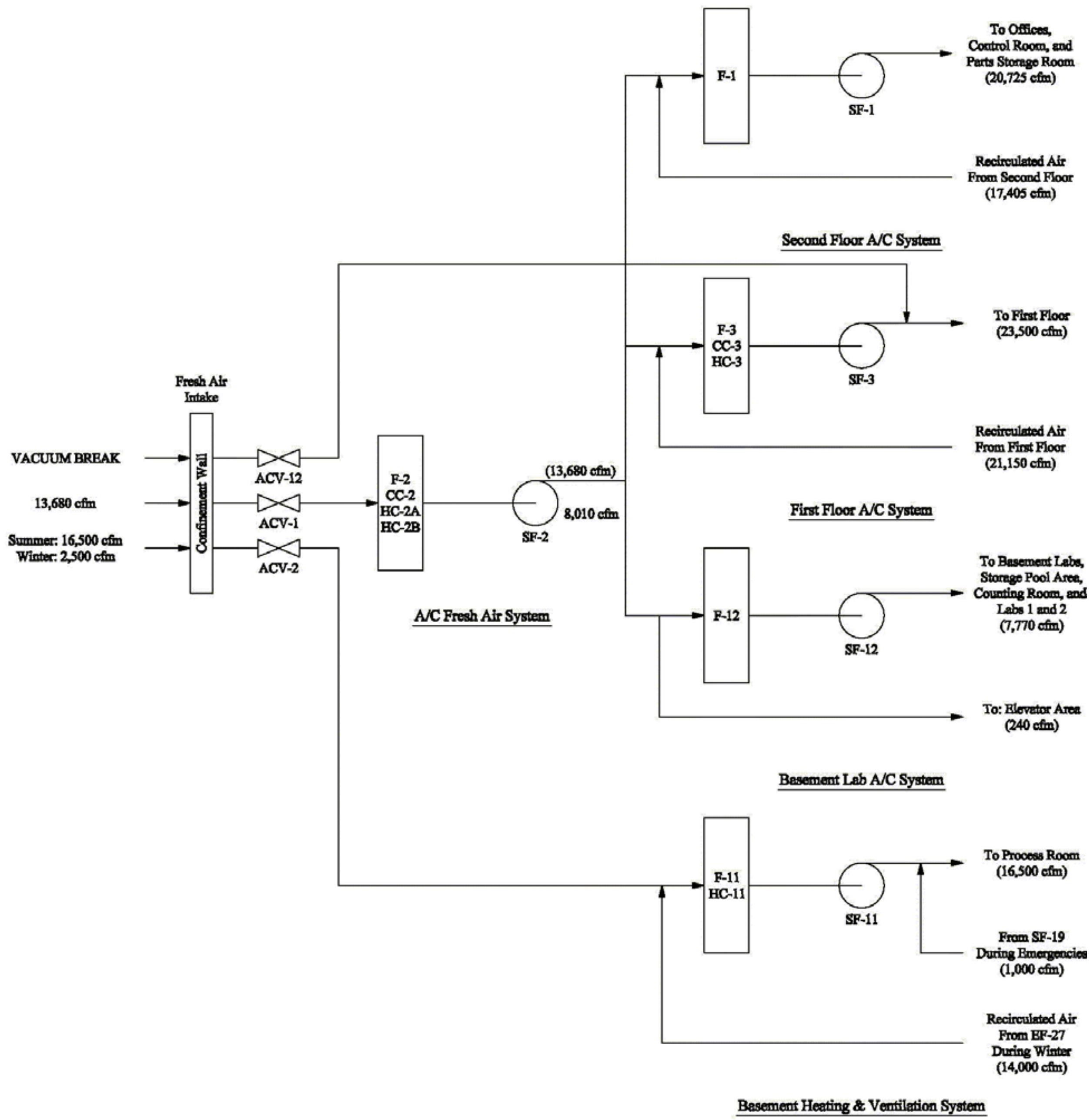

Figure 6.5: Normal Air-Conditioning and Ventilation Lineup – Simplified Diagram

