2 PROPOSED ACTION AND ALTERNATIVE

The proposed action is to resume operation of L-Reactor as soon as practicable, now scheduled for October 1983. L-Reactor operated originally from 1954 until 1968, when the decreasing demand for special nuclear materials caused it to be placed in standby status. The proposed resumption of operations will produce nuclear materials for the national defense using the same techniques used by the three reactors (C, K, and P) currently operational at the Savannah River Plant (SRP) and similar to the methods used previously at L-Reactor. "No Action" is the only alternative considered; it would keep the renovated L-Reactor in standby status. However, the no-action alternative would not satisfy the Presidential mandate to produce the needed nuclear materials.

2.1 PRODUCTION PROCESS

This section describes the production process for nuclear materials at the Savannah River Plant (SRP). SRP facilities associated with the production of special nuclear materials include five reactors (three currently operating), a fuel and target fabrication plant, two chemical separations plants, a heavy-water production plant (on standby), and waste-storage facilities. The planned Defense Waste Processing Facility, is being designed to immobilize high-level wastes currently stored in underground storage tanks.

Each reactor building houses a production reactor and its auxiliaries; each building incorporates heavy concrete shielding to protect personnel from radiation. The reactor uses heavy water (D_2O) as a neutron moderator and as a recirculating primary coolant to remove the heat generated by the nuclear fission process. Figure 2-1 shows the reactor process system. The reactors produce plutonium and tritium by the absorption of neutrons in uranium and lithium, respectively. Various fuel and target assemblies, all clad with aluminum, have been irradiated in SRP reactors (ERDA, 1977).

The fuel and target fabrication plant manufactures elements to be irradiated in production reactors; its major products are extruded enriched uranium-aluminum alloy fuel, aluminum-clad depleted-uranium metal targets, and lithium-aluminum control rods and targets.

The chemical processing plants dissolve or melt the irradiated fuel and target materials to liberate volatile fission and activation products. The initial separation usually yields (1) solutions of plutonium, uranium, or neptunium and (2) a high-heat liquid waste, containing the nonvolatile fission products. After the product solutions are decontaminated sufficiently from the fission products, further processing can be performed in unshielded areas, where the product elements can be converted from solution to solid form for shipment off the Savannah River Plant.

Heavy water is separated from river water at the heavy-water facility by a hydrogen sulfide extraction process, and then purified by distillation.

