4. WASTE STORAGE FACILITIES

HIGH-LEVEL LIQUID WASTES (F- AND H-AREA FARMS)

General Process Description

Liquid radioactive wastes are produced at SRP primarily from nuclear fuel reprocessing operations in the F and H Areas. These wastes are stored in large underground tanks in these areas by methods that do not foreclose any of the possible options for long-range management of the wastes. A discussion of the current status of long-range planning is presented in Appendix I.

Recovery processes in the hot (heavily shielded) and warm (moderately shielded) canyons generate aqueous waste streams that contain most of the fission products. These waste streams that come from the warm canyon are referred to as low-heat waste (LHW) and those from the hot canyon are high-heat waste (HHW). This terminology is used to identify the source of the waste and to indicate that LHW will not require auxiliary heat removal, as does HHW. In all other respects, LHW is similar to HHW, that is, the chemical composition is similar and LHW must be stored indefinitely rather than released in a controlled way to the environment. The term "high-level liquid waste" includes both HHW and LHW. The wastes are made alkaline and flow by gravity from the processing buildings to the waste storage tank farm through underground pipes that are enclosed in a secondary concrete conduit for double containment.

Figure II-11 illustrates schematically the high-heat waste process in the waste tank farm. The waste from the canyon is received in a cooled HHW tank that has secondary containment. Fresh waste is aged for one to two years to permit settling and the decay of short-lived fission products. During this period insoluble materials settle to form a layer of sludge at the bottom of the tank. The sludge is a mixture of oxides and hydroxides of manganese, iron, and some aluminum; small amounts of uranium, plutonium, and mercury; and essentially all of the fission products originally in the irradiated fuel except cesium. After aging, the supernate, containing dissolved salts and radioactive cesium, is transferred to a continuous evaporator. Currently, the condensate from the evaporator is passed through an ion exchange column for removal of entrained cesium and then discharged to a seepage basin, but alternative capability is being provided to permit recycle to the canyons for usage as process water. When the process waste contains mercury, the condensate is also passed through a mercury trap upstream of the cesium removal column. The concentrate from the evaporator is transferred to a cooled waste tank where the suspended salts settle. After cooling, additional salt crystallizes. The supernate is returned to the evaporator for further concentration.

This process continues until the liquid has been converted to a crystallized salt cake.

The low-heat waste is handled similarly to high-heat waste (Figure II-12). Low-heat salts are now being accumulated in uncooled waste tanks.

Ranges of chemical compositions and other properties of high-level liquid wastes (LHW and HHW) are outlined in Table II-6 and II-7, respectively. The principal long-lived radioactive constituents in wastes are listed in Table II-8. Additional information on wastes is included in Appendix C.

Waste Tank Design

At present, SRP has 30 large subsurface tanks for the storage of aqueous radioactive wastes, as sludge, supernatant liquid of various salt concentrations, and salt cake. Sixteen of these tanks are adjacent to one separations plant (H Area) and 14 are adjacent to the other (F Area). Three additional tanks are nearing completion in H Area, and four tanks are under construction in F Area.

All of the waste tanks are below ground, and are built of carbon steel and reinforced concrete, but they are of four somewhat different designs. Three designs have double steel walls and bottoms and forced water cooling systems and are used primarily for high-heat waste and waste concentrate; the fourth design has a single steel wall directly supported by the encasing reinforced concrete, has no forced cooling, and is used primarily for low-heat waste and concentrate.

All of the waste tanks constructed, under construction, or planned for construction to date are listed in Table II-9. The tank types are discussed in the order in which they were built.

Tank Locations

F and H Areas are both located on relatively high ground between Upper Three Runs and Four Mile Creek. The locations of the F- and H-Area tank farms and the inter-area waste transfer lines are indicated in Figure II-13. The land contours are such that surface drainage from both F Area and H Area flows toward Four Mile Creek. The water table contours are such that drainage from the F-Area tank farm into the ground divides, some flowing toward Upper Three Runs and some flowing toward Four Mile Creek (Figure II-14). Drainage from H Area into the ground flows toward Upper Three Runs. Figure II-15 shows the depth below the surface of the maximum water table that occurred in March 1965.

The tank arrangements in each area are shown in Figures II-16 and II-17. For each group of tanks, Table II-10 lists the tank type; elevations of the ground surface, tank top, and tank bottom; and high and low recorded water table.

Waste Storage Tank Usage

Table II-11 summarizes the volumes of total waste, sludge, and salt in the tanks as of December 1975. Table II-12 gives the major type of waste currently stored in each tank; the history of waste tank usage is given in Appendix C. High-heat concentrate in Type IV single-wall tanks is scheduled for relocation to double-wall tanks as space becomes available. Figure II-18 shows pictorially the accumulation of waste and the effects of tank and evaporator construction.

