11.0 RADIOACTIVE WASTES AND RADIATION PROTECTION

11.1 WASTE DISPOSAL SYSTEM

11.1.1 DESIGN BASES

The Waste Disposal System collects, monitors and processes for safe disposal all liquid, solid and gaseous wastes. The system is designed to process fluid wastes for reuse or for discharge to the environment within the radiation tolerances established by applicable governmental regulations. Suitable facilities are provided for handling and on-site storage of solid wastes prior to disposal. The system is controlled from a central panel in the auxiliary building. All system equipment is located in or near the auxiliary building, except for the reactor coolant drain tank and pumps, which are located in the reactor containment. Secondary containment is provided for radioactive waste piping and equipment by locating pipes and equipment inside of buildings. Any spill will be picked up and returned to tanks within the building. Monitoring instruments are provided to detect leakage within the secondary containment. All liquid and gaseous wastes which may be discharged to the environment will be sampled prior to discharge and monitored during discharge assuring that releases are within the limits of 10CFR20. At least two valves must be deliberately opened to permit discharge from the Waste Disposal System.

System design is based on one percent of the fuel rods releasing fission products by diffusion out of the pellets through defects in the cladding into the coolant. It is also assumed that these defects exist at the beginning of the initial core cycle and each following cycle. Design experience has shown that systems of this type will actually permit safe operation of the plant for fractional fuel clad defects higher than the design basis. On the other hand experience from operating nuclear plants of this type has shown that the expected amount of defective fuel rods is much less than one percent.

11.1.2 SYSTEMS DESIGN

Waste Disposal System Process Flow Diagrams are shown on Figures 11-1 through 11-4.

11.1.2.1 Solid Waste Processing

The rate of miscellaneous solid waste accumulation will vary widely. The maximum occurs during refueling periods and the minimum during normal operation. The average rate of collection assumed for system design is a few hundred pounds per week which is equivalent to one 55-gallon drum filled per week at the maximum density produced by the baler. Solid wastes such as sampling paper, cardboard, wood, paper, broken or contaminated glassware, filter cartridges, etc., will be collected in drums and stored in the drum storage area. The disposal equipment consists of a hydraulic baler and 55, 30, and 15-gallon drums. When a sufficient amount of wastes has been accumulated, the baler will compress the wastes into 55-gallon drums. These drums will be placed in the drum storage area prior to shipment.

Spent ion-exchanger resin will be stored in the spent resin storage tank until a sufficient quantity has accumulated for packaging with concrete. Normally, a minimum of six months will be allowed for decay. The total resin and cement shipping weight, limited to the amount which can be hauled by one truck, is equivalent to approximately 130 cubic feet of resin plus shielding. The spent resin storage tank contains additional space for a liquid level above the resin to prevent resin degradation due to heat generation by decaying fission products and for a gas blanket above the liquid.

11.1.2.2 Liquid Waste Processing

Liquid wastes generated during plant startup, normal operation, and shutdown will be collected by the Waste Disposal System from the following sources:

a) Reactor coolant letdown flow diverted from the Chemical and Volume Control System by a high level signal from the volume control tank.

b) Equipment drains and relief valve discharge.

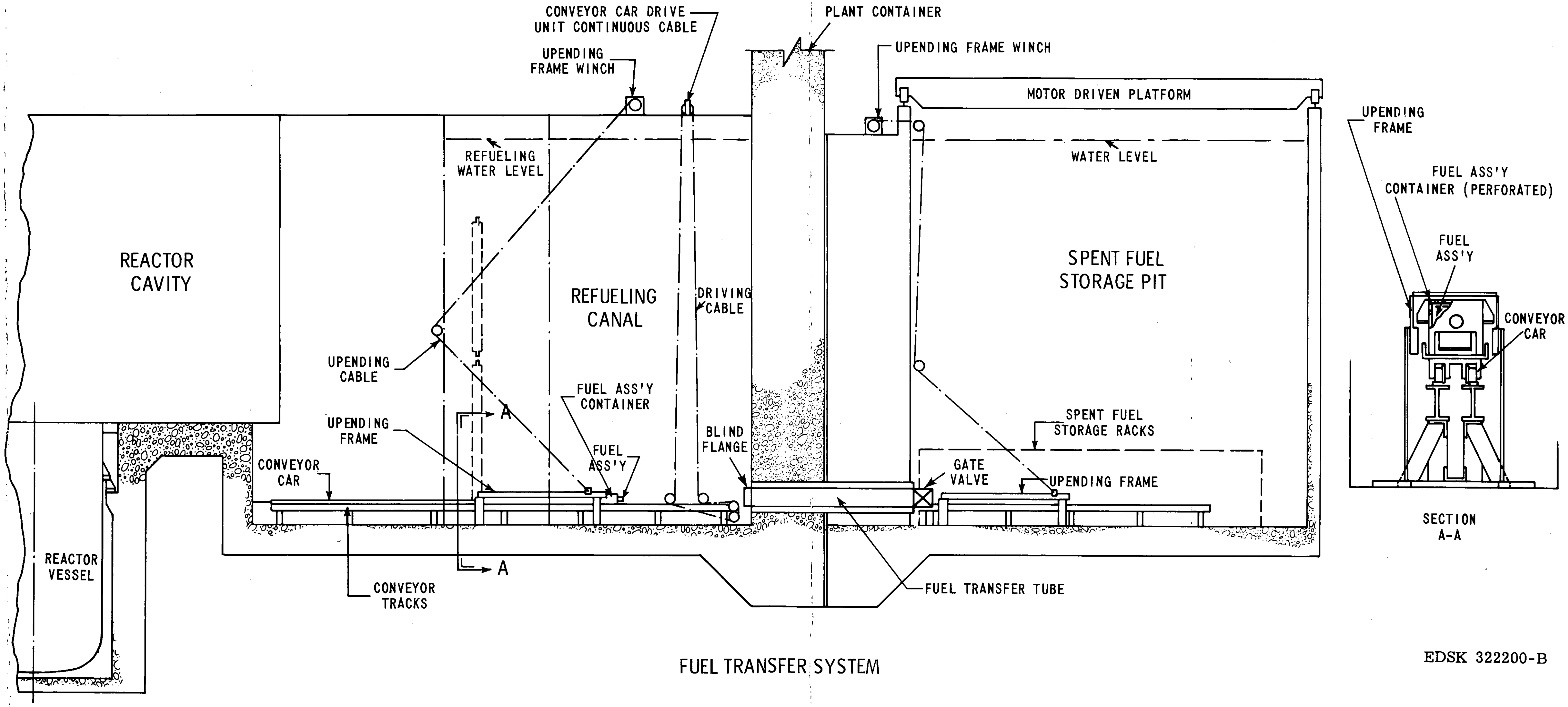
c) Resin bed regeneration and flushing operations.

d) Laboratory and sample drains.

e) Leak from pumps and valves.

f) Miscellaneous vent, low point and floor drains.

Primary plant drain lines are piped to the drain header. Fluid wastes from the drain header are collected in the sump tank. Gases accumulated in this tank discharge to a vent header for disposal by the gas processing equipment. Liquids are pumped to the spent regenerant chemical holdup tank which also collects wastes produced during resin bed regeneration. At this