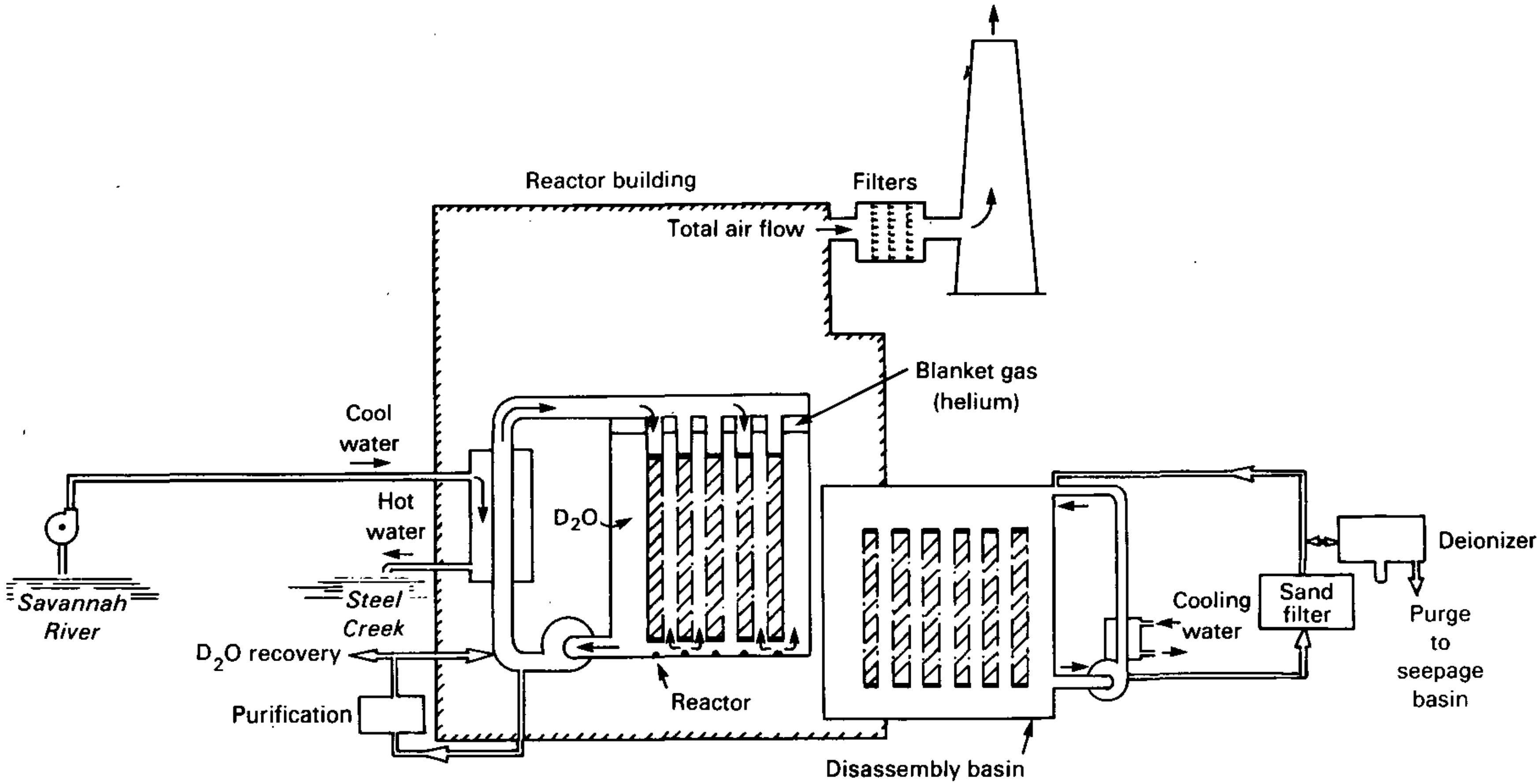

Figure 2-1. Reactor process systems.

The liquid radioactive wastes produced from the chemical processing of irradiated fuel and targets are stored in large underground tanks. The planned Defense Waste Processing Facility would immobilize the wastes in these tanks (DOE, 1982). One centrally located burial ground is used for the disposal of all low-level radioactive solid wastes produced at the Savannah River Plant.

The proposed restart of L-Reactor will increase the production rate of the fuel and target fabrication facility and the chemical separations facilities. These facilities originally were designed to support five reactors; even with the restart of L-Reactor, only four reactors will be operating. Thus, the L-Reactor restart is not expected to cause major operational changes in these facilities. With the operation of the Defense Waste Processing Facility by 1990, new waste tanks, beyond those currently planned, will not be required for L-Reactor operations.

2.2 L-REACTOR AND SUPPORT SYSTEMS

The L-Reactor site covers about 82 acres in the south-central portion of the Savannah River Plant. This site is about 13 kilometers northwest of the closest SRP boundary, and about 3 kilometers south of the geographic center of the Savannah River Plant (see Appendix C for conversion table). The site is on an upland area between Steel Creek and Pen Branch. The facilities closest to L-Reactor include K- and P-Reactors, which are approximately 4 kilometers to the west and east-northeast, respectively. Figure 2-2 shows the major L-Reactor area structures. The following sections describe L-Reactor and its support systems.

2.2.1 Reactor system

2.2.1.1 System description

The L-Reactor vessel is a stainless-steel cylinder about 4.5 meters high and 5 meters in diameter. Coolant enters a heavy-water plenum at the top of the reactor through six nozzles and leaves through six nozzles in the bottom of the vessel. A gas plenum and top shield are located under the inlet water plenum. Under the reactor vessel, a shield containing 600 monitor pins provides flow and temperature monitoring for each fuel position. The vessel is surrounded by a 50-centimeter-thick water-filled thermal shield, and a 1.5-meter-thick concrete biological shield.

The reactor contains positions for 600 fuel and target assemblies; other principal positions in the reactor lattice are used for control rod housings, spargers, gas ports, and pressure-relief tubes. Interspersed among the principal lattice positions are 162 secondary positions, which are filled by safety and instrument rods.