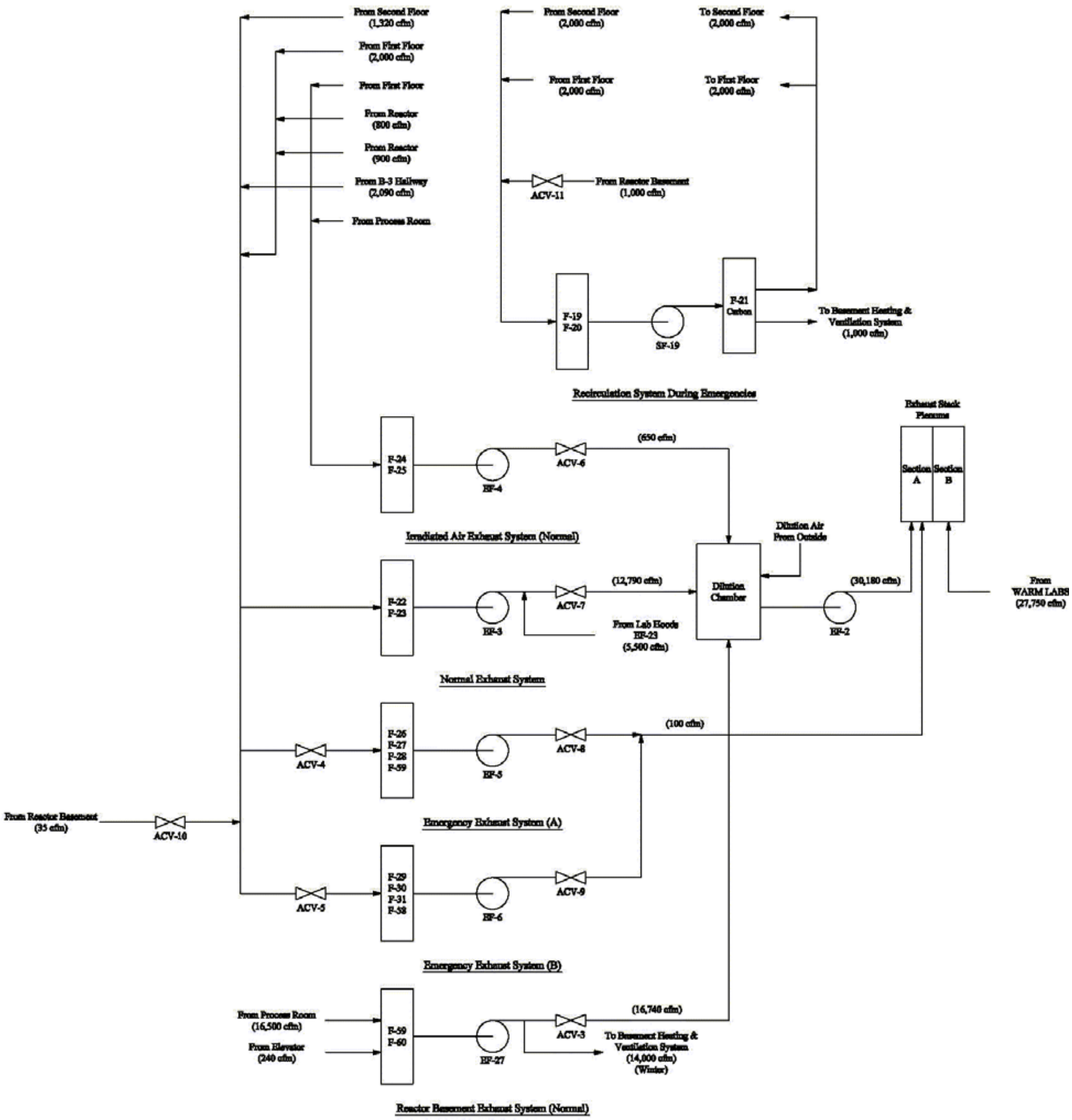

Figure 6.6: Normal Exhaust and Emergency Ventilation