Net accumulation of stored waste from current fresh waste receipts and tank farm evaporator operation is expected to continue at no more than an average rate of one million gallons per year. The volume of liquid supernate stored in the waste tanks will vary with time as waste management operations are carried out to relocate existing and new wastes. Transfer of existing salt cake and sludge to new or improved tanks will temporarily increase the total volume of waste because of the water added to accomplish the transfers. Addition of new evaporators and improved in-tank coolers will reduce the liquid volume.

Spare volume is maintained in sound double-wall tanks in each of the two waste tank areas (F and H). This volume is equivalent to the largest volume of waste stored in any one tank. Steam jets are installed in the annulus of each double-wall tank and are available for installation in any primary tank to transfer liquid waste in case of a severe leak. The inter-area waste transfer lines are also available for transfer of waste between F and H Areas so that all available spare tanks are available to either area if necessary.

[*K.8*] New waste tanks that are now under construction or planned will enable the replacement of seven single-wall tanks, those double-wall tanks that have leaked waste liquid and salt into the annulus between the primary and secondary steel container, and all tanks without full-height secondary containment with the same fabrication history as the tanks that have leaked waste into the secondary container.

All of the new tanks will be of the latest type, with the primary container fully stress-relieved and a full height secondary container. Priority for tank replacement, which will begin by 1978 on completion of the tanks now under construction, will be placed on:

1. Remove liquid waste from cracked double-wall tanks with measurable waste in the annulus pan.

2. Remove high heat waste from single-wall Tank 24 (H Area).

3. Empty and clean cracked double-wall tanks with measurable waste in the annulus pan.

4. Empty and clean single-wall tanks with activity in the leak-detection sump.

5. Empty and clean other single-wall tanks.

6. Empty and clean other cracked double-wall tanks.

7. Replace tanks without full secondary containment which have the same fabrication history as the 8 cracked tanks.

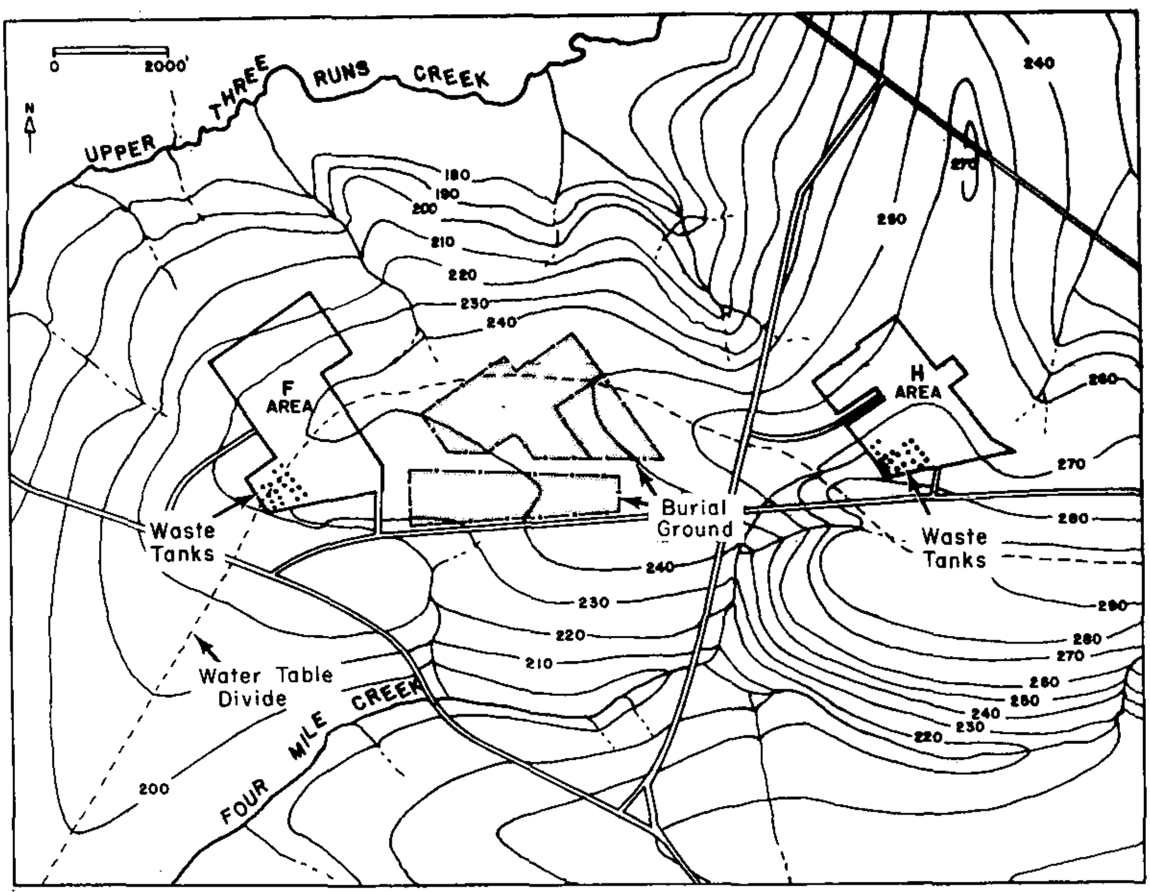

FIGURE II-14. Prevailing Elevation of the Water Table at the Tank Farms and Burial Ground (Contours shown in feet above sea level)

By the mid-1980s, all of the high-level liquid waste is estimated to be stored in tanks completed in 1970 or later. Evaporators will be constructed as needed so that waste evaporation capacity will not limit the tank replacement program.