Neutron flux in the reactor is controlled by neutron-absorbing rods in 61 positions, each of which contains seven individually motor-driven control rods. These control rods can be moved in gangs for simultaneous positioning, or individually in sequence.

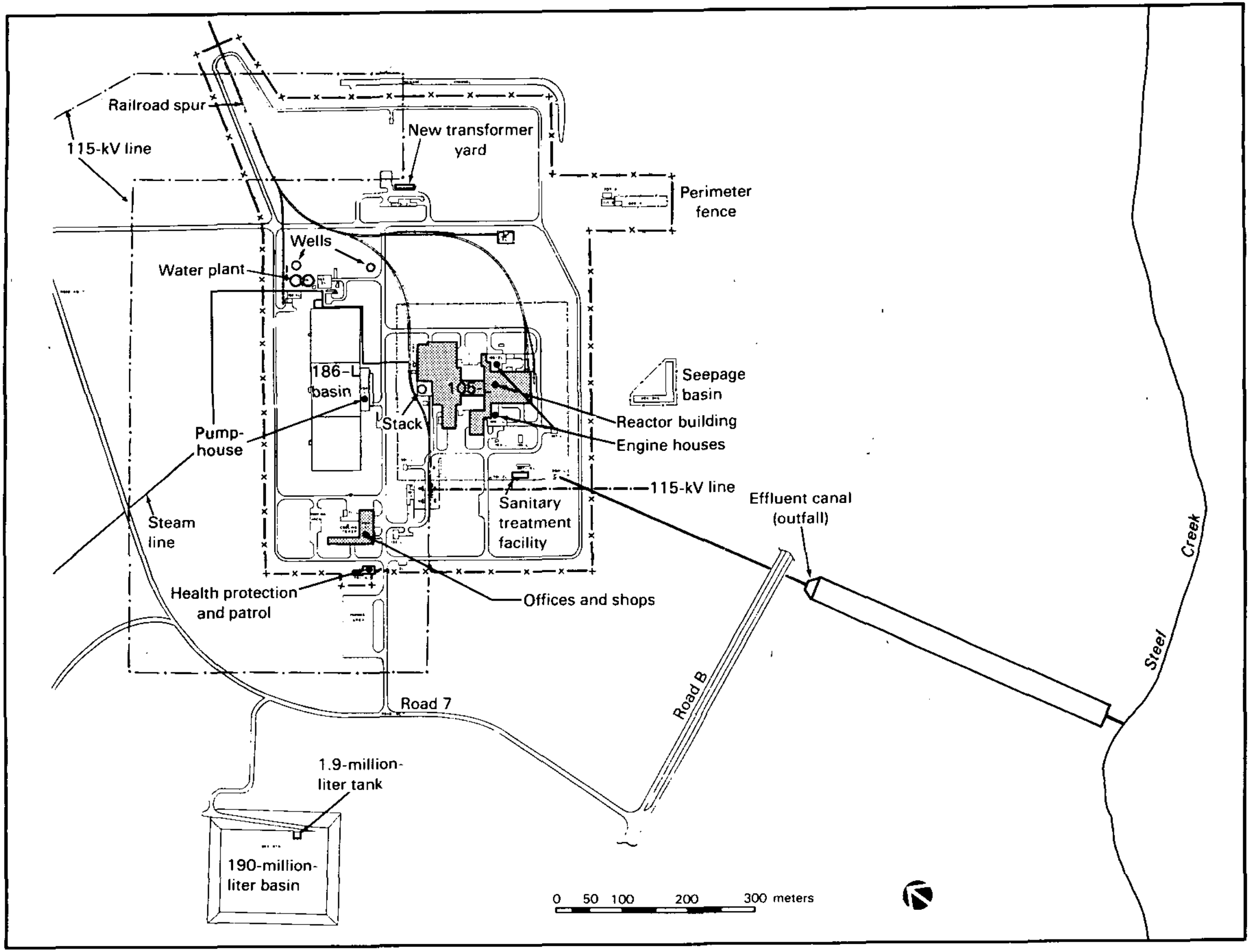

Figure 2-2. Major L-Reactor area structures.