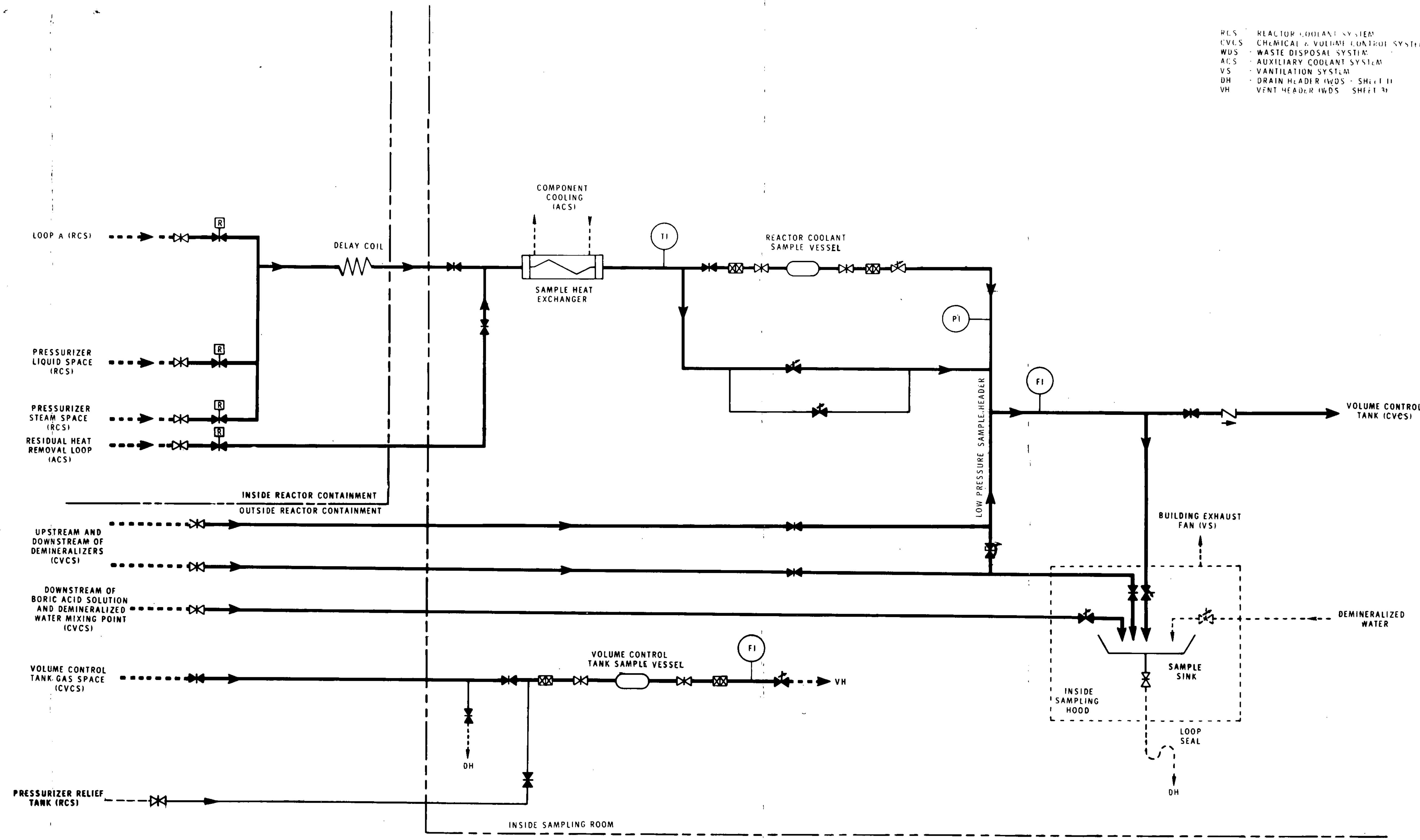


FUEL TRANSFER SYSTEM

EDSK 322200-B

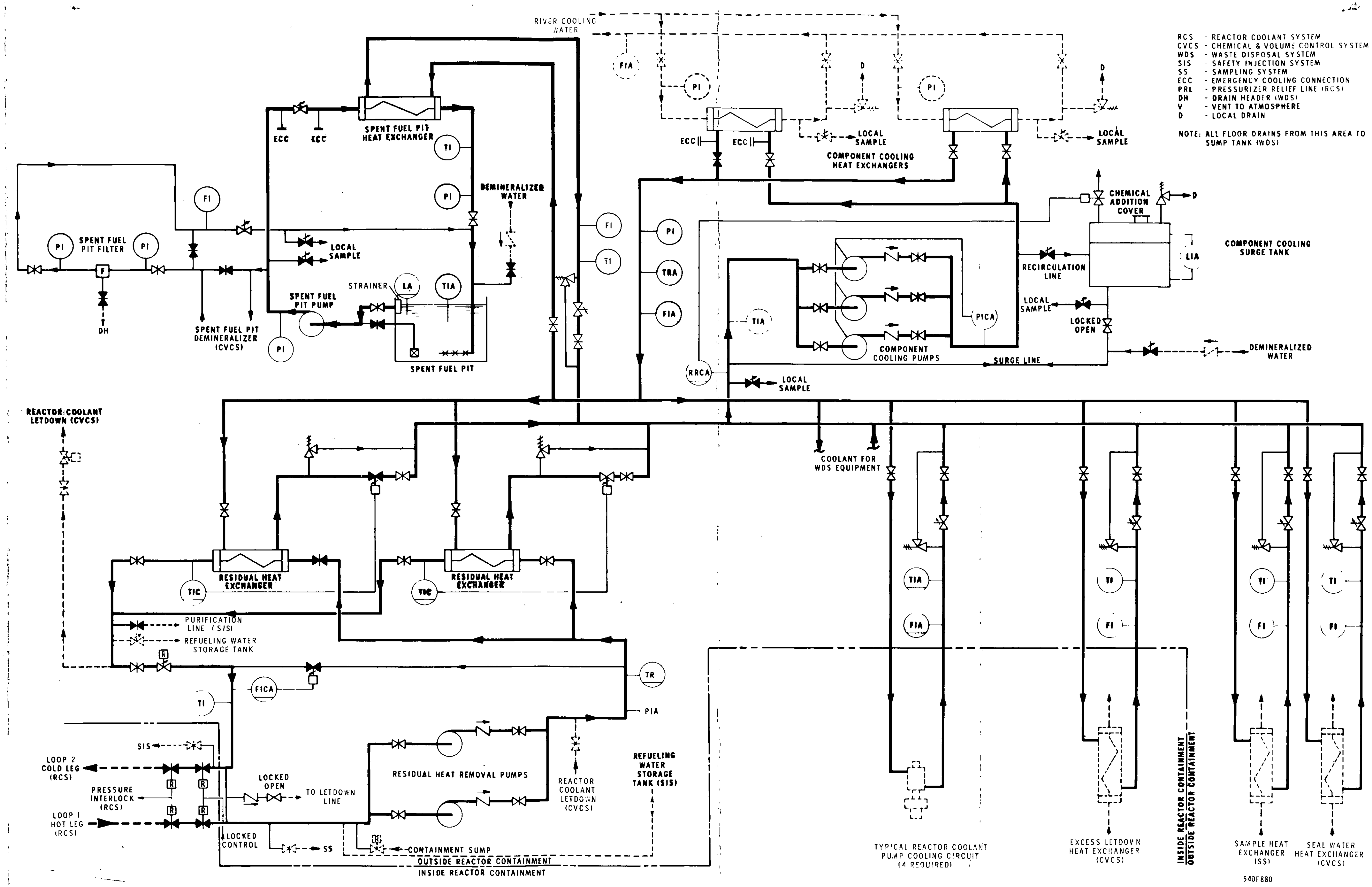
FUEL TRANSFER SYSTEM
FIG. 9-4

RCS - REACTOR COOLANT SYSTEM
CVCS - CHEMICAL & VOLUME CONTROL SYSTEM
WDS - WASTE DISPOSAL SYSTEM
ACS - AUXILIARY COOLANT SYSTEM
VS - VANTILATION SYSTEM
DH - DRAIN HEADER (WDS - SHEET 1)
VH - VENT HEADER (WDS - SHEET 3)