Current waste management practices, including the construction of new double-wall waste tanks to replace the older single-wall and leaking double-wall tanks, do not foreclose any of the possible options for long-term management of SRP wastes. The range of options being investigated is discussed in Appendix I. These options include, on the one hand, improvement in current practices based on continued surveillance and maintenance, and at the other extreme, complete removal of the wastes from tank storage and conversion to an inert solid form for ultimate storage. It has been demonstrated at SRP that the waste salt can be redissolved and that the settled sludge can be removed by a combination of hydraulic and chemical cleaning. Retrieval of waste from tanks is also discussed in Appendix I.

Tank Substructure

The installation of each group of tanks was preceded by a drilling exploration designed to characterize the type of earth, load-bearing capacity, presence of cavities, and profile of the water table. Holes were drilled to a depth of at least 150 ft, one at the center of each proposed tank position. In 1951 and 1952, during soil explorations of the sites chosen for Type I tanks, some cavities and soft spots were found and grouted. Soil explorations for all subsequent tank installations did not reveal deep cavities extensive enough to require grouting, but some surface soft spots were grouted in preparing foundations for Tanks 25-28 and 35-37.

The tank substructures were built on undisturbed earth from about 20 to 60 ft below original grade. The last few feet down to the bottom of the pit was excavated carefully to avoid loosening the earth below the desired elevation. A 4- to 6-inch concrete working slab was first laid completely over the bottom of the multiple-tank excavation. On that foundation, individual base slabs for the support of each tank were constructed.

The cooled waste tanks (Types I, II, and III) are heavy structures with large columns to support their radiation-shield roofs. In use they have sizable thermal stresses in the base slab. Consequently they are set on reinforced concrete bases with thicknesses varying from 30 inches for Type I to 42 inches for Types II and III, and footings under center columns are as thick as 64 inches.

The uncooled tanks (Type IV) are of lighter construction and without roof support columns, and have a 4-in.-thick reinforced concrete base slab with a 13-in.-thick reinforced concrete perimeter footing to carry the weight of the tank wall, roof, and earth cover.

Tank Descriptions

Type I Tanks

The original 12 storage tanks constructed during 1951-1953 are designated Type I tanks. Tanks 1 through 8 were placed in F Area and Tanks 9 through 12 in H Area. Each primary tank holds 720,000 gallons, is 75 ft in diameter, and is 24-1/2 ft high. Figure II-19 shows the essential features of Type I tanks, including the primary tank, the secondary pan, and the concrete support structure.

Structure. The primary container is a closed cylindrical tank with flat top and bottom constructed from half-inch-thick steel plate. The top and bottom are joined to the cylindrical side wall by curved knuckle plates. The primary tank is set in a circular pan of half-inch steel plate, 5 ft deep, and 5 ft larger in diameter than the tank. The secondary vessel, the pan, thus provides an intervening annulus 2-1/2 ft wide. The assembly of tank and pan is surrounded by a cylindrical reinforced-concrete enclosure with a flat concrete roof and foundation slab. Twelve concrete columns - each two ft in diameter, having flared capitals, and encased in half-inch steel plate - are installed within the primary tank to support the flat concrete roof. The concrete wall and roof are 22 inches thick.

In F Area where the water table is relatively low, standard waterproofing was applied to the exterior of the concrete encasement. An additional brick encasement with a poured asphaltic interlayer was used in H Area where the water table sometimes rises above the tanks. A 9-ft layer of earth was placed over the tanks for radiation shielding. Tank cooling is provided by 36 parallel cooling water pipe coils. A condenser, fiberglass filter, and blower are installed to provide ventilation of the tank interior.

All welds in the pan and primary tank were radiographically inspected, defects were corrected, and the welds were rechecked radiographically. The welds in the flat bottoms of both the pan and the tank were vacuum-tested for leaks. Additionally, both vessels were hydrostatically tested. The water was maintained at full height in the tank for 24 hours before inspection for leaks was made. Cooling water piping was hydrostatically tested at 300 psig and then leak-tested with 100 psig air pressure in the piping.

