11.0 RADIOACTIVE WASTE MANAGEMENT

11.1 SOURCE TERMS

The sources of radioactive materials resulting in the generation of all liquid, gaseous, and solid radioactive wastes originate from: 1) leakage of fission products from the fuel rods into the reactor coolant, 2) activation of corrosion and wear products in the reactor coolant system, and 3) activated corrosion products that are sloughed from spent fuel shipped to the SHNPP from other CP&L stations.

Two models are used to predict the concentration of radionuclides in the reactor coolant. The first model, which is conservative and developed by the Nuclear Steam System supplier, establishes the design bases source term. This source term is used to: 1) develop shielding requirements, 2) demonstrate that the installed radioactive waste processing system can ensure compliance with 10 CFR 20 limits on off-site doses and radionuclide concentrations in station effluents, and 3) calculate the consequences of postulated accidents (Chapter 15). The second model, which was developed by the NRC (the GALE Code), predicts the "normal" or "expected" source term. This source term is used in demonstrating compliance with the design objectives defined in Appendix I to 10 CFR 50.

Since the SHNPP is receiving spent fuel from other CP&L stations, design basis and normal source terms have been developed for the spent fuel pool. These new spent fuel pool source terms are discussed in Subsection 11.1.7.

11.1.1 DESIGN BASIS FISSION PRODUCT ACTIVITIES

Maximum fission product activities have been used as design basis source terms for shielding, facilities design, and for calculating the consequences of postulated accidents. The isotopes chosen for consideration in the maximum case are those which are significant for design purposes by reason of a combination of energy, half-life, or abundance. Parameters used in the preparation of the design basis source term are presented in Table 11.1.1-1.

11.1.1.1 Reactor Coolant Activities

The mathematical model used to determine the maximum concentration of nuclides in the Reactor Coolant System (RCS) involves a group of linear, first order differential equations. These equations are obtained by applying a mass balance for production and removal of fission products from the fuel pellet region as well as the coolant region. In the fuel pellet region, the mass balance includes fission product production by direct fission yield, by parent fission product decay, and by neutron activation, while the removal includes decay, neutron activation, and escape to the coolant. In the coolant region, the analysis includes the fission product production by escape from the fuel through defective fuel rod cladding, parent decay in the coolant, and neutron activation of coolant fission products. Removal is by decay, coolant purification, and feed and bleed operations (for fuel burnup).

In these calculations, small cladding defects equivalent to one (1) percent of the fuel rods are assumed to be present at initial core loading and uniformly distributed throughout the core. Similar defects are assumed to be present in all reload regions.

The fission product activity in the reactor coolant during operation with defects in the fuel rod cladding is computed using the following differential equations:

For parent nuclide in the coolant,

$$\frac{dN_{c_i}}{dt} = \frac{R_i N_{F_i}}{M_c} - \left[\lambda_i + D_i + \frac{Q_L}{M_c}\left[\frac{\psi_i + DF_i - 1}{DF_i}\right]\right] N_{c_i} \quad (1)$$

for daughter nuclides in the coolant,

$$\frac{dN_{c_j}}{dt} = \frac{R_j N_{F_j}}{M_c} + f_j \lambda_j N_{c_j} - \left[\lambda_j + D_j + \frac{Q_L}{M_c}\left[\frac{\psi_j + DF_j - 1}{DF_j}\right]\right] N_{c_j} \quad (2)$$

where:

N_C = Concentration of nuclide in the reactor coolant (atoms/gram)

N_F = Population of nuclide in the fuel (atoms)

t = operating time (seconds)

R = Nuclide release coefficient (1/sec.) = Fv

F = Fraction of fuel rods with defective cladding

v = Nuclide escape rate coefficient (1/sec.)

M_C = Mass of reactor coolant (grams)

λ = Nuclide decay constant (1/sec.)

D = Dilution coefficient by feed and bleed

$$(1/sec.) = \frac{\beta}{B_o - \beta_t} \quad \frac{1}{DF} \quad (3)$$

B_o = Initial boron concentration (ppm)

B_t = Boron concentration at time t (ppm)

β = Boron concentration reduction rate (ppm/sec.)

DF = Nuclide demineralizer decontamination factor

Q_L = Purification or letdown mass flow rate (grams/sec.)

ψ = Nuclide volume control tank stripping fraction

f = Fraction of parent nuclide decay events that result in the formation of the daughter nuclide

Subscript i refers to the parent nuclide.
Subscript j refers to the daughter nuclide.

The above equations assume there is no activity reduction due to the pressurizer operation, and that the nuclide concentration in the volume control tank liquid may be approximated by

$$N_{VL} = \frac{(1-\psi)}{DF} N_c \qquad (4)$$

where:

N_{VL} = Concentration of nuclide in the volume control tank liquid (atoms/gram)

The parameters used in the calculation of the reactor coolant fission product concentrations, including pertinent information concerning the expected coolant cleanup flowrate, demineralizer effectiveness, and volume control tank noble gas stripping behavior, are presented in Table 11.1.1-1. The results of the calculations are presented in Table 11.1.1-2. The table lists nuclides of fission products which are significant from a shielding standpoint as well as those nuclides which are listed in NUREG-0017. The values tabulated are the maximums which occur during the fuel cycle from startup through the equilibrium cycle.

The specific activity for major nuclides in the pressurizer steam and liquid phases are given in Table 11.1.1-3. The pressurizer liquid specific activity is assumed to be the same as that of the reactor coolant. Table 11.1.1-3 lists the nuclides that are the major contributors to total source strength.

Pressurizer steam phase radiogas concentrations in Table 11.1.1-3 are based on the stripping of radiogases from the continuous 2-gpm pressurizer spray and the subsequent buildup of these radiogases in the steam space. The buildup time is assumed to be one effective full-power year. The radiogases are assumed to be completely stripped from the spray, except for krypton-85, where a stripping fraction of 0.9 is used.

Pressurizer steam phase iodine concentrations in Table 11.1.1-3 are obtained from the liquid phase nuclide activities and measured values of the partition coefficient for iodine-131. A partition coefficient of 100 was used and assumed to apply to all radioiodines.

The specific activity for major nuclides in the volume control tank liquid and vapor phases is given in Table 11.1.1-4.

The radiation sources in the volume control tank are based on a nominal operating level in the tank of 150 $ft.^3$ in the liquid phase and 150 $ft.^3$ in the vapor phase, and on the stripping fractions given in Table 11.1.1-1, assuming no volume control tank purge.

11.1.1.2 Maximum Fission Product Activities in the Secondary Coolant Activities

The radionuclide concentrations in the secondary coolant under design bases conditions are based on the assumptions presented in Table 11.1.1-1. The activities are presented in Table 11.1.1-5.