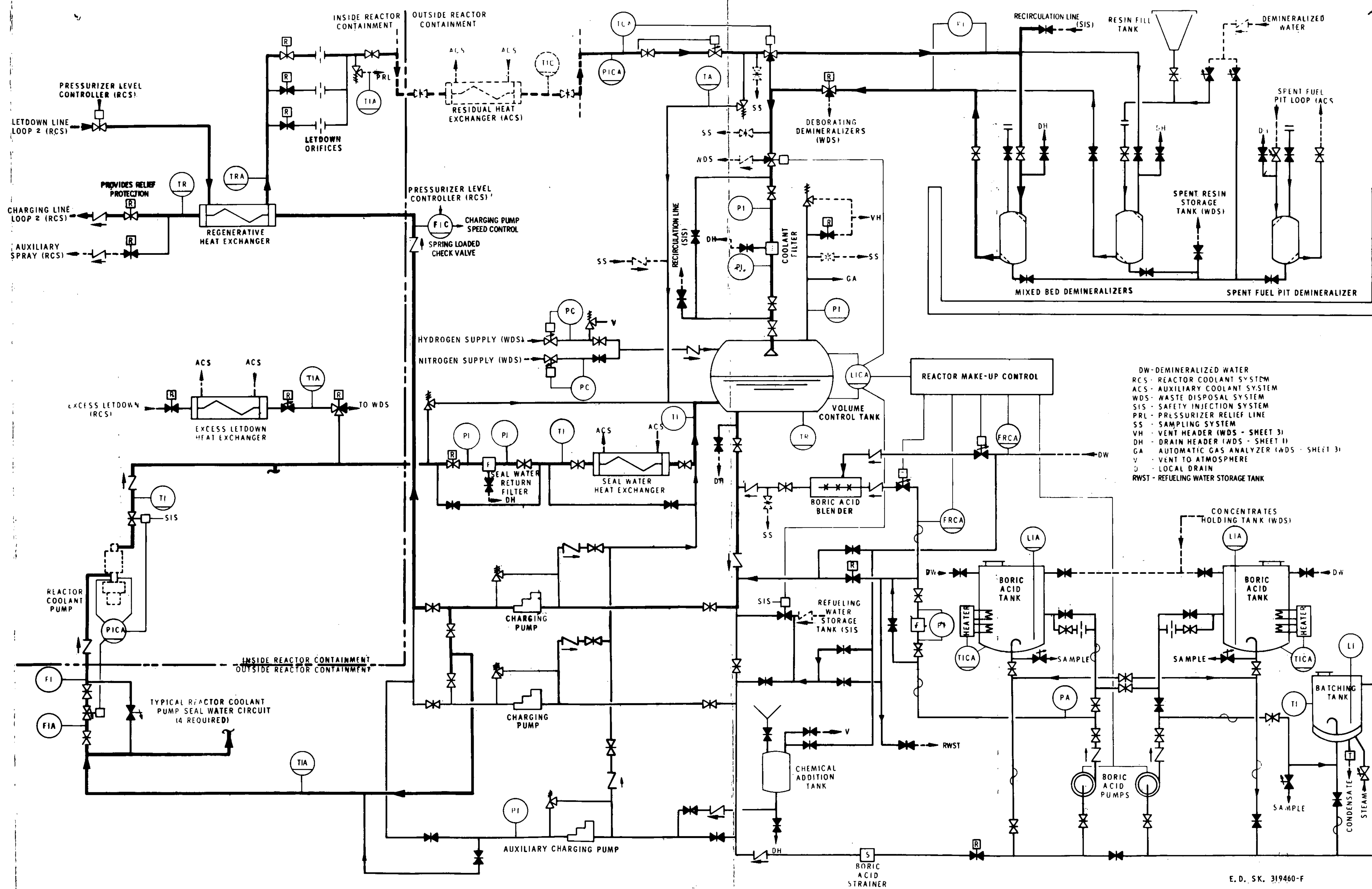


E D SK 319418-F

SAMPLING SYSTEM
FIG. 9-3



AUXILIARY COOLANT SYSTEM
FIG. 9-2



CHEMICAL AND VOLUME CONTROL SYSTEM
FIG. 9-1

point, the waste liquid is sampled and analyzed to determine appropriate subsequent handling operations. Wastes may be discharged from the tank to the waste holdup tanks if additional delay time is warranted for radioactive decay, to the gas stripper if the purity is low and radioactivity level is suitable for processing through the evaporator train, or to the condenser cooling water discharge if wastes can be released within the radiation tolerances established by 10CFR20.

Liquid wastes discharged from the spent regenerant chemicals holdup tank to the waste holdup tanks are collected with other liquid wastes which may be generated at radioactivity levels or in quantities warranting their handling in the waste holdup tanks. The gas space in the waste holdup tanks is filled with nitrogen at a low positive pressure to prevent accumulation of a potentially explosive mixture of hydrogen and oxygen. As liquid wastes enter the tanks, the cover gas is displaced to the waste gas tanks through the vent header. For convenience, a waste recirculation pump is provided to transfer wastes from one tank to another. When sample analysis indicates that wastes have been held a sufficient period of time for decay, wastes are pumped from the tanks, preheated, stripped of any remaining dissolved solid materials. If the liquid wastes do not require processing by the stripper-evaporator train, they may be discharged to the condenser cooling water by the waste recirculation pumps within radiation tolerances established by 10CFR20.

Vapor from the evaporator flows through a demister and a condenser to the surge tank where the condensate is cooled to the operating temperature of the evaporator condensate demineralizers. After any volatile evaporator carryover is removed by one of the two evaporator condensate demineralizers, condensate accumulates in the monitor tanks. Subsequent handling is dependent on the results of sample analysis. Discharge from the monitor tanks may be pumped to the demineralized water storage tank, recycled through the demineralizers, returned to the waste holdup tanks for reprocessing in the evaporator train, or released to the environment with the condenser cooling water within radiation levels established by 10CFR20.

If the sample analysis of the monitor tank contents indicates that they may be discharged safely to the environment, two valves must be opened to provide a discharge path. As the effluent leaves the Waste Disposal System, it will be continuously monitored and if an unexpected increase in radioactivity is sensed, one of the discharge valves will be closed automatically by a signal from the monitor.

Evaporator bottoms may be discharged to the evaporator concentrates processing train for filtration, removal of cations in demineralizers and then storage in the steam jacketed concentrates holding tank. Solution collected in the concentrates holding tank is sampled and then transferred to the boric acid tanks if analysis indicates that it meets specifications for use as boric acid makeup. Otherwise, concentrates are returned either to the concentrates processing train or to the waste holdup tanks for reprocessing by the evaporator train. The concentrated solution can also be drained from the evaporator to the drumming station where it is placed in 55-gallon drums and mixed with cement. These containers can then be stored at the plant site for ultimate shipment off site for disposal.

All liquid effluent releases will be monitored prior to release into and dilution with the condenser discharge. The condenser discharge flow rate will be approximately 840,000 gpm or about 3.19×10^9 cc per minute. As an example, the allowable release rate of iodine 131 (the isotope with the lowest permissible concentration in drinking water as defined in 10CRF20) would be about one μc per minute continuously, which would yield a total yearly discharge of about 500 millicuries. Experience with the design of similar systems has shown that the expected discharges will be less than about 0.03 MPC of 10CFR20 per year of all isotopes.

11.1.2.3 Gaseous Waste Processing

During plant operations, gaseous wastes will originate from:

a) Degassing reactor coolant discharged to the Waste Disposal System.

b) Degassing reactor coolant and purging the volume control tank prior to a cold or refueling shutdown.

c) Displacement of cover gases as liquid wastes accumulate in various tanks.

d) Miscellaneous equipment vents and relief valves.

e) Sampling operations and automatic gas analysis for hydrogen and oxygen in cover gases.

Most of the gaseous waste is nitrogen cover gas displaced by liquid waste accumulation. A small fraction (approximately 3%) is hydrogen removed from the reactor coolant.

One of two gas compressors is always in operation to maintain an operating pressure of 6 to 10 inches of water in components vented to the vent header.

The standby unit is available to handle peak waste gas conditions. The compressors discharge waste gases through a manifold to storage tanks where gases are held for a suitable decay period. When the tank reaches a predetermined pressure, it is isolated and a second tank is placed in service. When sample analysis indicates sufficient decay, the tank contents are released to the environment through the auxiliary building vent at a predetermined, controlled rate within radiation limits established by 10CFR20. Three tanks are provided for normal operation with one filling, one in decay and a third discharging. A fourth tank is provided to accommodate gaseous wastes resulting from unexpected plant operations such as cold or hot shutdowns.

To release effluent from the waste gas tanks to the environment, two valves must be opened deliberately. As the gases leave the Waste Disposal System, they are monitored continuously and if an unexpected increase in radioactivity is sensed, one of the discharge valves will be closed automatically on signal from the monitor.

The discharged gaseous effluent will be diluted in the atmosphere due to the turbulence in the wake of the containment building in addition to the effects of normal dispersion. Using the model for long term dispersion in the wake of a building as developed Section 12.2, and evaluating the yearly meteorological data from Volume I for various sectors, a worst sector average dispersion factor (χ/Q) of 1.2×10^{-5} sec/m^3 has been calculated at any point on the site boundary. Using the MPC values for air concentrations as outlined in 10CFR20, and assuming that this worst sector dispersion exists in all sectors during the year, the following yearly releases are obtained:

Xe^{135} : 4.7×10^6 curies

Kr^{85} : 1.42×10^7 curies

I^{131} : 4.7×10^3 curies

Experience in the design of such systems has shown that expected yearly releases will be less than 0.0005 MPC of 10CFR20.

11.1.3 WASTE DISPOSAL SYSTEM COMPONENTS

11.1.3.1 Chemical Drain Tank

The chemical drain tank is austenitic stainless steel and collects drainage from the hot section of the chemistry laboratory and decontamination area.

After analysis, the tank contents are pumped to the waste holdup tanks or to the condenser discharge.