Process monitoring and reactor control is accomplished from a central control room. The reactor can be controlled manually by an operator or automatically by an online computer.

Table 2-1 lists nominal values of the operating parameters for a typical L-Reactor charge.

Table 2-1. Typical L-Reactor operating parameters

Parameter	Value
Principal driver	Enriched uranium
Principal target	Depleted uranium
Primary coolant flow	9780 liters/sec
Power	2150 MW
Operating pressure	38,000 pascals (5 psi)
Effluent primary coolant temperature	
Driver	113°C
Target	85°-100°C

2.2.1.2 Reactor shutdown systems

Several redundant systems operate to rapidly shut down the reactor if necessary. The primary reactor shutdown mechanism is safety and control rod insertion, activated by the scram instruments; the secondary shutdown system is the Supplementary Safety System (injection of gadolinium nitrate), activated by the Automatic Backup Shutdown--Safety Computer.

Safety rods--The safety rods provide a primary rapid shutdown mechanism for the reactor and thus prevent exceeding operating limits and possible core damage. Upon receipt of a scram signal, the safety rods drop into the reactor core in about one second. L-Reactor has 66 safety rods made of cadmium--an efficient neutron absorber.

Control rods--When a shutdown (scram) signal is received, 61 clusters of control rods are automatically driven into the reactor. The control rod system is designed such that the reactor is subcritical when the control rods are inserted and the safety rods are withdrawn. The control rods can be driven in singly, or by a gang drive; the rate of insertion is less than that for the safety rods.

Scram Instruments--The scram circuits monitor reactor operation and will cause the safety rods to fall and the control rods to drive in. The scram instruments for a particular variable (e.g., neutron flux, coolant pressure, etc.) are set to produce a scram at the operating limit imposed for safe operation. A reactor scram at the setpoint will prevent damage to the fuel, the reactor, or the confinement system.

Supplementary Safety System--The Supplementary Safety System (SSS) is a fully independent system that acts as a backup shutdown system. The SSS can be actuated manually or automatically if safety rods fail to shut down the reactor. When the system is activated, gadolinium nitrate, an efficient neutron absorber, is injected into the moderator. The SSS is designed such that the reactor can be maintained in a subcritical mode even if all safety and control rods are in the fully withdrawn condition. The system has redundant tanks, piping, and valves.

Automatic Backup Shutdown--Safety Computer (ABS-S/C)--The ABS-S/C is a backup system which consists of two computers that each monitor an average of 300 assembly effluent temperatures every 0.36 second, and which will actuate the Supplementary Safety System to shut down the reactor if a requested scram is ineffective. It will terminate all identified transients for which the primary shutdown mechanism--safety rod insertion--fails.

2.2.1.3 Engineered safety systems

Besides the systems discussed above, there are a number of other engineered reactor safety systems. Several of these systems are described below.

Emergency Cooling System (ECS)--The ECS is designed to remove decay heat following a reactor shutdown by the direct addition of light water to the reactor core in case of loss of heavy water coolant or circulation. Four sources of light water are available, two of which have to be online for reactor operation.

1) A diesel-driven booster pump which supplies H_2O from the 95,000-cubic meter basin.

2) A 107-centimeter header pressurized by five pumps drawing H_2O from the 95,000-cubic meter basin.

3) Another 107-centimeter header pressurized by five additional pumps.

4) A line directly from the river pumphouse, pressurized by the river water pumps.

The ECS is actuated by changing liquid levels in the reactor tank. When the ECS is actuated, the diesel-driven booster pump starts, and valves are automatically opened or closed to couple the reactor system with the primary sources of light water. If the booster pump does not start, the other sources of emergency cooling are sufficient.

Water removal and storage--If the heavy water system ruptures, the heavy water and light water emergency cooling water would flow to sump pumps in the basement of the reactor building. The sump pumps pump the water first to a 225,000-liter underground tank; the flow then goes to a 1.9-million-liter tank that sits in the 190-million-liter emergency earthen basin. Some of the water on the 0-level process room floor would drain directly to the 1.9-million-liter tank. If this tank should become full, the additional water spills out into the emergency basin. The 1.9-million-liter tank is vented to the activity confinement system in the reactor building.