Lineup– Simplified Diagram

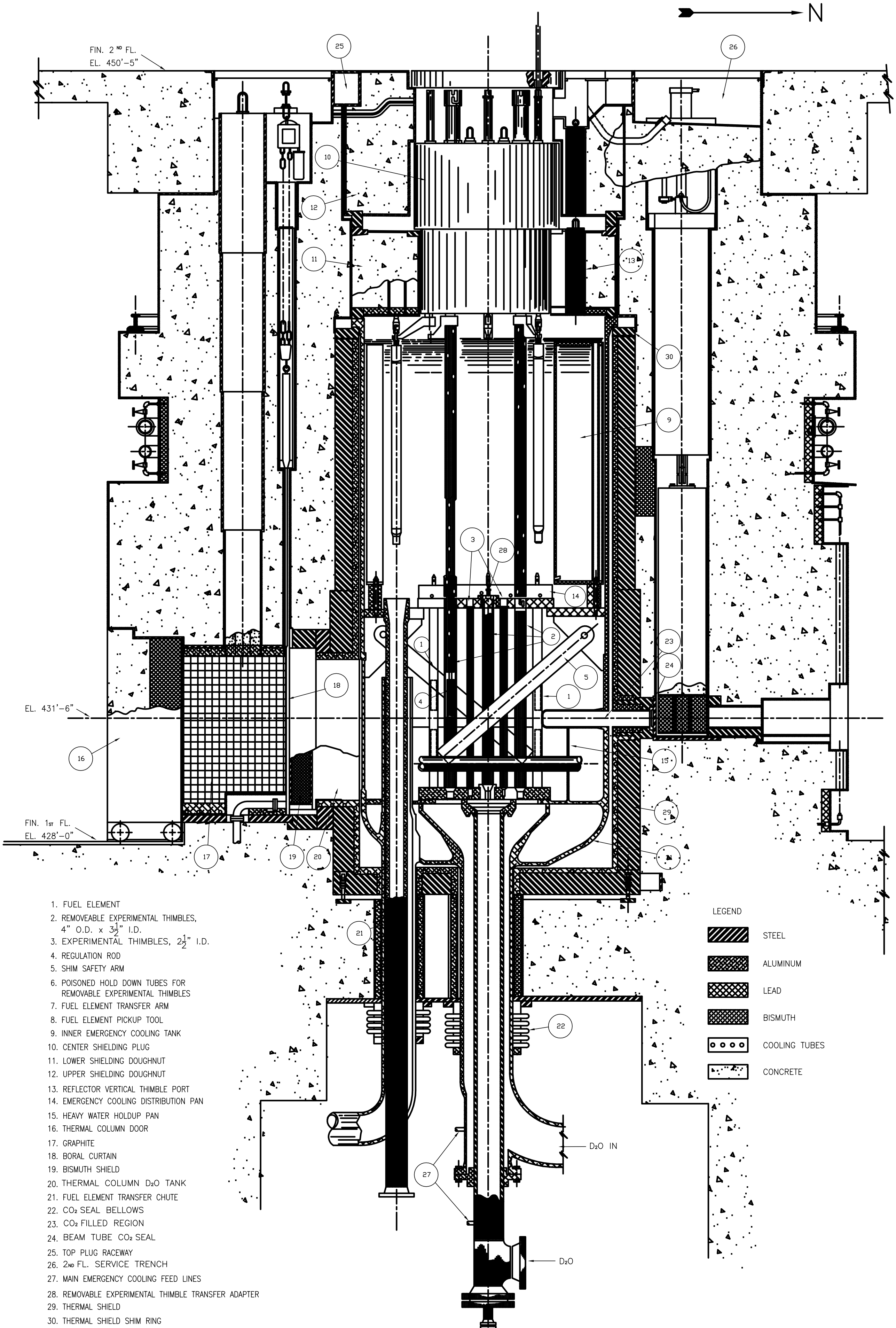

Figure 6.7: Reactor Vessel Showing Internal Components