11.1.3.2 Reactor Coolant Drain Tank

The reactor coolant drain tank is a right circular cylinder with spherically dished heads. The tank is all welded austenitic stainless steel and has a manhole mounted on the top portion of the tank. This tank serves as a drain collecting point for the Reactor Coolant System and other equipment located inside the reactor containment.

11.1.3.3 Waste Holdup Tanks

Three waste holdup tanks retain radioactive liquids. The contents of one tank are normally being processed by the gas stripper and evaporator while another tank is being filled. The third tank is normally kept empty to provide additional storage capacity if required. The tanks are stainless steel of welded construction.

11.1.3.4 Surge Tank

The surge tank collects and cools condensate from the evaporator condenser and serves as a collection tank for the discharge of various relief valves. A cooling coil is installed inside the tank to cool the contents to approximately 100°F. All welded austenitic stainless steel construction is used for this tank.

11.1.3.5 Monitor Tanks

Two tanks collect evaporator condensate and contents are periodically sampled and analyzed for radioactivity and purity. If the water is of sufficient purity and low in radioactivity, it may be transferred to the water makeup system for reuse by the primary plant or may be mixed with the condenser cooling water discharge. When purity is low and radioactivity is high, the water is returned to the waste holdup tanks or evaporator condensate demineralizers for reprocessing. These tanks are all welded carbon steel lined with a suitable protective coating.

11.1.3.6 Sump Tank and Pump

The sump tank serves as a collecting point for waste discharged to the drain header. It is located at the lowest point in the auxiliary building. All floor drains entering this tank contain loop seals to prevent gas from leaving the pressure vent system. A sump pump with externally mounted motor and submerged impeller is used to drain this tank. The rotating pump shaft is sealed at the top of the tank by circulation of the fluid pumped. The pump is sealed to the top of the tank by a flanged and gasketed fitting. All wetted parts of the pump are stainless steel. The tank is all welded austenitic stainless steel.

11.1.3.7 Spent Resin Storage Tank

The spent resin storage tank retains spent resin normally discharged from the mixed bed, spent fuel pit, base removal and cation demineralizers. The de-borating demineralizers and evaporator condensate demineralizers are regenerated and therefore will be discharged infrequently. Normally, the tank is filled over a long period of time, the contents are allowed to decay and then emptied prior to receiving any additional resin. However, the contents can be removed at any time, if sufficient shielding is provided for the spent resin shipping vessel. A layer of water is maintained over the resin surface to prevent resin degradation due to heat generation from decaying fission products. Excess water is removed by a steam operated eductor. Resin is removed from the tank by first back flushing with nitrogen to loosen the resin and then flushing the resin out with nitrogen entering the top of the tank. The tank is all welded austenitic stainless steel.

11.1.3.8 Spent Regenerant Chemical Holdup Tank

This tank collects liquid wastes produced during regeneration of the deborating demineralizers and evaporator condensate demineralizers, and discharge from the sump tank. Subsequent processing of the tank contents is determined by sample analysis. The tank is all welded carbon steel with a suitable protective coating.

11.1.3.9 Gas Decay Tanks

Four welded carbon steel tanks are provided to contain compressed waste gases (hydrogen, nitrogen, oxygen and fission gases). After a period for radioactive decay, these gases may be released at a controlled rate to the atmosphere through the auxiliary building exhaust vent. All discharges to the atmosphere will be monitored.

11.1.3.10 Compressors

Two compressors are provided for continuous removal of gases from all equipment that contains or can contain radioactive gases. These compressors are of the centrifugal displacement type, consisting of a round, multi-blade rotor revolving freely in an elliptical casing partially filled with water. The water provides a seal between the rotor blade tips and the casing and a heat sink for the heat of compression. A chevron type moisture separator and interconnecting piping are attached to the compressor. The compressors are cast iron. Water from the moisture separator is cooled and pumped back to the compressor. A small canned motor pump is used to avoid leakage of any fission gases contained in the recirculating seal water. The pumps, heat exchangers and piping are ferrous or non-ferrous materials as required. The operation of the compressors is automatically controlled by the gas manifold pressure.

11.1.3.11 Gas Stripper

A gas stripper removes dissolved gases from the waste water. The stripper consists of a hot well to store stripped water, a stripping section packed with pall (or similar) rings, a spray type liquid inlet header and an overhead integral reflux condenser. The stripper is of all welded austenitic stainless steel. Waste liquid flow to the gas stripper is automatically maintained at a constant rate by a flow controller. Waste liquid flows from the gas stripper to the evaporator by gravity.

11.1.3.12 Evaporator

An evaporator concentrates dissolved solids in the liquid wastes. It consists of two vessels. Boiling takes place in the evaporator body which is a vertical tube calandria with steam on the outside of the calandria tubes. The concentrating solution is collected below and in the lower portion of the calandria. A vapor dome above the calandria allows water droplets to return to the boiling liquid. Steam leaves the vapor dome tangentially and enters the demister tangentially. The demister contains a section packed with very fine stainless steel wool designed to remove aerosols from the steam. The aerosols coalesce into water droplets and are returned to the boiling liquid. Waste liquid flows to the evaporator by gravity. The flow of steam from the evaporator to the evaporator condenser is automatically controlled by a level controller which controls the supply of auxiliary steam to the evaporator. The length of an evaporator operating cycle is determined by the boiling point rise of the solution as the solids concentration increases. The entire evaporator is austenitic stainless steel of welded construction except for the calandria, which is flanged and gasketed to allow tube maintenance.

11.1.3.13 Deborating Demineralizers

Two anion demineralizers remove boric acid from the reactor coolant letdown flow through the Chemical and Volume Control System. They normally are used near the end of a core cycle, but they can be used at any time. Hydroxyl form ion-exchange resin is used. Facilities are provided for regeneration of the resin whenever necessary. When regeneration is unsuccessful, the resin is flushed to the spent resin storage tank. The demineralizer vessels are all welded austenitic stainless steel.

11.1.3.14 Evaporator Condensate Demineralizer

Two anion demineralizers using hydroxyl form resin remove boric acid and negatively charged fission products contained in the evaporator condensate. Facilities are provided for regeneration of the resin whenever necessary. When regeneration is unsuccessful, the resin is flushed to the spent resin storage tank. The demineralizer vessels are all welded austenitic stainless steel.

11.1.3.15 Baler

A hydraulically operated baler is used to compress solid wastes into drums. A 55-gallon drum is used when no shielding is required. If required, a 15 or 30 gallon drum is placed inside an empty 55-gallon drum and the annulus is filled with concrete or other shielding material. The baler is operated manually from a local station.

11.1.3.16 Nitrogen Manifold

Nitrogen, used to purge the vapor space of various components to reduce the hydrogen concentration or to replace fluid that has been removed, is supplied from a dual manifold. A pressure controller, which automatically switches from one manifold to the other, assures a continuous supply of gas. The manifold is all brazed brass.

11.1.3.17 Hydrogen Manifold

Hydrogen is supplied to the volume control tank to maintain the hydrogen partial pressure as hydrogen dissolves in the reactor coolant. The hydrogen is supplied from a dual manifold. A pressure controller, which automatically switches from one manifold to the other, assures a continuous supply of gas. The manifold is all brazed brass.

11.1.3.18 Gas Analyzer

An automatic gas analyzer is provided to detect the presence of a hazardous concentration of hydrogen in any of the equipment of the Waste Disposal System. Upon indication of a hazardous condition, provisions are made to purge the equipment to the gaseous waste system with an inert gas.

11.1.3.19 Pumps

Pumps used throughout the system for draining tanks and transferring liquids are as follows:

a) Two gas stripper feed pumps
b) Two surge tank drain pumps
c) Two monitor tank pumps
d) Two reactor coolant drain tank pumps
e) One sump pump
f) One sump tank pump
g) One chemical drain tank pump
h) One waste recirculation pump
i) Two compressor seal water pumps
j) Two holding tank transfer pumps
k) Two evaporator concentrate transfer pumps

The wetted surfaces of the compressor seal water pumps are cast iron, carbon steel, bronze, or similar materials. The wetted surfaces of all other pumps are stainless steel or other materials of equivalent corrosion resistance.

11.1.3.20 Heat Exchangers

The gas stripper preheater is a horizontal shell and tube exchanger with steam condensing on the shell side. The tube bundle is removable and the tubes are welded to the tube sheet. Liquid waste circulates through the tubes. The preheater tubes are austenitic stainless steel and the shell is carbon steel.

The evaporator overhead condenser is a vertical shell and tube exchanger with steam condensing on the shell side. The tube bundle is removable and the tubes are welded to the tube sheet. Component cooling water circulates through the tubes. The condenser is austenitic stainless steel.