Instrumentation. Several top openings are provided into the tank and annulus, and they are fitted with steel-lined, reinforced-concrete risers through the earth cover to grade level. The risers are stoppered with concrete plugs. Many of the openings are used for instruments installed in the primary tank or in the annulus. A few of the openings are used for tank venting and annulus dehumidification connections. Others serve for the installation of steam jets and associated piping, for transferring supernatant liquid waste out to other tanks for evaporation or other processing. The principal instruments installed in each tank are:

- *Liquid Level.* Liquid level in the primary tank is measured by two different systems: one uses a conductivity probe on the end of a gear-driven perforated metal tape which is automatically lowered and raised cyclically to sense the liquid level; the other uses built-in dip tubes (three pneumatic bubbler tubes terminated at various elevations above the tank bottom) and a portable manometer and air supply. Stationary conductivity probes and dip tubes are installed in each annulus to detect the presence of any liquid in the secondary pan.

- *Temperature.* At least four thermowells, each with multiple thermocouples, are installed in every tank. In addition, a thermocouple measures tank vent temperature. Temperatures are recorded in the control house, which has high-temperature alarms. All cooling coils are equipped with thermowells at the outlet end. Active coil thermowells and condenser cooling water outlets are supplied with indicating thermometers.

- *Pressure.* All cooling coil units are equipped with pressure relief valves at the outlet end. The inlet side of both active and spare coil circuits is equipped with a connector for attachment of a pressure gage, if needed. Pressure gages are installed at several points in the tank ventilation system to detect cessation of flow, filter plugging, etc.

Ventilation. Tank ventilation equipment, consisting of a reflux condenser and heated fiberglass filter, is connected to a tank top riser opening designed to accommodate two additional condenser-filter systems, if needed. The reflux condenser is designed to remove one-third of the maximum anticipated tank heat load. If all cooling coils should become inoperative, the one installed condenser plus two additional condensers installed in parallel would handle the total heat load of a tank full of fresh high-heat waste. However, coil cooling of fresh waste tanks has always been adequate, and installation of auxiliary condensers has not been needed.

Initially, the ventilation load was considered to be tank breathing plus fill displacement. It was verified after startup that radiolytic decomposition of water and organic materials in the tanks generates hydrogen and that there must be continuous ventilation in tanks containing high-heat waste to control the hydrogen concentration below the flammability limit. Changes were made to each tank ventilation system to provide a tank vapor space purge of about 100 cfm of air.

Dehumidification equipment consisting of a fan, a heater, and ductwork is installed at each tank to maintain the annular space in a dry condition. The design intent is to maintain the annular space temperature above the dew point.

Type II Tanks

Tanks 13 through 16, constructed in H Area in 1955-1956, are designated Type II tanks. Figure II-20 is a cross section diagram of this type. Each primary tank holds 1,070,000 gallons, is 85 ft in diameter, and is 27 ft high. Figure II-21 is a photograph of these four tanks during their construction.

Structure. The primary container for Type II tank consists of two concentric steel cylinders assembled with a flat bottom and a flat top into a form somewhat like a doughnut. The top and bottom are joined to the outer cylinder by rings of curved knuckle plates. The inner cylinder is flared at the top to accommodate the roof support column. This cylinder is joined to the flat steel top with a continuous butt weld and to a base fastened to the bottom with a continuous "T" weld. Steel plates used in the construction of the tank are of various thicknesses, as follows:

Top and bottom plates	1/2 inch
Upper knuckle plates	9/16 inch
Wall plates	5/8 inch
Lower knuckle plates	7/8 inch

The primary tank is set on a one-inch sand bed within a circular pan of half-inch steel plate, 5-ft deep, and 5-ft larger in diameter than the tank. The tank and pan assembly is surrounded by a cylindrical reinforced-concrete enclosure with a 33-inch wall and a flat concrete roof 45 inches thick. The tank and pan assembly and the surrounding wall are set on a foundation slab that is 42 inches thick. The roof is supported by the wall and by a central concrete column that fits within the inner cylinder of the vessel. The tanks were placed above the highest expected elevation of the water table, so only standard waterproofing was applied.* Cooling is provided for each Type II tank by 44 parallel cooling water coils. A condenser, fiberglass filter, and blower or exhauster are installed on the tank vent.

All welds in the primary tanks were radiographically inspected, defects were corrected, and the welds were rechecked radiographically. The pans were not inspected radiographically. The welds in the flat bottoms of the pans and the primary tanks were vacuum-tested for leaks, and the primary and secondary vessels were hydrostatically tested. Cooling water piping was hydrostatically tested at 300 psi and then leak-tested, using soap solution, with 100 psi air pressure in the piping.

Instrumentation and Ventilation. The top openings in the tanks and annuli are similar to those in the Type I tanks, and are used for instrumentation and for waste transfer and ventilation system connections. Both the instrumentation and ventilation systems are similar to those of Type I tanks.