The time dependent equations used for calculating the activities in the steam generator liquid and steam are described here. The equilibrium activities of each nuclide in the secondary water (that is the same as the blow-down water activities) are calculated. This calculation is based on the following differential equation:

$$d/dt\,[M_S C_S + M_L C_B] = \text{nuclide input - nuclide removal}$$

The input is from primary leakage, $m_P C_P$, and the removal consists of the following terms:

(1) decay $-\lambda[M_S C_S + M_L C_B]$

(2) resin absorption $- m_B C_B (1 - 1/DFW)$

(3) steam side cleanup $- (m_S - m_f) [C_S(1-X) + XC_B] [1 - 1/DF_S]$

(4) bleeding from system $- m_f [C_S(1-X) + XC_B]$

where:

M_S	=	mass of secondary steam (g)
C_S	=	secondary steam specific activities (uCi/g)
M_L	=	mass of secondary water (g)
C_B	=	secondary water specific activities (uCi/g)
m_B	=	blowdown rate (g/sec)
DFW	=	resin decontamination factors
m_s	=	secondary steam flow rate (g/sec)
m_f	=	feed water make up rate (g/sec)
X	=	steam side water carryover
DF_S	=	steam decontamination factor
m_P	=	primary to secondary leak rate (g/sec)
C_P	=	primary water activities (uCi/g)
λ	=	decay constant (sec^{-1})

In solving this equation for the secondary water activities at equilibrium, two parameters are introduced. The first parameter assigns the resin decontamination factor to each nuclide. The resin decontamination factors (DFW) are as follows.

-Halogens and others	10.0
-Monovalent nuclides	2.0
-Tritium	1.0

The second parameter assigns the steam side cleanup or stipping rate S to each nuclide is, where $S = [1 - 1/DF_S]$. The stripping rates are as follows.

-Tritium	S = 0.0%	DF_S = 1.0
-Iodine and Halogens	S = 1.0%	DF_S = 1.01
-Noble Gases	S = 99.9%	DF_S = 1000

The specific activities of each nuclide in the secondary steam at equilibrium are then calculated, using the steam side water carryover rate and the nuclide partition factor. The partition factor, P, is simply the ratio between the secondary water specific activities and the secondary steam specific activities. The partition factors (and inverse partition factor, p) that is assigned to each nuclide are as follows.

-Iodine partition factor	P = 100	p = 0.01
-Noble gas partition factor	P = 1.0E-6	p = 1.0E+6
-Tritium partition factor	P = 1.0	p = 1.0
-Particulate partition factor	P = ∞	P = 0.0

The final specific activities for each nuclide in the secondary water and the secondary steam are calculated considering the decay chains using the previously calculated initial secondary water activities.

11.1.2 NORMAL OPERATION SOURCE TERMS INCLUDING ANTICIPATED OPERATIONAL OCCURRENCES

The model used to develop the expected fission product concentrations in the primary and secondary coolants under normal operating conditions including anticipated operational occurrences was that presented in ANSI/ANS-18.1 1984. These concentrations are provided in Table 11.1.2-1, and the assumptions used to calculate these activities are presented in Table 11.1.2-2.

11.1.3 CORROSION PRODUCTS

The corrosion product reactor coolant concentrations are presented in Tables 11.1.1-2 and 11.1.2-1. The design basis reactor coolant corrosion product activities are based on measurements at operating plants. The normal operational corrosion product reactor activities are from NUREG-0017. As shown in the tables, the design basis and normal operational activities are very similar, this is as expected since these activities are independent of fuel defect levels.

The reactor coolant chemistry changes from alkaline and reducing during power operation to acidic and oxidizing during cold shutdown. This chemistry change results in a significant release of corrosion product activity that has been historically referred to as a shutdown "crud burst" and is considered important to minimizing plant exposure rates, localized high radiation areas, and refueling water clarity problems. The magnitude of the crud burst may cause corrosion product activities to spike above the design basis reactor coolant values reported in Table 11.1.1-2 by a factor of 100. During shutdown, maximum purification is employed to reduce the reactor coolant activity to levels that insure acceptable dose rates during refueling operations.

11.1.4 NITROGEN-16 ACTIVITY

Nitrogen-16 is produced by the 0^{16} (n,p) N^{16} reaction. The N^{16} decays, emitting high energy gammas 75 percent of the time. The gamma energies are 6.13 Mev (69 percent), 7.14 Mev (9 percent), 2.74 Mev (0.76 percent) and 1.75 Mev (0.13 percent). The N-16 half-life is 7.11 sec. The threshold energy for the O^{16} neutron reaction is 10.2 Mev.

The N-16 activity of the coolant is the controlling radiation source in the design of the secondary shielding and is tabulated in the Table 11.1.4-1 in μCi as a function of transport time in a reactor coolant loop.

The pressurizer nitrogen-16 activity calculations are based on a coolant to the pressurizer following a 10 percent step load power decrease. It is assumed that the incoming reactor coolant mixes only with the pressurizer liquid below the first baffle (82.7 $ft.^3$) and that the nitrogen-16 concentration is corrected for decay during transit through the surge line. With these assumptions, the pressurizer nitrogen-16 activity is found to be 7.7 micro-Curies per gram.

11.1.5 CARBON-14 PRODUCTION

The principal source of Carbon-14 (C-14) is an oxygen-17 (n,α) reaction. The C-14 source term can be estimated through a calculational approach, assuming typical or maximum values for the various calculational parameters. However, an alternative to the calculational approach is provided by NUREG-0017, which gives a C-14 source term based on measurements at 10 operating power plants. The C-14 source term recommended by NUREG-0017 is 7.3 curies/year, with the following release distribution:

Source	Release (Ci/yr)
Containment	1.6
Auxiliary Building	4.5
Waste Gas System	2.3

11.1.6 TRITIUM

11.1.6.1 Production

Tritium is produced in light water reactors from several sources. Most occurs as a ternary fission product whose source is fissioned fuel.

Tritium from this source, along with tritium produced from boron reactions in burnable poison rods and fuel rods containing boron as a burnable absorber, must diffuse through the fuel or burnable poison material and cladding before release to the Reactor Coolant System. Tritium can also be produced directly in the reactor coolant through nuclear reactions involving boron, lithium, and deuterium.

Tritium in nuclear power plants is a concern because its long half-life (12.3 years) leads to increased levels of radioactivity if it is retained in the plant. Tritium exists primarily as tritium oxide, that is tritiated water either liquid or vapor. Tritiated water presents a hazard because it can enter the body by inhalation, ingestion, or absorption through the skin. Tritium has a relatively short biological half-life (12 days), and a low beta decay energy (19 kev maximum, 6 kev average).

Sources of tritium are discussed in the following paragraphs.

1. Fission-Produced Tritium - Ternary fission produces more tritium than all other sources in light-water-cooled reactors. Ternary fission is also the main contributor of tritium in the primary coolant because a fraction of the fission-product tritium diffuses out of the fuel and cladding into the reactor coolant.

2. Tritium Produced From Soluble Boron Reactions - Neutron reactions with the boron present in the coolant as a soluble chemical neutron absorber constitute another important source of tritium in pressurized water reactors.

The neutron reactions with boron that produce tritium are as follows:

a. B^{10} (n,2α) T

b. B^{10} (n,α) Li^7 (n,nα) T

c. B^{11} (n,T) Be^9

Of the above reactions, only the first two contribute significantly to tritium production in a PWR. The B^{11} (n,T) Be^9 reaction has a threshold of 14 Mev and a cross section of approximately five millibarns. Since the number of neutrons produced at this energy is less than 10^9 neutrons per square centimeter per second, the tritium produced for this reaction is negligible.