11.1.3.21 Concentrates Holding Tank

The concentrates holding tank retains the evaporator concentrates for sampling and analysis. The concentrates are then pumped to the boric acid tanks of the Chemical and Volume Control System, to the waste holdup tanks, or are recycled to the concentrates filters.

The tank is stainless steel with a manhole mounted on the top and a steam jacket on the lower portion.

11.1.3.22 Base Removal Ion Exchangers

Two cation demineralizers installed in parallel remove the base ions from the evaporator concentrates to permit the subsequent removal of any cesium and molybdenum isotopes present. Hydrogen form ion exchange resin is used. Spent resin is flushed to the spent resin storage tank. The ion exchange vessels are welded austenitic stainless steel.

11.1.3.23 Cation Removal Ion Exchanger

Two cation demineralizers, installed in parallel, remove any cesium and molybdenum isotopes after the base has been removed. Hydrogen form ion exchange resin is used. Spent resin is flushed to the spent resin storage tank. The ion exchange vessels are all welded austenitic stainless steel.

11.1.3.24 Concentrate Filters

Two filters, installed in parallel, remove particulate matter from the evaporator concentrates. Each filter consists of multiple disposable filter cartridges constructed of viscose or similar material. The cartridges are removed manually, placed in plastic bags and a 55-gallon drum with the necessary shielding. The filter shell is drained prior to removing the cartridges. The filter shell is constructed of austenitic stainless steel.

11.1.3.25 Piping and Valves

Piping carrying liquid wastes is predominately stainless steel while all gas piping is carbon steel. Piping connections are welded except where flanged connections are necessary to facilitate equipment maintenance. No threaded fittings are used in waste piping.

11.1.3.26 Valves

All valves exposed to gases are carbon steel. The compressor seal water supply and cooling valves are carbon steel. All other valves are stainless steel. All valves have stem leakage control. Globe valves are installed with flow over the seats when such an arrangement reduces the possibility of leakage.

Stop valves are provided to isolate each piece of equipment for maintenance, to direct the flow of waste through the system, and to isolate storage tanks for radioactive decay.

Relief valves are provided for tanks containing radioactive wastes if the tanks might otherwise be overpressurized by improper operation or component malfunction. Tanks containing wastes which are normally of low radioactivity are vented locally.

11.2 RADIATION PROTECTION

11.2.1 SHIELDING

The radiation shielding is designed to provide biological protection from radiation sources in the nuclear plant for both the operating personnel and those living in surrounding areas. It is further designed to permit continued operation of the first unit in the unlikely event that the second unit experiences the postulated accident of Chapter 12. These radiation sources are located in the reactor vessel, the Reactor Coolant System, and certain auxiliary systems. The shielding for these sources is divided into four categories according to function: primary shield, secondary shield, fuel handling shield, and auxiliary shields. No shielding is required in the turbine electric plant. Figures 5-1 and 5-2 show the shielding arrangement inside the containment vessel.

11.2.1.1 Primary Shield

The primary shield is a reinforced concrete structure immediately surrounding the reactor vessel. It attenuates the nuclear radiation from the reactor to a level comparable to the gamma radiation emanating from the primary loop, prevents neutron activation of equipment near the reactor and reduces the dose rate from the core to a safe level so that maintenance may be performed on primary loop components after shutdown.

The lower portion of the primary shield is 7 feet thick and is an integral part of the main structural concrete support for the reactor vessel. It extends upward to join the concrete refueling cavity over the reactor. The refueling cavity, which is approximately octagonal in shape, extends upward to the operating floor with vertical walls 4 ft. thick, except in the area adjacent to fuel handling, where the thickness is increased to 6 ft.

11.2.1.2 Secondary Shield

The secondary shield surrounds the reactor and Reactor Coolant System and reduces the radiation levels emanating from the primary plant to tolerable levels. The minimum required secondary shield surrounding the Reactor Coolant System in a radial direction is 5-1/2 feet of concrete and includes the shielding afforded by the polar crane support wall and the reactor containment. The minimum required shield over the Reactor Coolant System is 2-1/2 feet of concrete and is provided by the reactor containment hemispherical dome.

The reactor containment, which also serves as a part of the secondary shield, insures that even for the hypothetical condition of a complete core meltdown the average dose rate at the site boundary (due to the contained sources) will be much less than 2 mr/hr. This average is taken over the first week (168 hrs.) following a hypothetical accident.

The minimum required reactor containment concrete shielding to insure continued operation of Unit No. 1 in the unlikely event of a hypothetical accident in Unit No. 2 is a 3-1/2 foot thick wall and a 2-1/2 foot thick hemispherical dome. However, for structural reasons the proposed container concrete consists of a 5-1/2 foot thick wall extending to a height of 30 feet above the container base pad. The wall thickness then decreases uniformly to a minimum of 4-1/2 feet at the hemispherical dome.

The integrated whole body dose outside the proposed container for various exposures times are shown in Figure 11-5. The doses shown in Figure 11-5 are the integrated whole body doses due to the contained radioactive sources in the reactor containment.

11.2.1.3 Fuel Handling Shield

The fuel handling shield facilitates the removal and transfer of spent fuel assemblies and control rods from the reactor vessel to the spent fuel transfer pit. It is designed to attenuate radiation from spent fuel, control rods, and reactor vessel internals to tolerable radiation levels.

The reactor cavity, which is formed by the upper portion of the primary shield, is flooded during refueling operations to provide a temporary water shield above the components being withdrawn from the reactor vessel. The water height during refueling is approximately 24-1/2 feet above the reactor vessel flange. This height assures that the minimum of 10 feet of water will be above a withdrawn fuel assembly. The refueling canal is a 3 foot wide passageway connected to the reactor cavity and extending to the inside surface of the plant container. The canal is formed by two concrete walls each 6 feet thick, which extend upward to the same height as the reactor cavity. During refueling, the canal is flooded with borated water to the same height as the reactor cavity.

The spent fuel assemblies and control rods are remotely removed from the containment vessel through the horizontal spent fuel transfer tube and placed in the spent fuel storage pit. Concrete shields the spent fuel transfer tube. This shielding is designed to protect personnel from radiation during the time a spent fuel assembly is passing through the main concrete support, the containment vessel and the spent fuel tube.

The concrete walls of the reactor cavity and the spent fuel canal are designed to shield personnel from radiation emanating radially from the spent fuel assemblies and control rods during refueling. The sections of the walls are 4 feet and 6 feet thick. Water in the spent fuel transfer pit protects personnel who are above the fuel assemblies and control rods during handling operations. The water depth above the transfer pit assures that sufficient water will always be above the fuel assemblies and control rods during storage and handling.

11.2.1.4 Auxiliary Shielding

Auxiliary shielding is designed to protect personnel working in the vicinity of Auxiliary Systems. These systems include Chemical and Volume Control System, Residual Heat Removal Loop, Waste Disposal System and the Sampling System.

Auxiliary equipment which is located in the primary auxiliary building is shielded to protect operating and maintenance personnel. The concrete walls and floors in these buildings vary in thickness, depending upon the radiation emanating from the equipment and piping. In some cases, removable concrete block walls are provided to allow personnel access to equipment during maintenance periods.

The radiation levels outside shielded areas within the building and levels outside the building will not exceed 0.75 mr per hr. In summary, the shielding provided for auxiliary equipment is as follows:

Equipment	Shielding Provided Ft-In
Demineralizers	4-0
Charging Pumps	2-6
Volume Control Tanks	3-6
Liquid Waste Storage Tanks	2-6
Gaseous Waste Storage Tanks	3-6

Dose rates for specified radiation shielding are given in Table 11-1, showing the dose rates at various locations, including Indian Point Unit No. 1.

TABLE 11-1
DOSE RATES FOR RADIATION SHIELDING

Equipment	Design Power Operation Mr/hr
Outer surface of containment vessel No. 1 which faces containment vessel No. 2	Less than 0.75
Opposite surface of containment vessel No. 1	Negligible
Outer surface of containment vessel No. 2	0.75
Operating floor level inside containment vessel No. 1 due to radiation from from Unit No. 2	Negligible
Property boundary 520 meters from center line of containment vessel No. 2	Negligible
Outside of control room	Negligible
Inside of control room, Unit #1 or Unit #2	Negligible
Surface of the refueling water during refueling	2
Working stations and intermittently manned ground level areas. (Waste disposal handling equipment and valve operating stations)	Less than 0.75

11.2.2 RADIATION MONITORING SYSTEM

The Radiation Monitoring System detects, computes, indicates, annunciates, and records the radiation level at selected locations inside and outside the reactor plant and is divided into the following subsystems:

a) The Operational Radiation Monitoring System consists of channels which primarily give early warning of a plant malfunction and secondarily warn personnel of increasing radiation which might result in a radiation health hazard.

b) The Area Radiation Monitoring System consists of channels which primarily warn personnel of increasing radiation that might result in a radiation health hazard.