Remote control station--A remote control station 18 kilometers from L-Area is manned full time. The station is a data display and control facility for the reactors that can provide remote control of important reactor cooling and activity confinement systems in the event the control room in the reactor building cannot be occupied.

2.2.2 Primary coolant system

Heavy water (D_2O) serves as both the moderator and the primary coolant. The heavy water is circulated through the reactor by six parallel pumping systems; the system operates with an overpressure (blanket gas) of about 38,000 pascals. The six primary coolant pumps and motors are separated in groups of three in two pump rooms and two motor rooms. Each pump is driven by an alternating-current (a.c.) motor; each motor also drives a 2.7-metric-ton flywheel that stores enough energy to continue pumping heavy water for about 4 minutes after a loss of a.c. power. Power for the a.c. motors is supplied from two substations. Six direct-current (d.c.) motors provide backup pumping capacity for the circulation of heavy water; they normally are online when the a.c. motors are operating. If a.c. power fails, each d.c. motor will drive a pump to provide about 25 percent of the normal flow. Power to the d.c. motors comes from eight diesel generators. Six of these generators and six d.c. motors are in continuous operation; two generators are kept in reserve.

2.2.3 Secondary coolant system

Each of the six pumping systems contains two parallel, single-pass heat exchangers to transfer heat from the heavy water (primary coolant) to the secondary cooling water drawn from the Savannah River and discharged to Steel Creek, which flows back to the Savannah River. The water is drawn from the river at two pumphouses and delivered to the L-Reactor area cooling-water reservoir (186-Basin; Figure 2-2). The reservoir has a capacity of 95 million liters. An alternate tieline provides an emergency supply of cooling water from the river to the reservoir if the primary line from the river fails.

A pumphouse adjacent to the cooling-water reservoir delivers water to the reactor building. If pumphouse power is lost, the options available to deliver water to the reactor building for cooling the heat exchangers include (1) forced flow from the reservoir through a diesel-powered booster pump, (2) forced flow from the river pumphouses to the reactor building using a pipeline that bypasses the reservoir and delivers cooling water directly to the reactor building, (3) gravity flow from the reservoir through the pumphouse, (4) gravity flow from the reservoir to the emergency pumps in the reactor building via a bypass line to each supply header, (5) recirculation of reservoir water with the emergency pumps, and (6) recirculation of disassembly-basin water with the emergency pumps. The flows from options 1 and 2 can be delivered directly to the reactor for cooling if the primary coolant system fails. The effluent cooling water flows from the reactor building to the effluent sump. The water overflows a weir in this sump and flows to Steel Creek.

2.2.4 Core reloading

Equipment provided for core reloading includes a charge machine, a discharge machine, and an irradiated-component conveyor. The charge and discharge machines are similar, and each can perform most of the functions of the other; however, only the discharge machine can provide heavy- or light-water cooling of an irradiated assembly. Both machines travel on tracks on two parallel ledges that are part of the reactor-room wall; the power for their operation is provided through cables along the length of the ledges. A sliding contact also provides a power source to each machine, and both are equipped with chain drives if all power is lost. Diesel generators provide backup power. Controls and interlocks prevent the machines from colliding.

Reloading operations are performed from a control room adjacent to the reactor control room. The operations can be controlled manually or automatically via a tape control system.

The irradiated-component conveyor is in a water-filled canal connecting the reactor room and the disassembly (storage) basin. The conveyor receives an assembly from the discharge machine and carries it under the reactor-room wall to the basin.

2.2.5 Fuel storage

New fuel is received and stored in the reactor assembly area. Racks and hangers maintain adequate spacing for criticality control; an additional safety margin for assemblies containing fuel is provided in racks constructed of material that contains borated concrete poison. Moderating materials are controlled strictly in the assembly area to prevent criticality. Procedural controls limit the type and amount of material in process at any time.

Irradiated assemblies are stored in a water-filled storage (disassembly) basin to allow radionuclides and heat to decay to a level low enough for shipment to the separations facilities. The assemblies are cooled by natural convection; hangers allow this cooling while maintaining adequate spacing for criticality control. The basin water also provides radiation shielding for the assemblies. Procedural controls and instrumentation prevent the shipment of insufficiently cooled fuel and targets.