Type IV Tanks

Tanks 17 through 24 are of different design than those constructed previously and are called single-wall, uncooled, or Type IV tanks. They were designed for storage of waste that does not require auxiliary cooling. Tanks 17 through 20 were built in F Area in 1958, and Tanks 21 through 24 were built in H Area in 1959-61. Each tank holds 1,300,000 gallons, is 85 ft in diameter, and is 34 ft high (Figure II-22).

Structure. Each Type IV tank is basically a steel-lined, prestressed-concrete tank in the form of a vertical cylinder with a domed roof. Carbon steel plates, 3/8 inch thick, were used to form the cylindrical sides and flat bottom portion of the steel liners. The knuckle plates at the juncture of the bottom and

* The actual water table has subsequently risen as high as 8 ft above the bottom of the tanks (Table II-10).

the side wall are 7/16 inch thick. Concrete was built up around the steel vessel by the "shotcrete" technique, a pneumatic method of application in which the thick semi-fluid mixture is blown through a nozzle to form a built-up structure. A dense, high-strength concrete is formed which enhances the load-carrying capability of the wall. No secondary steel pan was provided for these tanks. The wall was prestressed by embedding girths of steel under tension in the outer layers of the wall, thereby applying a compressive force to the inner layers and to the steel liner. When a tank built in this manner is filled, the outward pressure of the contained fluid offsets, approximately, the compressive pre-stresses in the inner layers of the concrete. In effect the concrete wall becomes a structure with negligible internal circumferential stresses, and the burden of the tank's contents is transferred to the steel bands near the outer surface of the concrete.

All welds in the steel liners were x-rayed. All of the welded tank-bottom seams and the upper seams of the knuckle rings were vacuum leak-tested. Each tank was hydrostatically tested by filling with water to the normal fill line, prior to the backfilling operation, and then was allowed to remain filled until the time it was to be placed in use for waste storage.

Leak detection for the bottoms of these tanks is provided by a grid of channels in the concrete foundation under the tank that drain to a sump outside the periphery of the tank wall. A 4-inch pipe rises to grade from the sump to allow for liquid level measurement, sampling, and pumpout of collected fluid. To detect gross leakage through the sidewalls, an additional leak detection feature was provided for the H-Area tanks in the form of a circumferential open-topped drainage channel, filled with crushed stone, outside the concrete tank wall adjacent to the wall foundation. Two vertical pipes, 180° apart, were installed down to the channel to provide a means for detecting leakage, should any come through the tank wall. The channels are submerged in ground water "perched" above the concrete working pad around the tank bases, hindering the sensitivity of the system.

Radiation shielding of the Type IV tanks in F Area was accomplished by applying at least 32 inches of earth over each of the 7-inch-thick concrete domes. H-Area tanks were shielded similarly, except that the earth cover was at least 44 inches thick to accommodate a somewhat higher radiation level from the waste.

Ventilation. To prevent the spread of particulate contaminants by uncontrolled venting of the waste tanks, fiberglass filters are installed in the vent lines. Tanks 17 and 19 are joined by a 6-inch carbon steel vent connection below grade, and

Tank 19 is connected by a steam-jacketed carbon steel vent line to the filter chamber mounted above the tank. Tanks 18 and 20, 21 and 22, and 23 and 24 are likewise paired, with one filter for each pair of tanks. The filters are similar to those used on Type I and Type II waste tanks. Each is packed with fiberglass matting in layers of various densities. All tanks have forced exhaust ventilation.

Instrumentation. Instruments for in-tank measurements are installed through the risers in tank dome openings. The principal instrumentation systems provided for each tank are as follows:

- *Liquid Level.* Liquid level in the primary tank is measured by two different systems: one uses a conductivity probe on the end of a gear-driven perforated metal tape which is automatically lowered and raised cyclically to sense the liquid level; the other uses built-in dip tubes (three pneumatic bubbler tubes terminated at various elevations above the tank bottom) and a portable manometer and air supply. Stationary conductivity probes and dip tubes are installed in each annulus to detect the presence of any liquid in the secondary pan.

- *Temperature.* At least two thermowells are provided in each tank 180° apart. Each thermowell holds two thermocouples, one for bottom temperature and one for measurement at an intermediate elevation. H-Area tanks also have thermocouples in a 2-inch pipe at the tank centerline.

Type III Tanks

The tanks constructed most recently are designated as Type III. Figure II-23 depicts the basic Type III structural form. Six Type III tanks have been built. Four of them, Tanks 29 through 32, were built in H Area in 1967-1970; two others, Tanks 33 and 34, were built in F Area in 1969-1972. Seven additional tanks of this type are under construction and 18 others are budgeted or planned for construction (Table II-19).