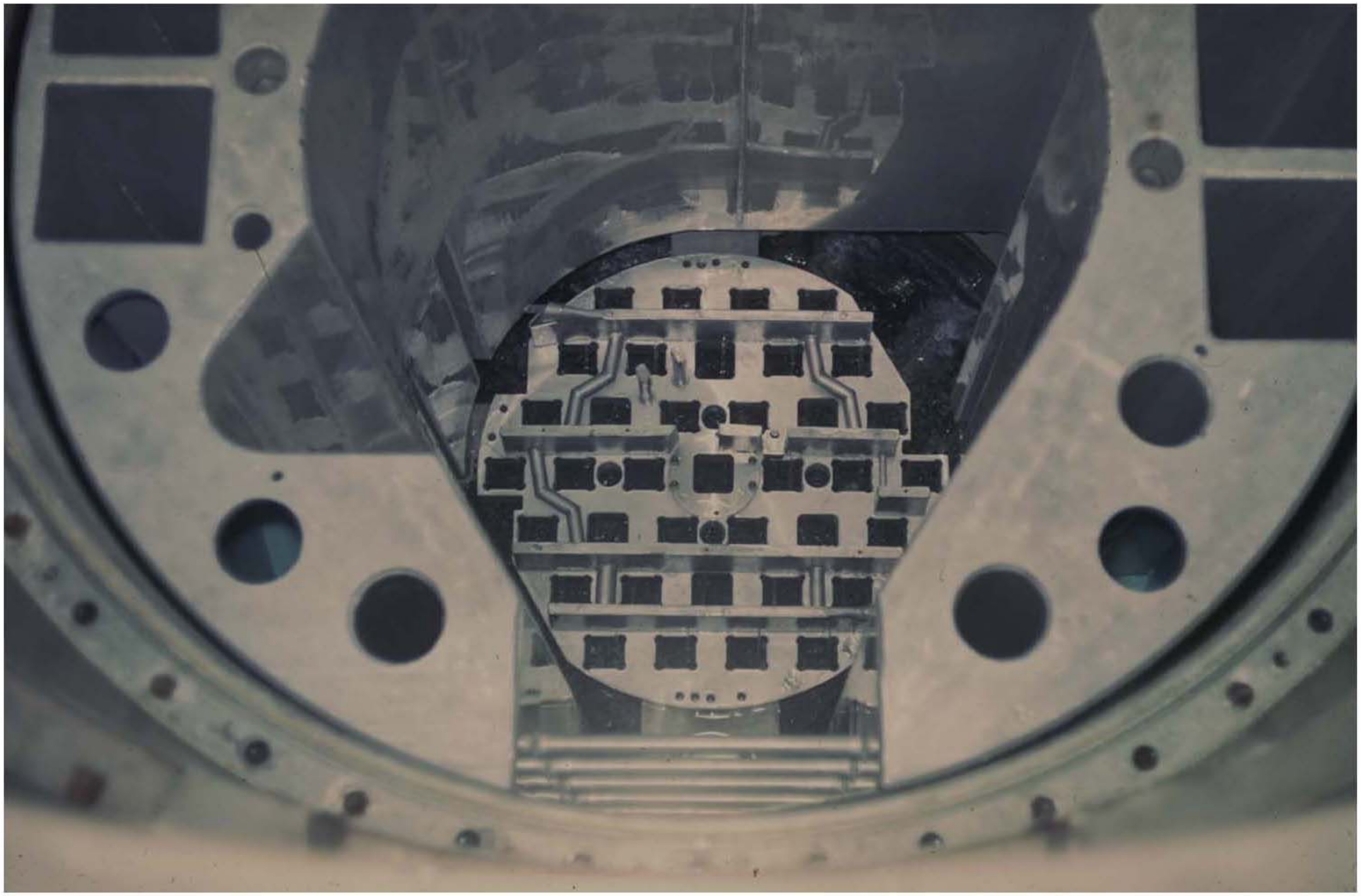

Figure 6.8: Inner Reserve Tank and Emergency Cooling Distribution Pan