3. Tritium Produced from Soluble Lithium Reactions - Lithium is used for pH adjustment of the reactor coolant. The maximum Lithium concentration in the reactor coolant is 3.5 ± 0.2 parts per million (except for brief periods at the beginning of the fuel cycle and during normal operations when the CVCS demineralizers are not available for Lithium removal) and is controlled by the addition of Li^7OH and by a cation demineralizer included in the chemistry and volume control system.

This demineralizer removes excess lithium, such as that produced in the B^{10} (n,a) Li^7 reaction.

The neutron reactions with lithium resulting in the production of tritium are as follows:

a. Li^7 (n, nα) T

b. Li^6 (n,α) T

The Li^6 (n,α) T reaction is controlled by limiting the Li^6 impurity in the Li^7OH used in the reactor coolant and by saturating the demineralizers with high-purity Li^7. SHNPP utilizes lithium with 99.7 weight percent Li^7, although some plants have considered the use of 98.4 atom percent Li^7OH because of its greater availability. If 98.4 percent lithium is exclusively substituted for the 99.9 atom percent lithium in the RCS and demineralizers, the tritium produced from Li^6 reactions would increase by a factor of 16.

4. Tritium Produced from Burnable Poison Rods and Fuel Rods Containing Boron - In a fixed burnable poison rod or fuel rod containing boron as a burnable absorber, there are two primary sources of tritium generation; the B^{10} (n, 2α) T and the B^{10} (n,α) Li^7 (n,na) T reactions. Unlike the coolant in which the Li^7 level is normally controlled at less than 3.5 ±

0.2 parts per million, there is a buildup of Li^7 in the burnable poison rods and fuel rods containing boron. The burnable poison rods are normally removed after one cycle of operation.

The utilization of burnable poison rods in fuel cycles beyond the first may be likely because of design considerations such as 18-month fuel cycles, elimination of the positive moderator coefficient, and the poison used for shaping the power distribution.

5. Tritium Produced from Deuterium Reactions - Since the amount of naturally occurring deuterium in water is less than 0.015 atom percent, the tritium produced from this reaction is small (less than 5 curies per year).

Table 11.1.6-1 presents the design basis tritium production rate.

Based on the reported liquid and gaseous tritium releases at nine operating PWRs, NUREG-0017 has developed a tritium production rate of 0.4 Ci/year per MWt. This methodology will be used to calculate the normal operational, including anticipated operational occurrences, tritium production rate (please note that production rate and release rate are the same thing).

11.1.6.2 Concentration

The concentration of tritium in the reactor coolant is a function of:

1. The rate at which tritium is produced via the various mechanisms discussed in the previous subsection, and the rate at which the tritium enters the reactor coolant (if not produced in the reactor coolant).

2. The extent to which tritiated water is recycled or discharged from the station. The tritium release rate given in NUREG-0017 is based on data collected on the tritium release rates from a number of PWR stations as well as specific measurements of the tritium inventory and releases at a selected PWR station. The distribution of the calculated tritium releases between the gaseous and liquid effluents reflects the extent of liquid waste recycle performed at the SHNPP.

Table 11.1.1-2 presents the tritium concentration in the reactor coolant under design basis conditions. The value is based on preventing excessive personnel exposures. Primary system leakage into the containment at this concentration is expected to limit the containment atmosphere activity to a level which would permit personnel entry without the use of protective equipment.

11.1.7 SPENT FUEL POOL FISSION PRODUCT AND CORROSION PRODUCT ACTIVITIES

It is assumed that upon shutdown for refueling, the RCS is cooled down for a period of approximately two days. During this period, the primary coolant letdown is through the purification filter, purification heat exchanger, and volume control tank. This serves two purposes; removing the noble gases in the volume control tank avoids large activity releases to the Containment following reactor vessel head removal, and the ion exchanger and filter reduces dissolved fission and corrosion products in the coolant which would otherwise enter the spent fuel pool and refueling water cavity. At the end of this period, the coolant above the reactor vessel flange is partially drained. The reactor vessel head is unbolted and the refueling water cavity is filled with approximately 475,000 gallons of water from the refueling water storage tank. Remaining reactor coolant volume containing radioactivity is then mixed with water in the refueling cavity. The refueling cavity water mixes with the spent fuel pool water via transfer tube and fuel transfer canal. Refueling is normally accomplished by removing the entire core from the reactor vessel and depositing it in the spent fuel pool. Some corrosion products (crud) on the fuel cladding dissolve in the spent fuel pool liquid; the remaining crud either spalls off the bundles and settles on the fuel pool floor or remains on the bundle when placed back into the reactor vessel. Additional activity sources accumulate in the spent fuel pool as a result of spent fuel transfer from other nuclear plants within the CP&L system into the Harris spent fuel pool. Crud spalls off these bundles into the spent fuel pool. Activity from leaking fuel rods also accounts for a portion of the activity within the spent fuel pool.

The objective regarding the spent fuel pool radionuclide concentrations is to maintain them at levels that will ensure the dose rate in the area of the spent fuel pool is 2.5 mrem/hr or less. Presented in Table 11.1.7.1 are key radionuclides and the concentration for each nuclide that would result in a dose rate (from the specific radionuclide) of 2.5 mrem/hr in the area of the spent fuel pool.

When calculating the normal station discharges using the GALE Code, the normal radionuclide inventory for the spent fuel pool has been defined as that fraction of the total GALE Code primary coolant activities (as given in Table 11.1.2-1) that would produce a dose rate in the area of the spent fuel pool of no more than 2.5 mrem/hr.

Based on a spent fuel pool volume of 398,000 gallons, a processing rate of 325 gallons per minute through the Spent Fuel Pool Cleanup System, and a combined decontamination factor of 2 for Cs, Rb, and 10 for all others for the filter and demineralizer, the cleanup rate for Cs, Rb and other particulate radionuclides is 0.59 and 1.06 cycles per day, respectively.

As discussed in Section 9.1, the fuel storage pools will be used for the safe storage of PWR and BWR spent fuel shipped from other nuclear plants on the CP&L system. A design basis maximum Spent Fuel Pool was completely full of fuel and all Fuel Pool Cleanup Operations were never operated, a rupture of the RWST which is the only possible postulated release pathway of the Spent Fuel Pool would not exceed a 10 CFR 20 unrestricted dose to the public.

11.1.8 LEAKAGE SOURCES

Systems containing radioactive liquids are potential sources of leakage of radioactive material which is ultimately discharged to the environment. Table 11.1-8-1 provides a listing of assumed leakage values from valves and pumps. Leakage of primary coolant into the containment building atmosphere, which is ultimately exhausted to the environment at times of containment purge, is assumed to be one percent per day of the primary coolant noble gas activity and .001 percent per day of the iodine activity in the primary coolant. An additional potential source of gaseous discharge is coolant leakage (via the CVCS and BRS) into the Reactor Auxiliary Building and Waste Processing Building.

A leakage rate of 160 lbs/day of a mixture of hot and cold primary coolant leakage is assumed, with an iodine and noble gas partition factor of .0075 and 1.0 respectively. The liquid from these leakage sources is collected and processed in the Liquid Waste Management System which is described in Section 11.2.