The Type III tank design was developed after an investigation into the causes for leaks from Type I and Type II primary tanks. At that time (1965), four primary tanks had leaked into the secondary containment. Four more have developed leaks since then, so leaks now affect a total of eight tanks (see Appendix C). The conclusions of the study were that the primary leak-producing mechanism was stress corrosion cracking at sites in or near the weld seams, and that stress relieving after fabrication should eliminate the cracking. For the Type III tanks, means were provided for heating each finished tank to relieve the stresses generated during fabrication. In addition, some stress patterns were avoided, or minimized, by mounting the roof supporting column on the foundation pad rather than on the bottom of the primary tank (as in Types I and II), and by providing an annular clearance around the roof-supporting column. Each primary tank holds 1,300,000 gal, is 85 ft in diameter, and is 33 ft high.

Structure. The form of the Type III tanks is similar to the ring-like shape of the Type II tanks. Each primary vessel is made of two concentric cylinders joined to washer-shaped top and bottom plates by curved knuckle plates. Steel thicknesses are as follows:

Top and bottom plates	1/2 inch
Upper knuckle plates	1/2 inch
Outer wall plates	
Upper band	1/2 inch
Middle band	5/8 inch
Lower band	3/4 inch
Inner wall plates	
Upper band	1/2 inch
Lower band	5/8 inch
Lower knuckle plates	
Outer	7/8 inch in Tanks 33 and 34, 1 inch in Tanks 29 through 32
Inner	5/8 inch

The primary tank sits on a 6-inch bed of insulating concrete within the secondary containment vessel. The concrete bed is grooved radially so that ventilating air can flow from the inner annulus to the outer annulus. Liquid would move through the slots, facilitating detection at the outer annulus, if any were to leak from the tank bottom or center annulus wall.

The secondary vessel is 5-ft larger in diameter than the primary, providing an outer annulus 2-1/2-ft wide. The secondary vessel is made of 3/8-inch steel throughout. Its side walls rise to the full height of the primary tank. The nested two-vessel assembly is surrounded by a cylindrical reinforced concrete enclosure with a 30-inch wall. The enclosure has a 48-inch flat reinforced concrete roof which is supported by the concrete wall and a central column that fits within the inner cylinder of the secondary vessel.

The ability to monitor the integrity of the secondary vessel is being provided on all future tanks starting with the four tanks under construction in F Area, Tanks 25-28 (Table 11-9). This system consists of a radial grid of slots in the concrete base pad of the waste tank. The apex of this grid is drained through a 4-in. pipe to a sump. The sump is equipped with a transfer jet and level measuring instrumentation. Two supply pipes, one to the center of the grid work and the other to the outer periphery of the tank grid, provide the capability to add water for testing the integrity as needed. A different system of monitoring for leakage is being provided for two of the three tanks being constructed in H Area. This system consists of pipes through which radiation measuring instrument probes can be inserted to measure the radiation beside and below the concrete tank vault should leakage occur. This system will be able to detect as little as 125 gallons of waste leakage, if the leak source is near one of the monitoring pipes, or a minimum of 1,000 gallons, if the leak source is midway between the monitoring pipes. This system was not installed on one of the three waste tanks being constructed in H Area because the tank construction was too far advanced when the system was designed.

Because of the high water table, the tanks in H Area are elevated above natural grade and surrounded with mounded earth. A lower water table in F Area permitted installation of Tanks 33 and 34 with their tops flush with natural grade. Because the tanks are above predicted water tables, only standard waterproofing was applied to the concrete enclosure.* The 48-inch concrete covers for these tanks reduce the radiation field above any of them with high-heat waste in the tank to less than the amount permissible for continuous occupancy by operating personnel; hence, no earth overburden is required.

The liquid waste and sludge is cooled by means of replaceable cooling coil bundles that are suspended in the tank through the concrete roof. Figure II-24 shows such a coil bundle. A maximum of 10 cooling units can be suspended in each tank through risers. Each cooling unit has a heat removal capacity of 600,000 Btu/hr.

* Highest measured water table is at least 3 ft below the tank bottoms (Table II-10).

Only one of the three waste tanks currently under construction in H Area will have this type of cooling bundle, which is designed for liquid wastes. The other two tanks and future Type III tanks, including those now being built in F Area, will have permanently installed cooling coils similar* to those in Type I and II tanks. In "as received" waste service (liquid plus approx 8% sludge), total heat removal capability, 6,000,000 Btu/hr, is the same for either cooling coil design. Widely distributed cooling surfaces are necessary in tanks to be used for forming and storing crystallized salt.