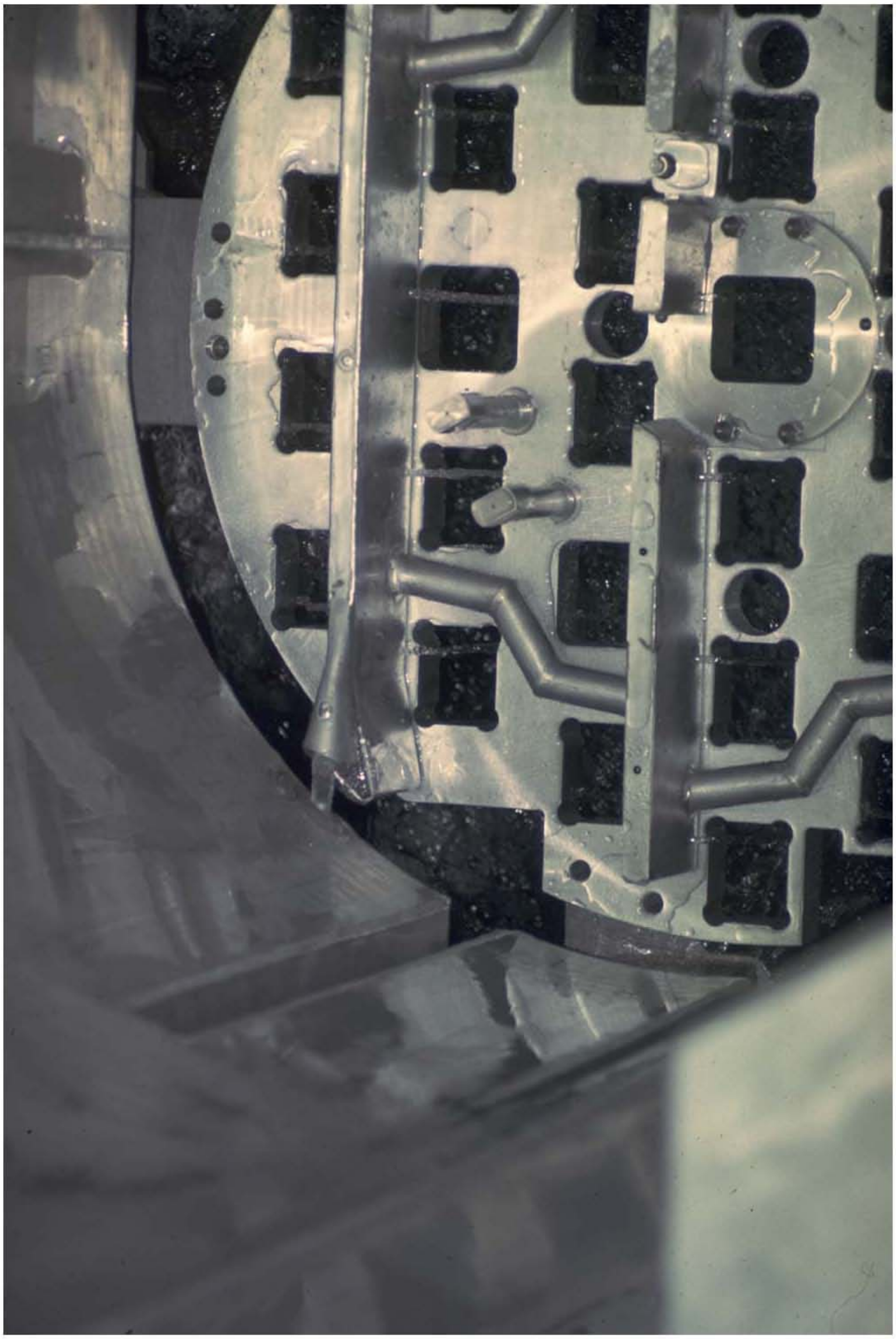

Figure 6.9: Emergency Cooling Distribution Pan