The Radiation Monitoring System continuously monitors plant effluents and various in-plant points selected to provide indication and warning in areas where radioactive sources exist and operating personnel are required to be present. Laboratory analysis equipment provides analytical information on the chemical and radiochemical contents from the many samples taken throughout and adjacent to the plant. Personnel monitors are provided to record integrated exposure for all site personnel. The above provides adequate information and warning for the continued safe operation of the plant.

11.2.2.1 Operational Radiation Monitoring System

This system consists of several channels with detectors located throughout the plant. The computing and readout equipment is located in cabinets in the control room.

a) Containment and Plant Gas Effluent - Air Particulate Monitors

These two identical channels take continuous air samples from the containment atmosphere and the plant gas effluent. The samples, drawn outside the containment and the plant effluent ductwork, are in closed, sealed systems and monitored by scintillation counterfilter paper detector assemblies. The filter papers collect all particulate matter greater than 1 micron in size, on their constantly moving surfaces, which are viewed by a crystal photomultiplier-scintillation combinations. The samples are returned to the containment and plant effluent ductwork, after passing through the gas monitors.

The detector outputs are amplified by preamplifiers and transmitted to the Radiation Monitoring System cabinets in the control room.

The activity is indicated on meters and recorded by a multipoint recorder. High-activity alarm indications are displayed on the control board annunciator in addition to the Radiation Monitoring cabinets. Local alarms provide operational status of supporting equipment such as the pumps, motors, and flow and pressure controllers.

b) Containment and Plant Gas Effluent-Radio Gas Monitors

These two identical channels take the continuous air samples from the containment atmosphere, and the plant effluent after they pass through the air particulate monitors and draw the samples through closed, sealed systems to the gas monitor assemblies. Each sample is constantly mixed in the fixed, shielded volumes, where it is viewed by Geiger-Mueller tubes. The samples are then returned to the containment.

The detector outputs are transmitted to the Radiation Monitoring System cabinets in the control room. The activity is indicated by meters and recorded by a multipoint recorder. High-activity alarm indications are displayed on the control board annunciator and the Radiation Monitoring cabinets. Local alarms annunciate the supporting equipment's operational status.

c) Condenser Air Ejector Gas Monitor

This channel receives a continuous air sample from the air ejector exhaust header and monitors it for gaseous activity which is indicative of an unlikely primary to secondary system leak. The sample gas is returned to the plant gas effluent.

The detector output is transmitted to the Radiation Monitoring System cabinets in the control room. The activity is indicated by a meter and recorder by a multipoint recorder. High-activity alarm indications are displayed on the control board annunciator and the Radiation Monitoring cabinets. Local alarms annunciate the supporting equipment's operational status.

d) Steam Generator Liquid Sample Monitor

This channel monitors the liquid phase of the secondary side of the steam generator for activity, which would indicate a primary to secondary system leak, thereby providing backup information to that of the air ejector gas monitor. Samples from each of the four steam generator bottoms are mixed in a common header and the common sample is continuously monitored by a scintillation counter and holdup tank assembly. Upon indication of a high-activity, each steam generator is individually sampled in order to determine which unit is leaking. This sampling sequence is achieved by manually selecting the desired unit to be monitored and allotting sufficient time for sample equilibrium to be established.

The detector output is amplified by a preamplifier and transmitted to the Radiation Monitoring System cabinets in the control room. The activity is indicated by a meter and recorded by a multipoint recorder.

High activity alarm indications are displayed on the control board annunciator, the Radiation Monitoring cabinets, and in the sampling room. The particular sample being monitored is indicated on the radiation monitoring cabinets.

e) Component Cooling Loop Liquid Monitor

This channel continuously monitors the component cooling loop of the Auxiliary Coolant System for activity indicative of a leak of reactor coolant from the Reactor Coolant System, Chemical and Volume Control System, Sampling System, and/or the residual heat removal loop of the Auxiliary Coolant System. A scintillation counter is inserted in an in-line well. The detector assembly output is amplified by a preamplifier and transmitted to the Radiation Monitoring System cabinets in the control room. The activity is indicated on a meter and recorded by a multipoint recorder. High-activity alarm indications are displayed on the control board annunciator and the Radiation Monitoring cabinets. The alarm signal also closes the valve in the component cooling surge tank vent line to prevent gaseous activity release.

f) Waste Disposal System Liquid Effluent Monitor

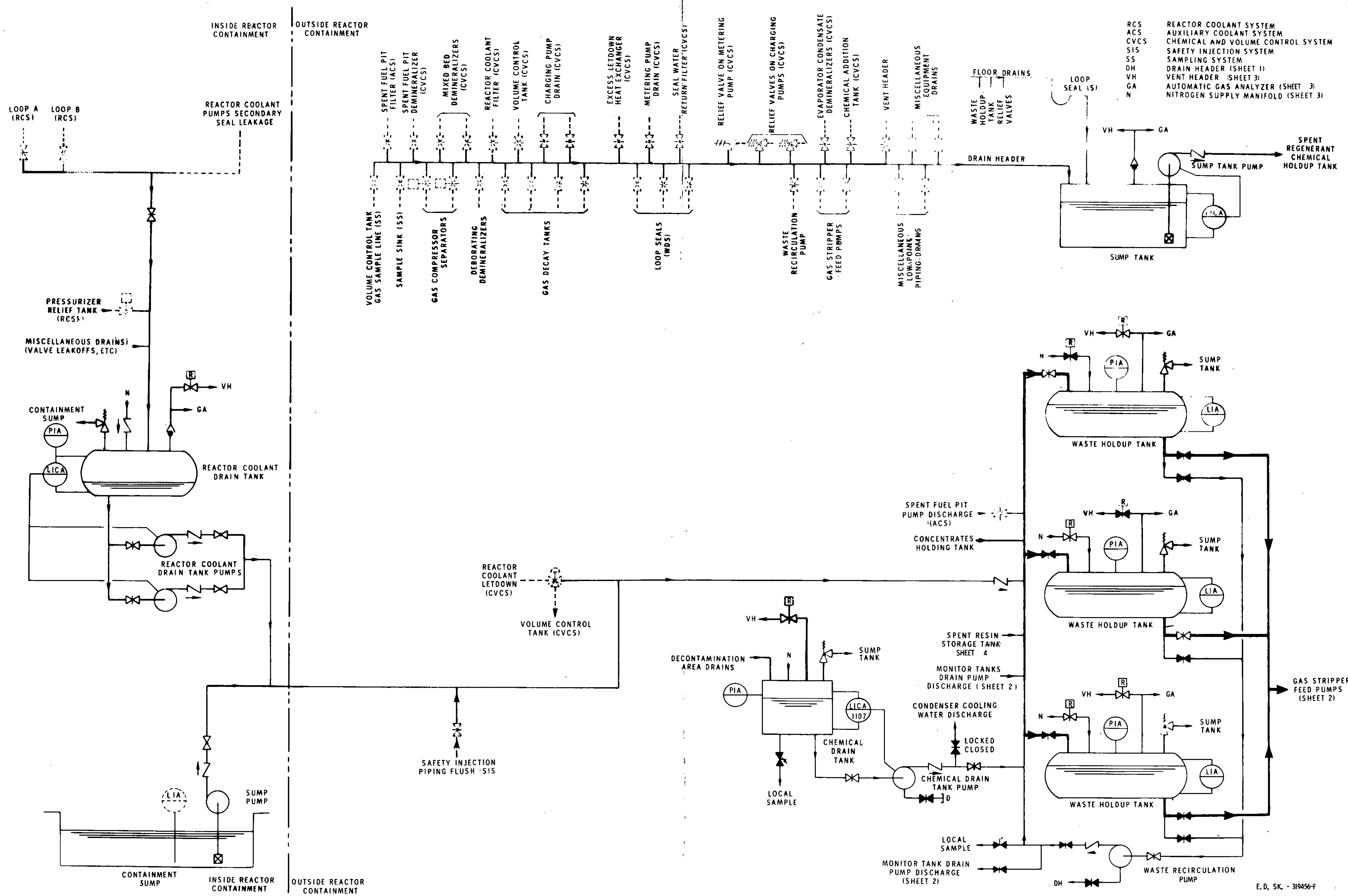
This channel continuously monitors all Waste Disposal System liquid releases from the plant. Automatic valve closure action is initiated by this monitor to prevent further release after a high-activity is indicated and alarmed. A scintillation counter monitors effluent from an in-line instrument well. The detector assembly output is amplified by a preamplifier and transmitted to the Radiation Monitoring System cabinets in the control room. The activity is indicated on a meter and recorded by a multipoint recorder. High-activity alarm indications are displayed on the control board annunciator and the Radiation Monitoring cabinets.