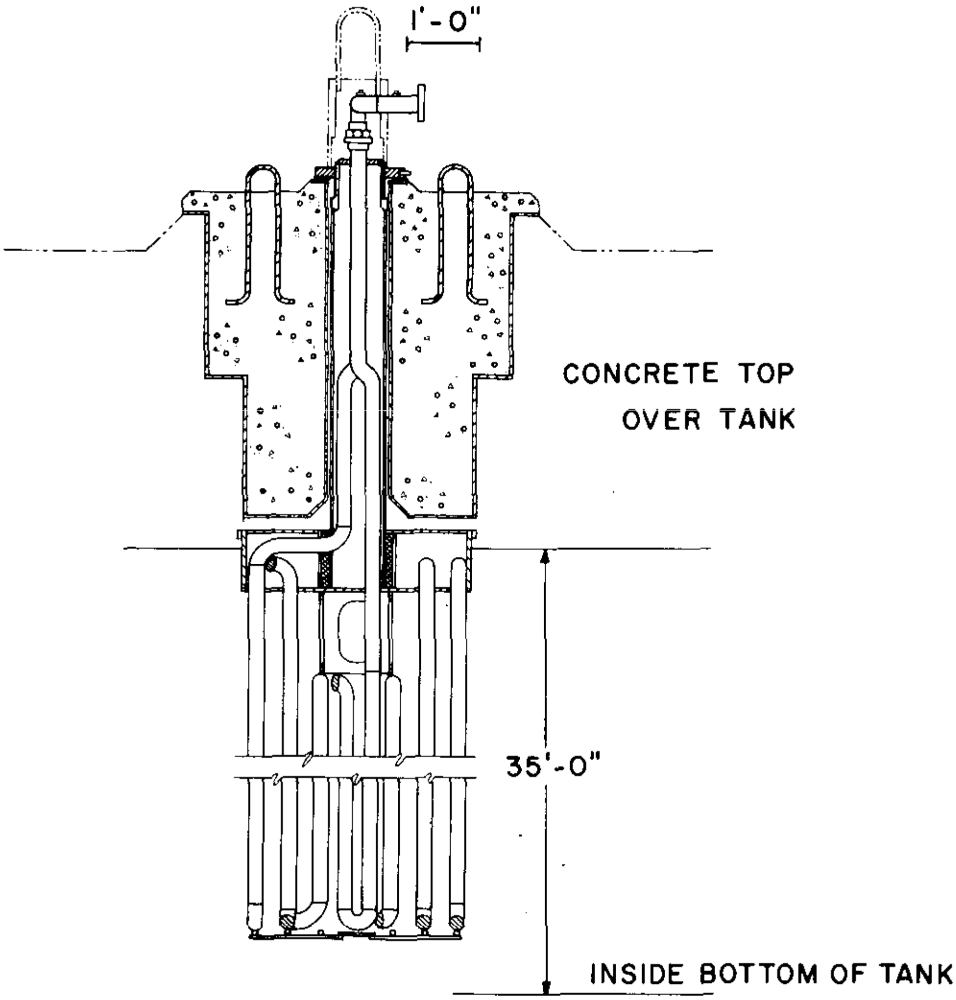

FIGURE II-24. Removable Cooling Coil, Type III Tanks

A demister, a condenser, a HEPA filter, and an exhaust blower are installed in series on the tank vent. A radiation monitor and air sampler will be provided on future tanks.

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*Vertical coils for new Type III tanks will be bottom-supported and on three-ft triangular centers, without installed spares. No horizontal coils will be installed.

All butt welds on the primary tanks, except welds on the horizontal roof surface, and all butt welds on the secondary tanks joining bottom plates, knuckle plates, and the lowest courses of center-column and outer-wall plates, were radiographically inspected. Defects were corrected, then they were rechecked radiographically. Beginning with the tanks currently under construction, all plate welds in the secondary tanks will be radiographically inspected. [*K.6*] The Quality Assurance Program includes inspection of all radiographs by two independent groups of certified weld inspectors and all radiographs are permanently stored for future reference. All spots on the inside or outside of the primary tanks, or the inside of the secondary tanks, where clips or lugs were removed, or where other excisions were made, were examined by magnetic particle or liquid penetrant techniques, and any defects were repaired. All butt welds on the secondary tanks were vacuum leak-tested. All welds in the bottom assemblies of the primary tanks, including knuckle rings and lowest course welds, were vacuum leak-tested before each bottom assembly was lowered into final position, and then tested a second time after the stress-relieving operation. A full hydrostatic test, consisting of filling each primary tank to a depth of 32 ft and allowing it to stand 48 hours, was conducted after stress relieving. No leaks were found by the hydrostatic tests. All circumferential welds in the pipe loops of the removable coil bundles (Figure II-24) below the 1/2-inch-thick plate at the base of the riser plug were radiographed. The assembled cooler piping was tested hydrostatically to 500 psi and halide leak-tested at 30 psi. Welds in the distributed cooling coils to be installed in future Type III tanks will be radiographed and similarly tested for leak tightness.