2.2.6 Electric power

Electric power is supplied to the L-Reactor area from the SRP power grid by two 115-kilovolt transmission lines. An outage of either line will not cause a loss of power to the L-Reactor area. Any of three 30,000-kilovolt-ampere transformers in the L-Reactor area can carry the entire load. Two 1000-kilowatt a.c. generators supply emergency power to the reactor building if normal power fails.

2.2.7 Gas systems

2.2.7.1 Blanket gas system

The blanket gas system, which uses helium (an inert gas), is the initial barrier to the release of radioactive gases from the reactor. This system has three primary functions: (1) to dilute deuterium and oxygen evolved from the moderator to a nonflammable concentration; (2) to recombine the deuterium and oxygen constituents of the gases evolved to heavy water; and (3) to maintain the pressure in the moderator (pressurize the gas plenum of the reactor to about 38,000 pascals and thus increase the heavy-water saturation temperature). Helium is used as the blanket gas because it neither reacts with moderator decomposition products nor absorbs neutrons to produce radioactive gases.

During operation, gases evolve from the reactor and enter the gas plenum. From the plenum, the gases are sent to catalytic recombiners and spray separators where the deuterium and oxygen are recombined and most of the entrained heavy water is removed from the helium. The gases then are returned to the gas plenum.

2.2.7.2 Activity confinement system

The L-Reactor has an activity confinement system. In the event of an accident, airborne fission products probably would be released into the reactor room, and possibly into the heat-exchanger bay or the pump room. As shown in Figure 2-3, the air from these areas is exhausted through a set of confinement filters before it is released to the stack. During normal operation, the process areas are maintained at a pressure that is lower than the pressure of the external atmosphere to ensure that all air from the process areas is exhausted through the activity confinement system.

Three large centrifugal fans exhaust the air from the process areas. Two of these fans normally are online, but only one is necessary to maintain the negative pressure. The fan motors can be powered by three electric sources:

- The normal building power
- The emergency building power
- The special confinement substation

Each of the three online fans has a backup motor; two of the fans can be powered simultaneously by diesel generators.

Exhaust filters remove moisture, particulates, and halogens. The filter banks are enclosed in five separate compartments; three to five of these compartments are normally online at one time. Each compartment can be isolated for maintenance and testing; each contains the following filter banks, in the order of air-flow treatment:

- Moisture separators, designed to remove about 99 percent of entrained water (spherical particles measuring 1 to 5 microns) to protect against significant blinding of the particulate filters.