11.2.2.2 Area Radiation Monitoring System

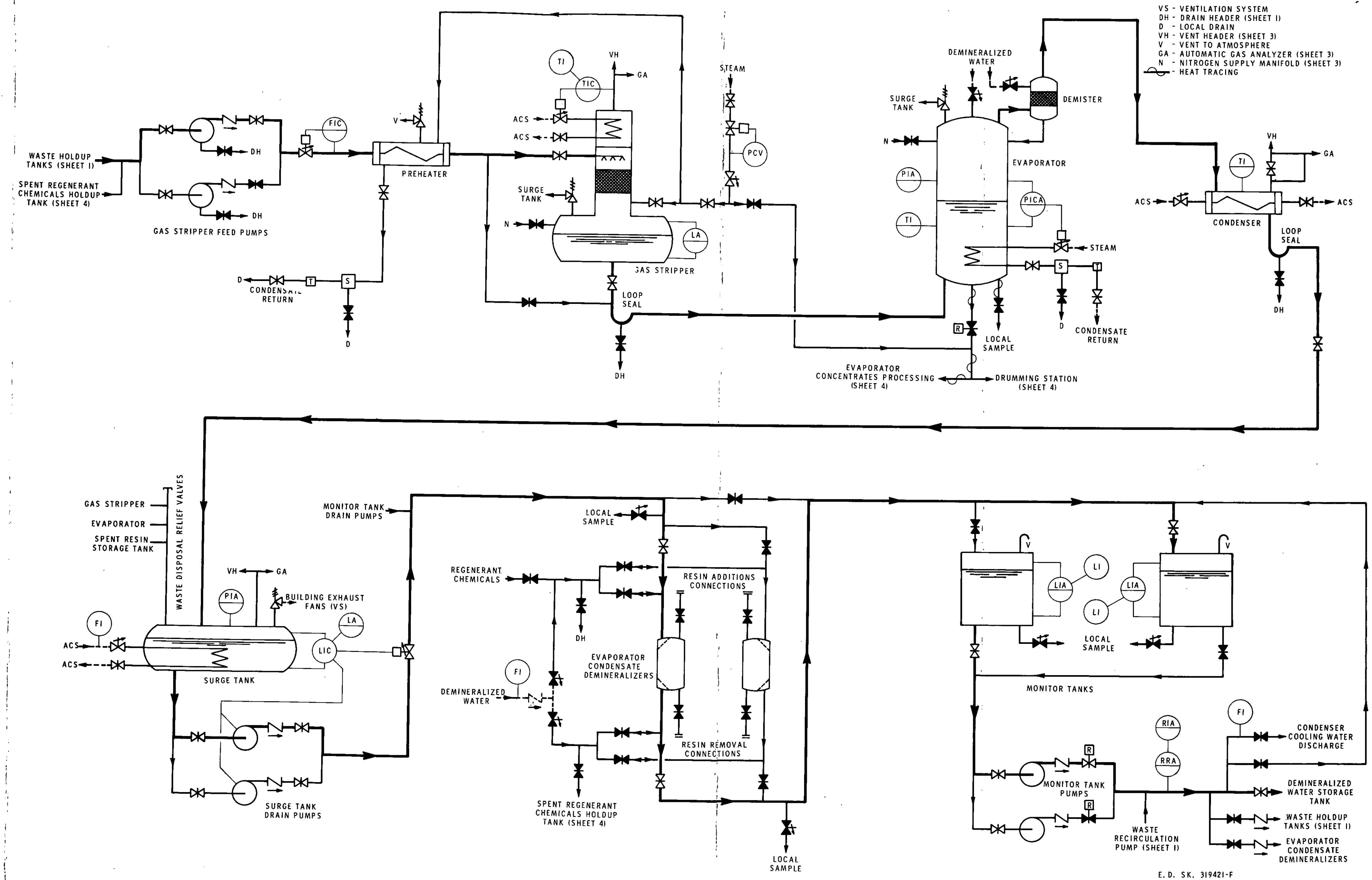
This system consists of several channels which primarily monitor and indicate radiation levels in various areas of the station.

Several channels continuously monitor areas such as the control room, containment, radiochemistry laboratory, and auxiliary building for gamma radiation with a fixed position G-M tube detector. The detector output is amplified and the log count-rate is determined by the integral amplifier at the detector. The radiation level is shown at the detector and is transmitted to the Radiation Monitoring System cabinets in the control room where it is indicated on a meter and recorded by a multipoint recorder.

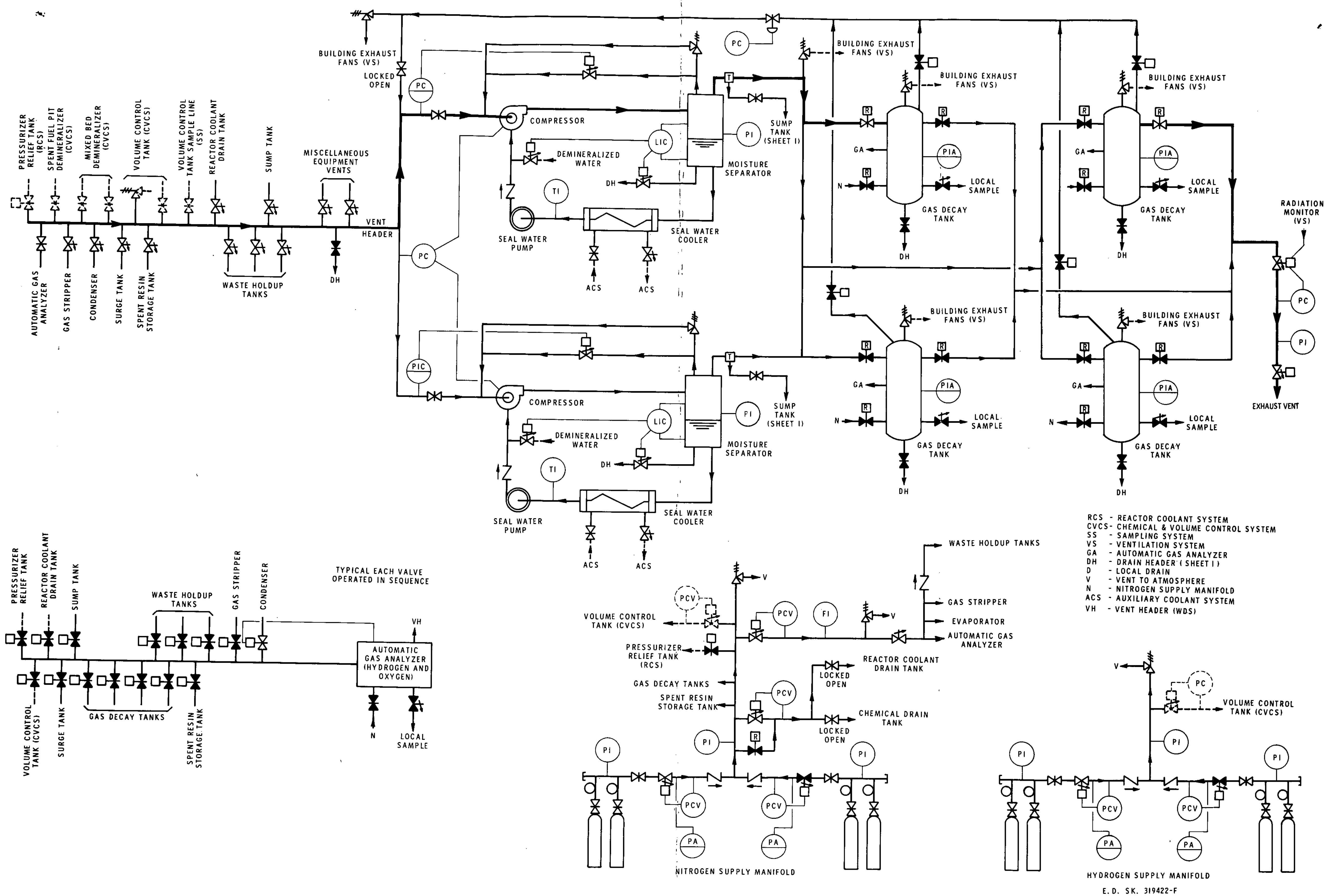
High-activity alarms are displayed on the control board annunciator and on the Radiation Monitoring cabinets.