The primary tank was stress-relieved in place after all burning, cutting, welding, and other high temperature work (other than roof attachments) had been completed. Full stress relief, at 1100°F, was accomplished in accordance with the general requirements of the ASME Boiler and Pressure Vessel code.[12]

Instrumentation. The top openings into the Type III tanks and annular spaces are much like those in Type I and II tanks. They are closed with stepped concrete plugs (lead plugs in a few cases) and the openings are used for instrumentation, cooling units, or for ventilation system connections. The principal instrumentation provided for each tank consists of:

- *Liquid Level.* Liquid level in the primary tank is measured by two different systems: one uses a conductivity probe on the end of a gear-driven perforated metal tape which is automatically lowered and raised cyclically to sense the liquid level; the other uses built-in dip tubes (three pneumatic bubbler tubes terminated at various elevations above the tank bottom) and a portable manometer and air supply. Stationary conductivity probes and dip tubes are installed in each annulus to detect the presence of any liquid in the secondary pan.

For each tank, four stationary conductivity probes are provided, one in each quadrant, for determining whether liquid is present in the annulus. Three of the probes are single-point devices and the fourth is a multipoint probe that can obtain an approximate determination of the liquid level in the annulus as well as the indication of leakage. Evidence of leakage into an annulus, as well as high liquid level in any of these waste tanks, is signaled to the tank farm control house. In future waste tanks, a high-liquid probe and alarm will also be provided.

- *Temperature*. A stainless steel thermowell is installed in each of four tank-top plugs, spaced 90° apart, on each Type III waste tank. Three thermocouples are installed in each thermowell, one at one inch from the tank bottom and the other two at higher elevations. Temperatures are recorded in the control house, and the recorders are equipped with high-temperature alarms. The tank vent temperature is also recorded.

- *Pressure and Flow*. The water supply line to the cooling units for each tank is equipped with a pressure gage, and connections for a portable flowmeter are provided. Each cooler is equipped with a pressure relief valve on the inlet piping and a pressure gage on the outlet. In the tank vapor space ventilation system, tank static pressure, pressure downstream of the filters, and differential pressure across the demister can be measured for each tank. Differential pressure switches are installed to signal vent exhauster failures and plugged filters.

Ventilation. The ventilation systems for Type III primary tanks are negative pressure systems designed for purging the interior volume at a rate in excess of 100 ft^3/min. In a typical installation, air enters through a dust filter and is conducted by a 4-inch pipe through the roof into the waste storage space. Air leaves the storage space by way of a 12-inch riser pipe positioned across the tank from the inlet. The exhaust air first passes through a demister in the riser, which intercepts droplets and returns them to the tank. Then the air passes through a condenser to extract potentially radioactive moisture and a HEPA filter to free it from solid particles and is finally discharged to the atmosphere through an exhaust blower. Hydrogen monitors will be installed in the ventilation system exhaust in the newest tanks.

The ventilation and dehumidification systems for Type III annuli differ from those installed at Types I and II tanks in that, in addition to the warmed air flow directly into the outer annulus, approximately 1000 ft^3/min of air is drawn through the inner annulus, passes beneath the primary tank through the radial grooves in the concrete base slab, and exhausts into the outer annulus. All future Type III tanks, beginning with those currently under construction, will have an annulus ventilation system with a capacity of about 8000 ft^3/min, up to about half of which can be passed through the inner annulus and beneath the primary tank. The increased flow is to aid in cooling the tank bottom. All of the Type III annuli are ventilated under negative pressure by means of exhausters (Type I and II annuli operate under positive pressure).

Description of Evaporators for Concentrating Waste

Radioactive waste as received and stored in the separations areas tank farms can be reduced to a third or less of its original volume and immobilized as crystallized salt, by successive evaporations of the liquid supernate. Such a dewatering operation has been carried on routinely in F Area since 1960 and in H Area since 1963. The evaporators used for this operation are single-stage "bent-tube" units fabricated of stainless steel. Evaporator enclosure shielding permits the concentration of wastes containing up to 26 Ci of ^{137}Cs per liter (~100 Ci/gal). One evaporator is located in each area.

In principle, waste concentration is a straightforward dewatering operation as illustrated in Figure II-25. Original design provided for processing continuously 9 gal/min of waste containing 35% dissolved solids to produce a concentrate with 70% dissolved solids. Cooling the hot concentrate in the receiving tanks causes part of the dissolved solids to crystallize out as a salt cake, after which the supernatant liquid is recycled to the evaporator for further water removal. A cesium removal column (CRC), a vessel packed with ion exchange zeolite, is used to reduce the ^{137}Cs content of the overhead condensate before disposal to seepage basins; alternate capability is currently being provided to permit condensate recycle to the canyons for use as process water. The zeolite column is installed in a riser on one of the uncooled tanks, and spent zeolite is disposed of by dumping into the storage tank.

Leak Detection and Waste Inventory Practices

Training and Procedural Control

Primary training of operating supervision and of operators at the Savannah River Plant is carried out on the job. The supervisors and operators learn the process and their duties while performing assignments under the direct surveillance of experienced supervision. Routine on-the-job training is supplemented by periodic meetings between operating and technical personnel at which technical aspects of the processes are discussed. Operations are performed by following detailed written procedures approved in advance by operating and technical