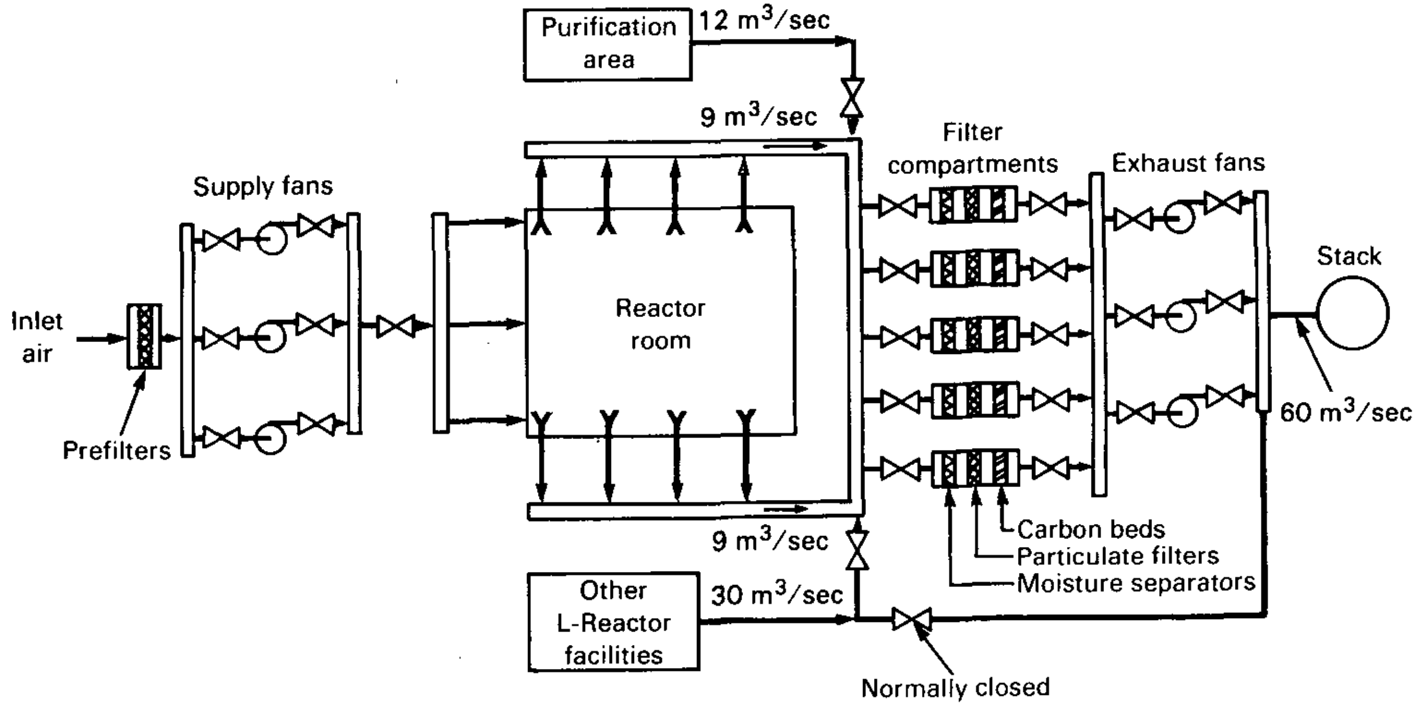

Figure 2-3. Reactor ventilation system.

- Particulate filters, designed to retain more than 99 percent of all particles with diameters of 0.3 micron or larger.

- Activated carbon beds that use an impregnated carbon to retain halogen activity if an accident were to occur.

2.2.8 Liquid radwaste system

Systems are provided to remove radionuclides from the moderator. The chemical purity of the moderator should be maintained to minimize the corrosion rate of aluminum and steel in the reactor; in addition, moderator impurities can absorb neutrons that would be utilized otherwise in the production of special nuclear materials. The neutron activation of moderator impurities and corrosion products contributes to the overall activity level in the moderator; fission product contamination also adds to the radiocontamination.

Many contaminating isotopes emit high-energy (0.3- to 2.5-MeV) gamma rays, which account for most of the radioactivity in the moderator. The moderator is treated continuously by the circulation of a side stream to a purification area to be deionized and filtered. Most of this side stream is returned to the reactor moderator system; a small amount is distilled to remove light water. If the Supplementary Safety System is used, the moderator purification system would remove the gadolinium nitrate solution from the water.

The purification system uses normal flow of 1.9 liters per second. The water is taken from the discharge of the number 1 heat exchanger and circulated through a filter, a deionizer, and another filter. The deionizer contains deuterized cation and anion exchange resin. The filters retain particles larger than 10 microns in diameter. The prefilter removes suspended solids that would foul the deionizers; an after-filter retains any resin fines that might leave the deionizer bed.

The moderator is deionized and filtered in a shielded cell area. Radioactive impurities are concentrated in disposable filter and deionizer units. The filters and deionizers are installed and removed remotely. Vessels containing spent deionizer are loaded into heavily shielded casks for transport to a facility for the eventual recovery of deuterium oxide by de-deuterization. After processing, these vessels are sent to the burial ground for disposal.

Part of the reactor side stream is diverted to the distillation area for the removal of light water. The bottoms material from the distillation is light-water-free deuterium oxide, which reenters the purification stream for deionizing and additional filtering before it returns to the reactor system.

The evaporator system removes particulate matter from deuterium oxide collected from such sources as spills, pump-seal leakage drains, and reboiler purge. No facilities are provided to remove tritium from the reactor moderator. When the deuterium oxide stills are emptied for maintenance or repair, the water is either collected into a tank to be reused or drummed to be reworked. Before the stills are opened to the atmosphere, they are dried with an inert gas and the water vapor is collected with a condenser.