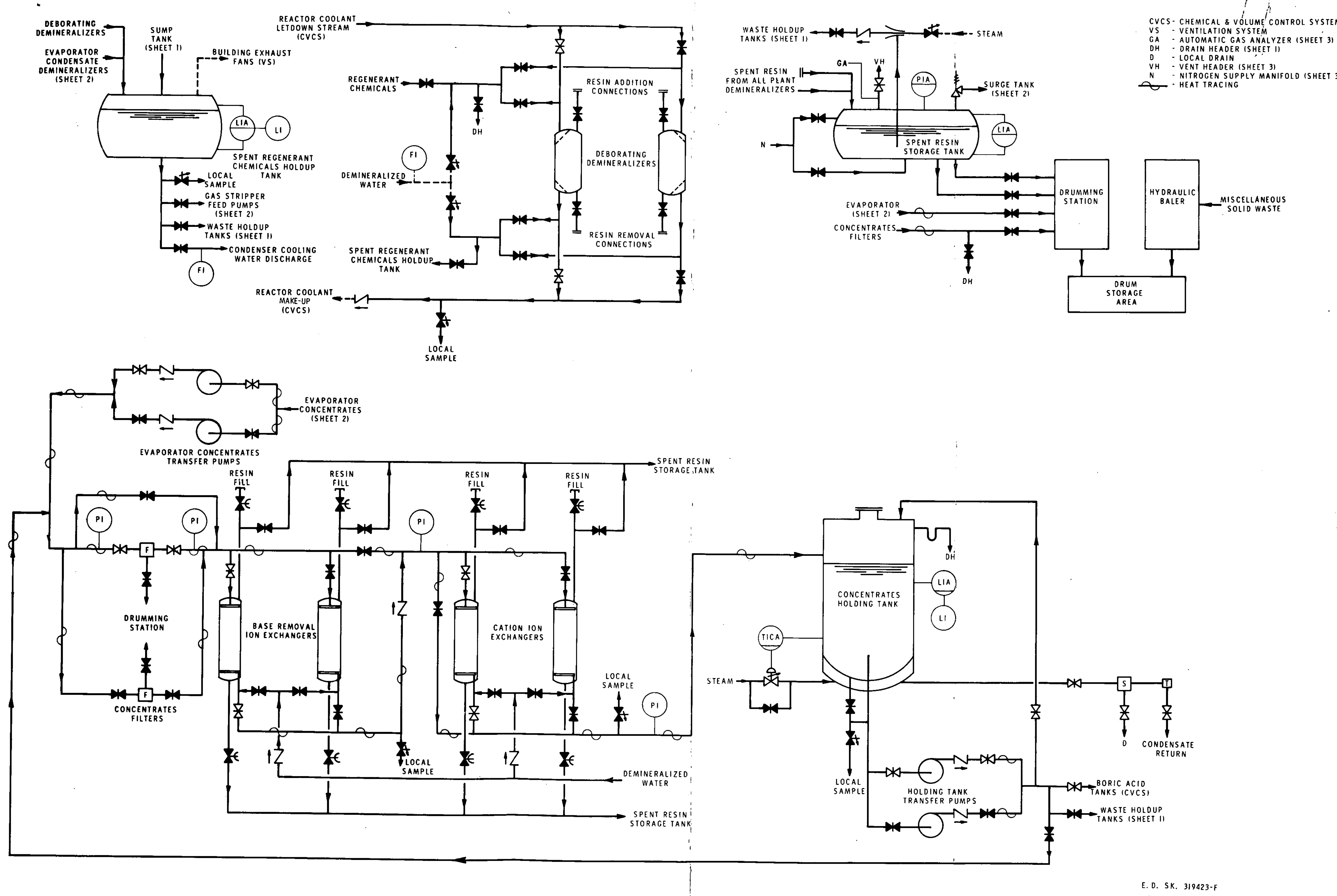
WASTE DISPOSAL SYSTEM, SHEET 1 OF 4
FIG. 11-1



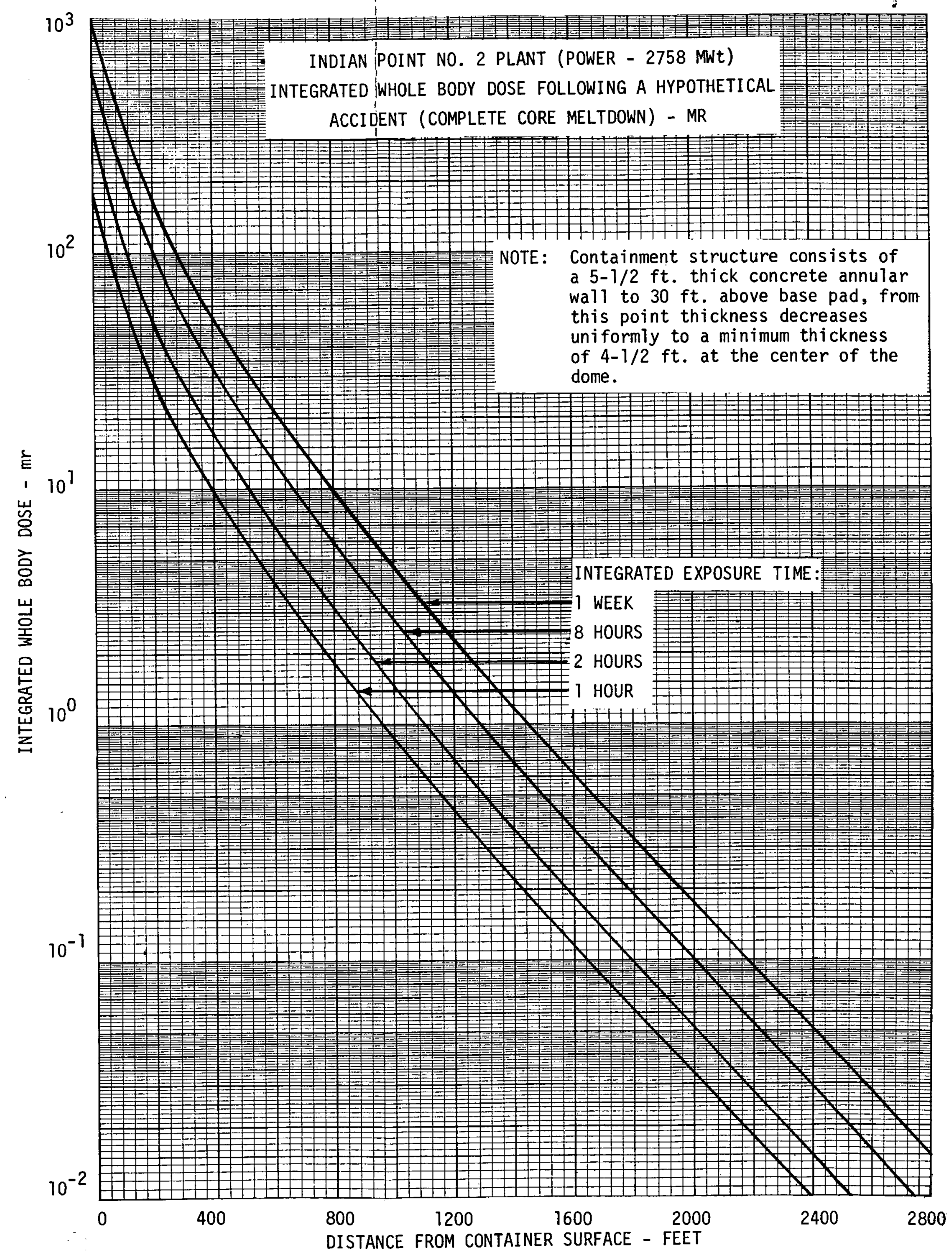
WASTE DISPOSAL SYSTEM, SHEET 2 of 4
FIG. 11-2



WASTE DISPOSAL SYSTEM, SHEET 3 of 4
FIG. 11-3



WASTE DISPOSAL SYSTEM, SHEET 4 of 4
FIG. 11-4



DIRECT RADIATION DOSAGE
FIG. 11-5