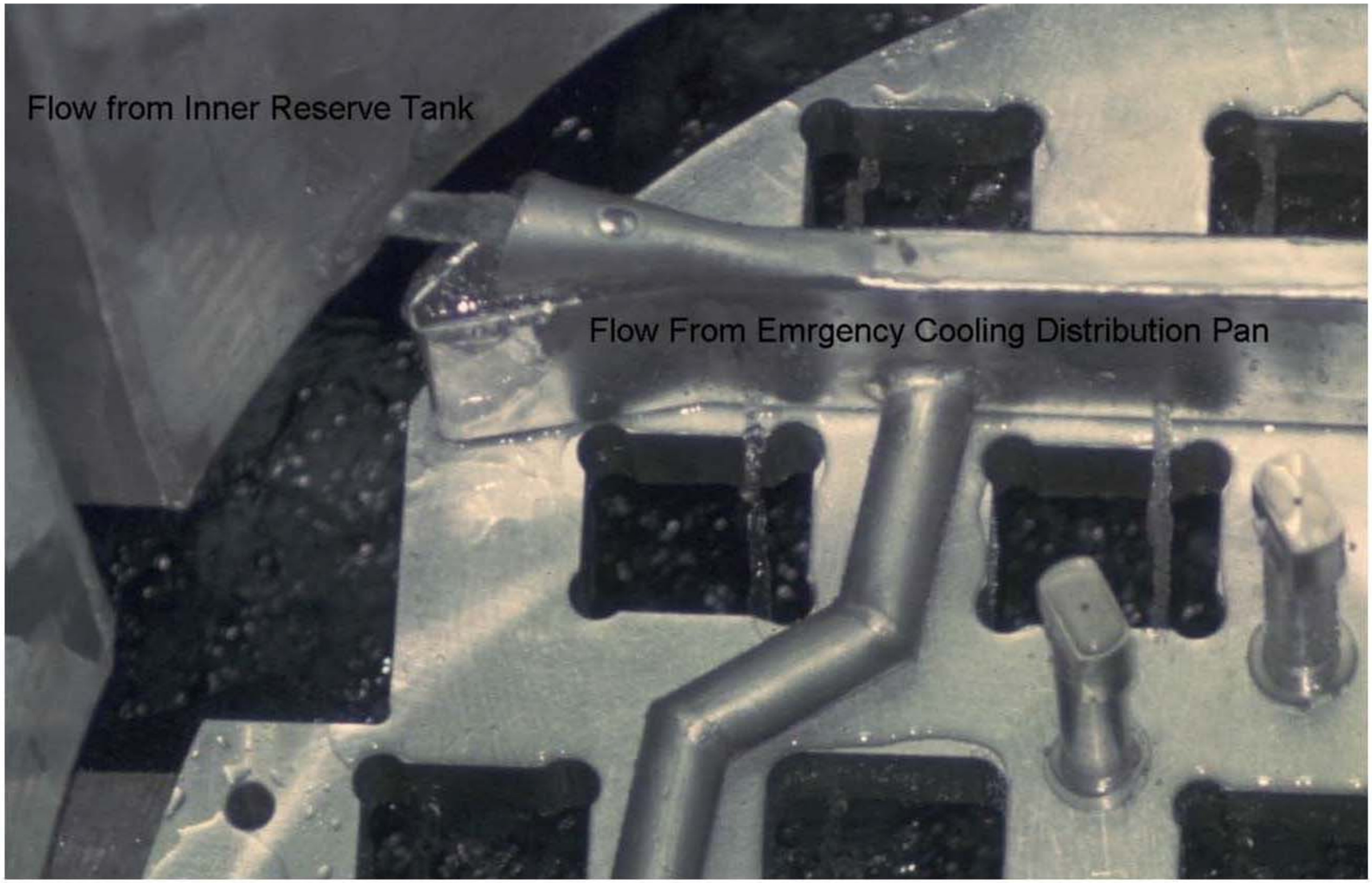

Figure 6.10: Emergency Cooling Distribution Pan – Coolant Flow to Each Fuel Element