Primary to secondary leakage can result in the buildup of radionuclides in the secondary coolant and Steam Generator Blowdown System (SGBS). Under normal operation a leakage rate of 75 lbs/day is assumed. This assumed primary to secondary leakage will result in the nominal release of radioactivity in gaseous and liquid effluents from secondary side systems. During periods of primary to secondary leakage, secondary side liquid effluents (e.g., regeneration waste and blowdown filter backwash) will be collected and processed, as necessary, in the Secondary Waste Treatment System, which is described in Section 11.2.2.4. It is assumed that leakage to the turbine building sump from secondary side systems is five gpm and that all of steam generator blowdown is processed and returned to the secondary coolant system. The SGBS is discussed in Section 10.4.8.

Gaseous releases from the secondary side can result from main steam leakage, the gland seal system exhaust and the discharge of noncondensible gases from the SGBS flash tank. Overall main steam leakage is assumed to be approximately 1700 lbs/hr and originates from many sources, each too small to identify. Turbine gland seal steam flow is sent to a gland steam condenser resulting in negligible discharges. Since all noncondensible gases from the SGBS flash tank are vented to the condenser, these releases are also negligible.

The above leakage rates and partition coefficients are based on the recommendations and experience presented in NUREG-0017.

Releases inside the plant are handled by the appropriate ventilation system. Containment air purification and cleanup systems are described in Section 9.4.7. Reactor Auxiliary Building, Waste Processing Building, and Turbine Building Ventilation Systems are discussed in Section 9.4 and continuous radiation monitors are discussed in Section 12.3.4. The source terms used as design bases for evaluating these systems are provided in Section 12.2.2.

Means of controlling leakage are discussed in Section 5.2.

11.1.9 SPENT RESIN VOLUMES

Present in Table 11.1.9-1 is a summary of projected spent resin volumes from demineralizers used to process reactor coolant letdown to either the Chemical and Volume Control or Boron Recycle Systems. The demineralizer resin source strengths are given in Section 12.2. The information is based on plant experience as further outlined in Reference 11.1.1-1.

REFERENCES: SECTION 11.1

11.1.1-1 "Source Term Data for Westinghouse Pressurized Water Reactors," WCAP-8253, Amendment 1, July, 1975.

11.1.2-1 Deleted by Amendment 43.

11.1.2-2 "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," NUREG-0017 Rev. 1, U.S. Nuclear Regulatory Commission, April, 1985.

11.2 LIQUID WASTE PROCESSING SYSTEM

The Liquid Waste Processing System (LWPS) provides for the collection, storing, processing, and controlled release of radioactive and potentially radioactive liquids associated with the operation of the nuclear power plant. The discharge of treated wastes is controlled and monitored to ensure that any discharges are as low as is reasonably achievable (ALARA) and that they are in conformance with the requirements specified in 10 CFR 20 and 10 CFR 50.

For discussion of compliance with 10 CFR 20 and the guidelines of 10 CFR 50, Appendix I, see Section 11.2.3.

11.2.1 DESIGN BASES

11.2.1.1 Design Objectives and Criteria

The LWPS is designed to collect all primary plant radioactive waste water and by processing reduce the radionuclide concentration to permit its discharge to the environs. In addition, the LWPS is designed to treat occasional batches of secondary liquids should primary to secondary leakage occur. Differences in primary and secondary system water chemistry must be considered prior to reusing liquids from these sources.

The LWPS is divided into six subsystems; the Equipment Drain Treatment System, Floor Drain Treatment System, Laundry and Hot Shower Treatment System, Chemical Drains System, Filter Backwash System, and the Secondary Waste Treatment System. These subsystems segregate the various types of liquid radwaste based on their source because of their composition and process requirements. Waste input to the Floor Treatment System, Laundry and Hot Shower System, and the Chemical Drain System have not differed to the point that separate processing trains have been necessary. These wastes are processed using the Modular Fluidized Transfer Demineralization System (MFTDS).

The process segregation described above has, however, been maintained. This has been accomplished by retaining the use of the various front-end waste collection tanks associated with the WPS subsystems. This waste segregation is used to control the tritium concentration of releases to the environment. The Equipment Drain System and the Filter Backwash System are generally kept segregated from the other waste streams, as they tend to be higher in tritium concentration due to their source being drainage from primary systems. Processing of these tritiated waste streams may be accomplished using the MFTDS, evaporation, or both. The primary objective for processing this waste stream is to recycle the majority of the purified evaporator distillate to the RMWST for reuse, thereby minimizing the impact to the environment of the Harris Lake.

Since the original process equipment is being removed from service but being retained and thus available for future reactivation, the discussions of the liquid waste process subsystems and the equipment comprising these subsystems will be retained. The segregation is used to provide the maximum water quality and radionuclide removal prior to release of treated water to the environs.

The primary objective of the MFTDS is to reduce the radionuclide concentrations in the station effluents, with no intent of producing reactor coolant quality water from the liquid radwaste.

Vendor-supplied services are being used to properly package spent filters and spent ion exchange resins for shipment and disposal (Section 11.4). The Liquid Waste Processing System as originally installed is shown on Figures 11.2.2-1 through 11.2.2-8. The new MFTD System is shown on Figure 11.2.2-9. The bulk of the radioactive liquids discharged from the Reactor Coolant System is processed by the Boron Recycle System (Section 9.3.4). Aerated wastes and other liquids are treated by the MFTDS which uses an appropriate combination of filtration and ion exchange.

Liquid radwastes are segregated into three main process streams. The first process stream collects the floor drains, chemical wastes, and spent fuel cask washdowns. This waste stream is low grade waste that has insignificant tritium contamination; this waste is processed using the MFTDS, then discharged to the environment. The second process stream collects filter backwash wastes and equipment drains from the RAB, FHB, and the Containment Building. This waste is generally higher in both tritium and boron concentrations; this waste is processed using the MFTDS, or an evaporator, or both then it may be recycled to the RMWST or discharged to the environment. The third waste process stream is dedicated to secondary side wastes consisting of potentially radioactive regenerant waste from the condensate polishers and steam generator blowdown demineralizers and effluents from the Turbine Building sumps.

Provisions have been made to sample and analyze processed liquids before they are recycled or discharged to the environment. Based on laboratory analysis and the limitations of the Offsite Dose Calculation Manual, these fluids will be either released under controlled conditions via the cooling tower discharge or retained for recycle or for further processing. The system is capable of processing all wastes generated during operation of the Reactor Coolant System. The annual input waste volumes for the systems and discharge quantities are shown in Table 11.2.1-1. The original process subsystems were designed to include excess capacity, backup equipment, and system cross ties to allow for abnormal liquid surges, equipment malfunction, and alternative processing. The placement of these subsystems into a lay-up status does not affect these design features. Should the original equipment be reactivated these features will be present. The MFTDS also has excess process capacity, thus ensuring the ability to process waste inputs resulting from abnormal surges in liquid radwaste inputs.

The exhaust system for the waste processing areas is equipped with HEPA filters and charcoal adsorbers; thus, any liquids volatilized will be filtered prior to discharge. In the event of accidental releases of liquid waste due to operator error, automatic alarms and controls prevent excessive waste release. Liquid waste tanks that operate at atmospheric pressure vent to the Waste Processing Building Ventilation System. All tank overflow connections are equipped with water traps to prevent release of volatile species inside the WPB. All waste gases which are vented from the liquid waste tanks are monitored at the point of release to the environment.