Targets and spent-fuel assemblies removed from the reactor are rinsed in the discharge machine. The rinse water is collected by the discharge machine water pan and sent to a 2270-liter rinse collection tank. All rinse water is drummed and reworked.

Even after rinsing, some radioactivity is transferred from the irradiated assemblies to the water in the disassembly basin. The concentrations of radioactivity in the basin are significantly lower than those in the reactor moderator. A periodic purging of the disassembly-basin water is necessary to minimize the radiation exposure to operating personnel from the accumulation of tritium. During the purging operation, water from the basin is passed through sand filters and two deionizer beds in series, and monitored before it is discharged to a low-level seepage basin. This procedure minimizes the release of any radioactivity other than tritium to the seepage basin. The spent resin from the deionizer beds is regenerated in the separations areas, and the spent regenerant is concentrated and stored in high-level radioactive-waste tanks in the separations areas.

The two sand filters also maintain clarity. Particulate matter in the basin water tends to agglomerate or adsorb radioisotopes. When the basin water passes through the sand filters, the particulate burden is reduced. The filtration rate can vary from 32 to 95 liters per second, depending on the initial fluid clarity and the demand for treatment. When the differential pressure across the filter beds indicates the need, a filter can be isolated and backwashed. The radioactive backflushed material is transferred to the separations area for concentration and storage.

2.2.9 Solid radwaste

Reactor operations produce solid radioactive waste. Contamination from induced activity accounts for most of the low-level solid waste. Work clothing, plastic sheeting, and kraft paper also become contaminated with radioactivity when they are used for personnel protection during operation or maintenance. Such material comprises the bulk of the low-level waste; valves, pipe sections, pumps, instruments, and other system components that are removed during maintenance and found to be irreparable also constitute such waste. Low-level solid waste is placed in boxes and packaged for transport to the SRP Burial Ground.

2.2.10 Process and effluent monitoring

All gaseous radioactive releases through the stack will be monitored continuously by gamma spectrometry. Stack effluent tritium will be monitored by two ion chambers in series with a moisture removal system between the two. A continuous sampling technique with daily quantitative analysis is also used. All other air and water samples will be monitored routinely and quantitative release records will be kept. Above-normal activity levels will be investigated to locate the source so the condition can be corrected.

Samples will be analyzed routinely to quantify the key surveillance radionuclides from the following sources:

- The moderator
- The stack exhaust air
- The effluent heat-exchanger cooling water
- The storage-basin effluent purge water

2.2.11 Other support systems

2.2.11.1 Steam

Steam is supplied to the reactor facility for process service and ventilation heat. A steam line will be built to the L-Reactor area from the K-Reactor area powerhouse.

2.2.11.2 Potable water

Potable water will be supplied to L-Reactor area from two deep wells producing from the Tuscaloosa Formation. This water is the source for service-clarified water, filtered water, and domestic and fire water after it is processed in a treatment plant.

2.2.11.3 Sanitary sewage

Sanitary sewage is processed by a secondary treatment plant large enough to meet the demands placed on it during normal operations by the projected L-Reactor area workforce of 350 people. Chlorinated discharges from the treatment plant will be sent to the process sewer, which discharges to Steel Creek.

2.2.12 Safeguards and security

Safeguards considerations for the L-Reactor include physical security and materials control and accountability. Applicable safeguards requirements are contained in the following DOE Orders:

- DOE Order 5630.1: Control and Accountability of Nuclear Material
- DOE Order 5630.2: Control and Accountability of Nuclear Materials, Basic Principles
- DOE Order 5632.1: Physical Protection of Classified Matter
- DOE Order 5632.2: Physical Protection of Special Nuclear Material

The physical security system for the L-Reactor will be part of the existing SRP physical security system. This system includes controlled and monitored access to the site as well as an additional security system around the L-Reactor area.

REFERENCES FOR CHAPTER 2

DOE (U.S. Department of Energy), 1982. Environmental Impact Statement, Defense Waste Processing Facility, Savannah River Plant, Aiken, South Carolina, DOE/EIS-0082.

ERDA (Energy Research and Development Administration), 1977. Environmental Impact Statement, Waste Management Operations, Savannah River Plant, Aiken, South Carolina, ERDA-1537.