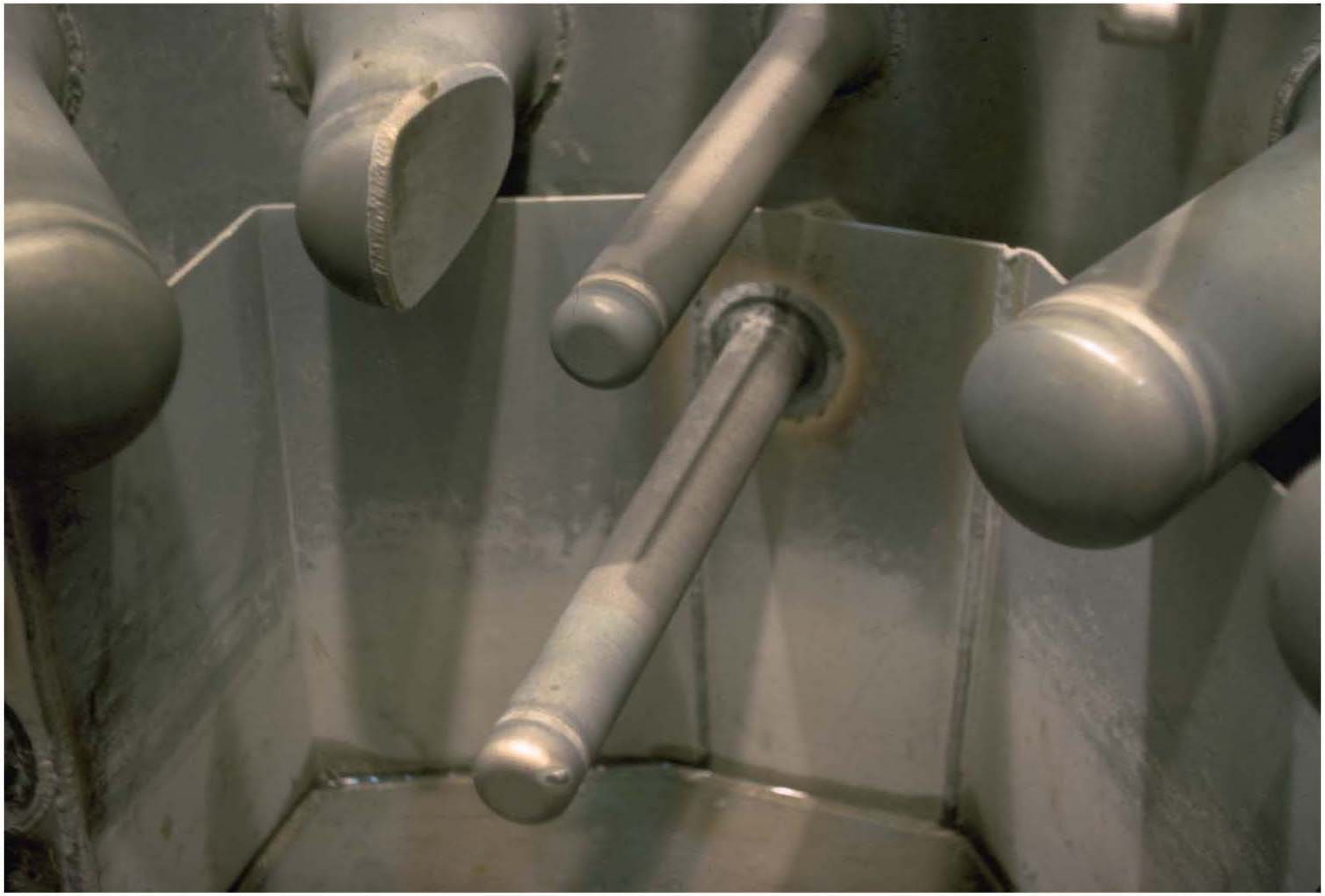

Figure 6.11: D_2O Holdup Pan