The LWPS is monitored and controlled from a central Control Room in the Waste Processing Building. Local instrumentation and controls, where necessary, are located on auxiliary racks near the equipment. Operation of the Floor Drain, Equipment Drain, and Laundry and Hot Shower Treatment Systems are a batch process; that is operator initiation with automatic termination. The Secondary Waste Treatment System may be operated either as a batch process or as a continuous process. The continuous process is used until treatment due to radioactivity of the secondary waste is required. All releases to the environment require operator action to initiate.

Releases to unrestricted areas of liquid effluents containing or potentially containing non-naturally occurring radioactive materials, excluding tritium, are made only from the waste evaporator condensate tanks, waste monitor tanks, treated laundry and hot shower tanks, and secondary waste sample tank. These releases are monitored before discharge to the cooling tower discharge. Discharge valves from the tanks to the environment are key locked shut to prevent inadvertent releases. Keys are controlled by a licensed SRO and are issued only by an approved pre-release discharge permit.

The discharge valve is interlocked with a process radiation monitor and will close automatically should the radioactivity concentration in the liquid discharge exceed a preset limit. The liquid waste discharge flow volume is recorded. In addition, an interlock system is provided to automatically isolate the liquid discharge in the event that dilution flow afforded by the cooling tower discharge falls below a preset value. The dilution flow is a summation of cooling tower blowdown and cooling tower makeup/cooling tower blowdown cross tie flow and can be varied depending on plant and environmental conditions.

Presented in Table 11.2.1-1 are projected expected annual and daily average inputs to the various LWPS subsystems. Table 11.2.1-2 details the anticipated operational occurrences which were considered in the design of the LWPS subsystems placed in lay-up. The MFTDS addresses anticipated operational occurrences through its variable range in processing rate (i.e., 15 gpm to 30 gpm) and its simplicity of design. The capability to increase the processing rate provides the ability to cope with surges in waste inputs. The simplicity in design (primarily transportable-sluiceable pressure vessels) coupled with significant tankage capacity readily facilitates bed changeout or even vessel replacement. A summary of the LWPS capabilities is presented in Table 11.2.1-3. The information presented in Table 11.2.1-3 demonstrates the capability of the process subsystems to cope with surges in waste inputs and the available process alternatives.

11.2.1.2 System Radioactive Release Requirements

The LWPS limits releases to the environs of liquid radwaste to meet the as low as reasonably achievable (ALARA) criteria. The design release volumes are based on normal operation including anticipated operational occurrences.

Section 11.2.3 discusses radioactive releases. The evaluation for releases of radioactive materials is based on the volumes given in Table 11.2.1-1, and radionuclide activities in Section 11.1 and Tables 11.2.1-5 and 11.2.1-6. The MFTDS is quite effective in processing the station's liquid wastes. The normal and design basis radionuclide releases are presented in Table 11.2.3-1 and 11.2.3-5, respectively. The bases for these calculated releases have meaningfully changed from the station's initial calculation and are presented in Table 11.2.3-2.

The Decontamination Factors (DF's) used to calculate the releases from the Liquid WPS presented in Tables 11.2.3-1 and 11.2.3-5 are given in Table 11.2.1-4. The MFTDS uses filtration and ion-exchange as the process technologies. The ion-exchange media (such as cation, anion, mixed bed, charcoal) used can be varied as necessary, based on waste stream composition and required DF's. The required DF's can be determined routinely by chemistry sampling of the waste streams. The DF's used were based on the guidance of Table 1-4 of NUREG-0017 Rev. 1. The calculation for normal operation of the MFTDS assumed the use of three cation and one mixed bed demineralizer. No credit was assumed for the third cation bed.

When operating with design basis failed fuel, the MFTDS assumed the use of two cation and two mixed bed demineralizers.

Also presented in Table 11.2.1-4 are the DF's for the process subsystems that are removed from service but are being retained for possible future use. Since the waste inputs have changed, DF's for the process subsystems are being presented to demonstrate that should they be returned to service, they could provide the same degree of radionuclide removal as the MFTDS currently being used.

11.2.1.3 System and Component Design Parameters

Table 11.2.1-7 is a tabulation of quantity, design pressure, design temperature, flowrate or volume, applicable material of construction and material code for equipment in the LWPS.

The LWPS, as described in Section 11.2.2 and as shown by the analysis in this Section and in Section 11.2.3, controls the releases of radioactive materials to the environment. The seismic design of the structure housing the LWPS is discussed in Section 3.8. Sections 11.2.1.6 and 11.5 describe the monitoring of releases. Thus, the requirements of General Design Criteria 60 and 61 of 10 CFR 50, Appendix A are implemented in the Liquid Waste Processing System.

11.2.1.4 Maintenance, Leakage, and Releases

The waste processing equipment is arranged to permit operation, inspection and maintenance with limited personnel exposure through controlled access areas. The general arrangement of the Waste Processing Building (WPB) is shown on Figures 1.2.2-47 through 1.2.2-54. Although the LWPS allows separate processing trains to maintain subsystem segregation, cross-connections provide for processing liquid radwaste by alternate methods and maintaining processing capability during equipment maintenance and equipment downtime. Process lines containing liquid radwaste are placed in pipe tunnels to the maximum extent possible. Air flows are from low activity areas to high activity areas.

Contained venting of high radiation level equipment is provided to prevent release of radioactive vapor and gases to the building. The gas collection headers, which collect gases from equipment vents, contain these gases within the plant. The gas collection headers route the vent gases to convenient ventilation ducts. Provisions are incorporated in the layout of the system to allow for periodic inspection, visually and with monitored instrumentation.

Thus, equipment is selected, arranged, and shielded to permit operation, inspection, and maintenance in accordance with ALARA considerations for personnel exposure.

In order to minimize leakage and reduce releases of radioactive gases, pressure-retaining components of process systems are welded when practicable. This practice extends to the first root valve on sample and instrument lines. Flanged joints or suitable rapid disconnect fittings are used only where maintenance or operation requirements clearly indicate that such construction is preferable. The pumps are flange connected. Screwed connections in which threads provide the only seal are not used, except for instrumentation connections and other components where welded connections are not suitable or available. Process lines are not less than 3/4 in. All main process systems welds for the Liquid Radwaste Processing System are of the butt-weld type.

Flushing connections are provided for all piping containing radioactive slurries.

Completed process systems are pressure tested to the maximum practicable extent. Testing of piping systems is performed in accordance with applicable ASME or ANSI Codes. The test pressurization is at least 75 psig. This test pressure must hold for a minimum of 30 minutes to indicate no leakage. Testing provisions are incorporated to enable periodic evaluation of the operability and functional performance of active components of the system. Materials for the pressure retaining components conform to materials specifications of Section II of the ASME Boiler and Pressure Vessel Code or ASTM Standards. Specific materials for each piece of equipment are shown in Table 11.2.1-7. Malleable, wrought, and cast iron materials have not been used. Manufacturer's material certificates of conformance with material specifications or certified materials test reports are required. All material specifications are in accordance with the Branch Technical Position ETSB-11-1 (Revision 1).

A quality assurance program has been established that is sufficient to assure that the design, construction, and testing requirements are met. The overall quality assurance program for the items listed in Table 11.2.1-7 is in accordance with the Engineering and Construction QA program which was approved by the NRC during construction permit review.

The MFTDS is also located in the WPB. The process vessels and filters are shielded to reduce radiation levels in the process area. Locating the MFTDS in the WPB ensures the ability to collect and control any system leakage. Design codes/standards, as well as the design temperature, are comparable to the WPS. This is demonstrated by the information in Table 11.2.1-7.

11.2.1.5 Expected and Design Inventories

The geometry and layout of equipment is shown in the Waste Processing Building general arrangements (Figures 1.2.2-47 through 1.2.2-54). This layout was used to determine shielding requirements. The expected and design specific activities of radionuclides at the inlet to the process subsystems are given in Tables 11.2.1-5 and 11.2.1-6. Section 12.3 further discusses details of shielding design. In addition, the activities of liquids in the primary coolant are given in Section 11.1 for normal operations and design basis fuel leakage. The annual volumes and flowrates are given in Table 11.2.1-1.

11.2.1.6 Provisions to Prevent Uncontrolled Releases

Instrumentation and controls are provided to isolate the LWPS in the event excessive radioactivity in the system effluent could result in the release of higher than permitted quantities of radioactivity. The monitoring of effluent is described in detail in Section 11.5 and is designed as required by NRC Regulatory Guide 1.21 (see Section 1.8). The LWPS is also monitored for flow, temperature, conductivity, pH, pressure and level to ensure system operations are performing as expected and that system limitations are not exceeded. Accordingly, the monitoring system meets the requirements of General Design Criteria 64 of 10 CFR 50, Appendix A.

Design features are included as system safeguards and precautionary measures to control leakage, spillage and overflow. Tanks and other equipment are provided with level indication and alarms for high-level conditions. The level alarms alert the operators when tanks are nearly full and operator initiated transfer from filled tanks to alternate tanks will proceed. For tanks containing radioactivity and located inside cubicles, curbing is provided in the tank cubicle entrance to prevent the spread of liquid from the cubicle in the case of a tank overflow. The floors in the cubicles are pitched to floor drains located at low points to facilitate floor drainage. These floor drains are drained to sumps or tanks which collect any fluid overflows where it can be routed back to the LWPS for processing.

The refueling water storage tank and the reactor make-up water storage tank are the only tanks that can hold radioactive liquid (including BRS and LWPS), which are not totally enclosed in a building. These tanks have level detection instrumentation which annunciates in the Control Room on a high level condition. Any flow from these tanks through overflow nozzles is contained within the retention dikes or ponds surrounding the tank. If a sample analysis indicates that treatment of the water is required due to its radioactive or chemical content, alternate connections can be used to route this spillage to the Liquid Waste Processing System.

Collection tanks and tanks which receive processed waste are generally provided in pairs. The pairing of tanks allows one tank to be in the fill mode while the other tank is in the sampling, recirculation, process or standby mode. Since the volume of influent waste (see Tables 11.2.1-1 and 11.2.1-3) can be processed with approximately 50 percent operational time or less using the subsystems described in Section 11.2.2, an empty standby tank is normally available for any filled tank. Thus, switching from one tank to another prevents overflow of a tank.

Provisions are incorporated into the system design to prevent spillage from both potential operator errors as well as equipment failure and provisions to collect all leakage within the Waste Processing Building and from the recycle holdup tank which is located in the Reactor Auxiliary Building. Therefore, operator errors or equipment malfunction (single failures) do not result in uncontrolled releases of radioactive material to the environment.

The installation of the MFTDS does not negate any of the design provisions discussed above which are intended to preclude the accidental release of radioactive liquids from either the station or LWPS.

11.2.2 SYSTEM DESCRIPTION

The processing of liquid radwaste is performed in the Waste Processing Building. Segregated collection and treatment of the various categories of liquid radwaste are provided in each of the following subsystems:

11.2.2.1 Equipment Drain Treatment System

Inputs into the Equipment Drain Treatment System consist of reactor grade water from drains from the Equipment Drainage System. For additional information see Section 9.3.3. The Equipment Drain Treatment System is designed to process the collected liquid for discharge to the environment. The system is shown on Figures 11.2.2-1 and 11.2.2-2.

Aerated tritiated reactor grade liquid enters the Equipment Drain Treatment System through connections to the waste holdup tank (WHT). Sources of this liquid are:

a) Aerated drainage from equipment in the WPB and the RAB.

b) Aerated drainage from equipment in the FHB.

c) Waste gas processing system drains.

d) Sample room sink drains (excess primary sample volume only).

e) Ion exchanger, filter, pump, and other equipment drains.

f) Aerated drainage from equipment inside containment.

The inputs are pumped into the waste holdup tank, which serves as the initial collecting point for all aerated reactor grade liquids. Normally the system is processed through the MFTDS or the floor drain reverse osmosis unit as described in Section 11.2.2.2. Normally this waste stream is kept segregated from the Floor Drain System in order to control the tritium concentration of liquid releases to the environment.

In order to further reduce the quantity of tritium in liquid releases, Equipment Drain Waste processing may be supplemented by evaporation. When processing the Waste Holdup Tank (WHT) using the MFTDS, the processed water is generally routed to the Waste Monitor Tanks, where it can be recirculated for direct release to the environment, or prepared for further processing through an evaporator for recycle. The WHT may also be processed using filtration and evaporation without "preprocessing" through the MFTDS. When processing using the waste evaporator, the concentrates may be transferred to the Solid Waste Processing System or recycled dependent on the amount of impurities present. The evaporator distillate will be collected in the Waste Evaporator Condensate Tanks and will generally be recycled for further use in the plant, but may be released to the environment if plant water demands are low.

The waste may also be processed by filtration and evaporation by the waste evaporator. The waste evaporator feed pump processes the contents of the WHT through a filter and an evaporator prior to discharge. The noncondensable gases are released to the gas vent header and/or WPB vent. The evaporator concentrates are sent to the Solid Waste Processing System. The waste evaporator distillate stream can be passed through a demineralizer to the waste evaporator condensate tank or returned to the waste holdup tank for reprocessing, depending upon the amount of ionic impurities. Contents of the waste evaporator condensate tanks are transferred to the Waste Monitor Tanks for discharge, or discharged directly to the environment after recirculation and sampling, or recycled to the Reactor Water Makeup Water Storage Tank.

Equipment drains in the Containment containing deaerated tritiated reactor grade liquids are routed to the reactor coolant drain tank. The inputs from the RCDT are pumped through the RCDT pump, RCDT Heat Exchanger, and into the Recycle Holdup Tank. These liquids are processed by the Boron Recycle System. For additional information see Section 9.3.4. The reactor coolant drain tank is cross-tied to the WHT for alternate processing when the boric acid is not to be reused. No direct release to the environment is possible except via the Equipment Drain Treatment System. This system is shown on Figures 11.2.2-1 and 11.2.2-2. Sources of deaerated reactor grade liquids are:

a) Reactor coolant pump seal leakoffs (No. 2 and No. 3 seals).

b) Chemical and Volume Control System, Safety Injection System, and Residual Heat Removal System valve leakoffs (piped connections).

c) Excess letdown heat exchanger effluent (during plant heat-up).

d) Reactor vessel flange leak-off.

e) Reactor coolant system drainage (to RCDT pump suction).

f) Accumulator drainage (the RCDT pump suction).

11.2.2.2 Floor Drain Treatment System

The Floor Drain Treatment System collects and processes water from the Floor Drain System. For additional information see Section 9.3.3. The Floor Drain Treatment System consists of a Modular Fluidized Transfer Demineralization System (MFTDS) and a reverse osmosis (R/O) subsystem. These systems treat the collected water by removing chemical and radioactive impurities to permit the safe discharge to the environment. Water is collected in one of four (4) 25,000 gallon floor drain tanks. The four tanks have sufficient capacity to allow for surges and other abnormal inputs. The system is cross-tied to the waste evaporator in the Equipment Drain Treatment System to allow for treatment by evaporation if conditions require it. The Floor Drain Treatment system is shown on Figure 11.2.2-9.

The MFTDS is comprised of four basic modules: (1) the Polymer Feed Module, (2) the Mixing Module, (3) the Filter Module, and (4) the Pressure Vessel Module. A flow diagram of this system is shown in Figure 11.2.2-9 and component design information is given in Table 11.2.1-7.

The Polymer Feed Module is used for polymer addition to the Floor Drain Tank's effluent, for the coagulant of colloidal particles. The Feed Module controls the polymer input rate to assure flocculation and increases the filterability of suspended solids.

The Mixing Module provides an inline mixer and a time delay chamber to assure mixing of tanks effluent and polymer. In addition, this module provides a filter drying system to aid in filter change out. The system provides compressed air to the filter vessels to remove excess moisture from the filters.

The MFTDS filter and pressure vessel modules include five (5) filter vessels and four (4) demineralizer vessels. The filter vessels consist of three (3) bag filters and two (2) deep bed filters. The selection of the type of resin and filter used in each vessel and the number of vessels used to process waste will vary, depending on the quality and radioactivity of the waste to be processed. The MFTDS meets Branch Technical Position ETSB 11.1, Rev. 1 as clarified in Sections 1.8 and 11.2 and is located in the WPB to ensure containment of any spills and leaks. Water is routed from the floor drain tank pumps through the system. The effluent is routed back to one of the existing effluent tanks for monitoring and held for reprocessing or release to the environment based on the effluent monitoring program requirements.

The reverse osmosis subsystem equipment includes four (4) filters, one (1) reverse osmosis unit, one (1) waste monitor tank demineralizer and two (2) waste monitor tanks. After mixing and sampling, treatment consists of filtration, reverse osmosis processing and demineralization. Treated water is routed to the Waste Monitor tanks for monitoring and release to the environment.

Water in the waste monitor tanks is sampled and either discharged to the environment via the cooling tower blowdown, transferred to the Treated Laundry and Hot Shower Tanks, or recycled for further treatment. All discharges to the environment will be in a controlled manner.

The design basis outlined in Section 11.2.1 was used to ensure the system integrity during normal plant operation and preclude any danger to the health and safety of plant personnel, the environs, and the general public.

11.2.2.3 Filter Backwash System

Filters in the CVCS, Boron Recycle System, Liquid Radwaste System, and Spent Fuel Pool Cooling and Cleanup Systems are backwashed and their filtered waste is sent to their respective backwash transfer filter tanks. These wastes consist of corrosion products, sludge, and other particulate matter suspended in a small amount of backwash water. These wastes are routed to a single backwash storage tank in the WPB where they are transferred to the waste holdup tank for processing. Equipment for handling filter backwash sludge includes four (4) backwash transfer tanks, one (1) backwash storage tank, one (1) filter particulate concentrate tank, and two (2) backwash storage tank filters. The Filter Backwash System is shown on Figure 11.4.2-5 and 11.4.2-6.

11.2.2.4 Laundry and Hot Shower Treatment System

Currently, off-site radioactive laundry services are being used to clean contaminated clothing. The equipment in this subsystem would, therefore, be available to augment the other process subsystems, should increased processing capacity (greater DF) be needed to cope with design basis conditions and projected waste input streams and volumes (see Table 11.2.3-2).

Inputs to the Laundry and Hot Shower Treatment System consist of detergent drains from the Detergent Waste Drainage System (See Section 9.3.3), cask rinse wastes, fuel pool drainage, and chemical drains. The system also serves as a backup to the Floor Drain Treatment System. The Laundry and Hot Shower Treatment System processes these wastes by filtration, reverse osmosis, and/or demineralization. Normally the system is cross-tied to the Floor Drain Treatment System for processing through the MFTDS as described in Section 11.2.2.2. This subsystem is shown on Figures 11.2.2-5 through 11.2.2-7 and input volumes are shown in Table 11.2.1-1.

11.2.2.5 Chemical Drain System

Laboratory samples (spent and excess sample liquids) which are likely to be tritiated and/or which may contain chemicals required for analysis are collected in the Chemical Drain System. These samples of relatively small volume are discarded in a separate sink which drains to the chemical drain tanks. Low activity drains from the laboratory, such as rinse water, are routed to the floor drain tanks by separate sample sinks. Two (2) chemical drain tanks are provided. The liquid wastes from the chemical drain tanks are sent to the Laundry and Hot Shower System for processing by filtration and reverse osmosis or transferred to the Laundry and Hot Shower Tanks then to the Floor Drain System for processing by the MFTDS. These tanks and associated pumps are shown on Figure 11.2.2-4, Sheets 1 and 2.

11.2.2.6 Secondary Waste Treatment System

The Secondary Waste Treatment System is designed to treat wastes generated from secondary or steam/condensate systems. This water will contain non-naturally occurring radioactive materials, excluding tritium only if steam generator leaks occur; however, all sources of secondary waste are considered potentially radioactive. The secondary waste treatment system consists of a low conductivity subsystem and a high conductivity subsystem. The design is shown on Figure 11.2.2-8 and the equipment is located in the south end of the Fuel Handling Building. Inputs are shown in Table 11.2.1-1.

Turbine building equipment drains, floor drains, and curbed area oil equipment and floor drains below the operating deck are collected by a common waste drainage system and directed to industrial waste sumps on the ground floor of the Turbine Building. Drains below ground elevation, including those in the heater drain pit area, are collected in a condensate pump area sump. Both the industrial waste sumps and condensate pump area sump discharge through a radiation monitor on a common discharge header. The radiation monitor is described in Section 11.5. The Industrial Waste System is described in Section 9.3.3.

In the event that a high radiation level is detected in the water being discharged, an alarm will be activated in the Control Room. This high alarm is calculated in accordance with the SHNPP ODCM and is equivalent to less than a 0.4 Ci/yr, excluding tritium, release rate at a continuous flow rate of 20 gpm. Upon a high alarm the sump discharge is automatically terminated. The discharge can then be lined up to the secondary waste treatment system for processing and disposal.

Since the radiation monitor is gamma sensitive only, the release of tritium through the Industrial Waste System is administratively controlled in accordance with the ODCM.

The selection of treatments for this effluent stream is dependent upon the activity of the secondary system water. Under the postulated adverse conditions of one percent failed fuel and significant primary to secondary leakage, this source may require processing. However, under normal conditions, this potential source will be small and will require little treatment.

Since the Turbine Building structure, systems, and components are not safety related and the Industrial Waste System classification is non-nuclear safety, the system or portions thereof are not designed to Seismic Category I requirements.

11.2.2.6.1 Secondary waste low conductivity subsystem

The secondary waste low conductivity subsystem is designed to treat potentially radioactive low conductivity wastes for discharge. Inputs to this subsystem come from condensate polisher rinse water, blowdown cleanup demineralizer rinse water, and the Industrial Waste System.

Waste is collected in a low conductivity holding tank. If the activity in the Secondary waste does not require processing, then the contents of the tank are transferred to the Secondary Waste Sample Tank as part of a continuous discharge process. If the activity in the Secondary waste requires processing, then the contents of the tank after mixing, sampling, and pH adjustment are treated by filtration and demineralization. The treated waste is routed to the secondary waste sample tank where it is analyzed for chemical and radiological impurities. The waste is either recycled for further treatment, sent to the condensate storage tank for reuse, or discharged to the environment.

All discharge is done in a controlled manner, and is monitored by a radiation monitor in the discharge header. This radiation monitor will automatically close the discharge valve if high radiation levels are detected.

11.2.2.6.2 Secondary waste high conductivity subsystem

Inputs to this system consist of chemical regeneration solutions from the condensate polishers and turbine building acid and caustic sumps. These wastes are collected in a High Conductivity Holding Tank. If the activity in the secondary waste does not require processing, then the contents of the tank are transferred to the secondary waste sample tank as part of a continuous discharge process.

The original design of the Secondary Waste High Conductivity Subsystem has been modified by removing the secondary waste evaporators. Should the activity in this waste stream require its processing, the waste is batch processed, using the following treatment sequence. The waste is collected in the High and Low Conductivity Holding Tank, where it is mixed, sampled and pH adjusted. The waste is then processed through the Secondary Waste Filter and Demineralizer from where it is routed to the secondary waste sample tank and ultimately discharged.

The projected radioactivity releases from the waste processing system presented in Tables 11.2.3-1 and 11.2.3-5 assume the secondary side waste processing described above.

11.2.2.7 Subsystem Processing Rates

The normal processing rate of the MFTDS is 15 gpm but the throughput can be varied so as to provide processing at flow rates of 15 to 30 gpm. Alternative processing rates using the waste processing subsystems are as shown below.

Subsystem	Alternative Processing Rates
Equipment Drain Treatment System	15 gpm
Floor Drain Treatment System	30 gpm
Laundry and Hot Shower Treatment System	30 gpm
Secondary Waste Treatment System	
Low Conductivity:	100 gpm
High Conductivity:	35 gpm

Table 11.2.1-1 tabulates the volume of flow (gallons per year and gallons per day) and the radioactivity for each influent source in each subsystem.

11.2.2.8 Evaporator Concentrates

Concentrated waste from the waste evaporators and reverse osmosis concentrates evaporators are collected in the waste evaporator concentrate tank before being routed to the Solid Waste Processing System.

11.2.2.9 Spent Resin

Spent ion-exchange resin from all potentially radioactive demineralizers is collected in four spent resin tanks in the Waste Processing Building. The design for spent resin storage is shown on Figure 11.2.2-3. Processing of spent resin is described in Section 11.4.

11.2.2.10 Liquid Waste Process Component Description

Materials of the Liquid Waste Processing System were selected to meet the material requirements of the system and the applicable codes. All radwaste systems and components are welded except where maintenance requirements dictate otherwise. Process systems and components are pressure tested to the maximum practical extent.

11.2.2.10.1 Pumps

Design parameters for pumps are shown in Table 11.2.1-7. Pumps are designed to either ANSI B73.1 or ANSI B73.2 Standard. The wetted parts of all liquid waste pumps are constructed of stainless steel.

The reactor coolant drain tank pumps are used to transfer reactor coolant from the reactor coolant drain tank to the recycle holdup tank for processing. These pumps are installed in the Containment.

The spent resin sluice pumps are used to sluice resin from the various demineralizers to the spent resin storage tank. The spent resin transfer pump feeds resin to the contractor processing area. The waste solidification system has undergone major modifications, as described in Section 11.4. The outcome of these modifications is that processing of wet waste for disposal will be performed under a contractor-provided service. Thus, the reference to the contractor processing area. (incomplete sentence)

The waste evaporator feed pumps are used to transfer liquid to the Floor Drain System for processing through the MFTDS or to supply feed to the evaporator based on level control in the evaporator.

The waste evaporator condensate tank pumps are used to discharge the contents of the waste evaporator condensate tanks to the environment, or transfer water to the Reactor Makeup Water Storage Tank.

The chemical drain tank pumps are used to transfer liquid to the laundry and hot shower system from where the waste is transferred to the floor drain tanks for processing via the MFTDS or to transfer the waste directly to the solid radwaste pretreatment tanks for solidification.

The treated laundry and hot shower storage tank pumps take suction from the treated laundry and hot shower storage tanks and are used to provide the pump head for discharge of processed water to the environment or for recycling of contaminated water if further processing is required.

The laundry and hot shower tank pumps are used to transfer water from the laundry and hot shower tanks to the floor drain tanks or directly to the MFTDS or RO/Evaporator subsystem for processing.

The floor drain tank pumps are primarily used to transfer water either to the processing equipment or to the waste monitor tanks. The pumps are installed in the system so that they can also be used to supply the waste evaporator feed if required.

The waste monitor tank pumps take suction from the waste monitor tanks and are used to provide the pump head for discharge of processed water to the environment or for recycling of contaminated water if further processing is required. The pump can be throttled to achieve the desired discharge rate.

The waste evaporator concentrates tank pumps are used to transfer concentrates from the waste evaporator concentrates tank to the Contractor Processing Area.

The reverse osmosis concentrates tank pumps are used to transfer concentrates from the reverse osmosis concentrates tanks to the reverse osmosis evaporators.

The floor drain tank mixing pump, laundry and hot shower tank mixing pump, and the high conductivity holding tank mixing pump are used to rapidly mix the contents of their respective tanks. During mixing, chemicals will be added to the floor drain and laundry and hot shower tanks for pH adjustment and filtration aid. Chemicals are added to the high conductivity holding tank for pH adjustment only.

The filter backwash transfer tank pumps are used to transfer the filter sludge to the filter backwash storage tank. The filter backwash storage tank pump transfers the waste to the waste holdup tank. From the waste holdup tank, the filter sludges are processed with the equipment drains.

The gas decay tank drain pump is used to transfer the condensate from the gas decay tanks to the volume control tank or to the recycle holdup tank.

The low conductivity holding tank pumps take suction on the low conductivity holding tanks and transfer the water to the secondary waste sample tank via the process equipment.

The high conductivity holding tank pumps are used to transfer liquid from the high conductivity holding tank to the secondary waste low conductivity subsystem filter and demineralizer. The secondary waste evaporators have been removed from service and abandoned.

The secondary waste sample tank pump is used to either recycle liquid from the secondary waste sample tank for further treatment or discharge it to the cooling tower blowdown or neutralization basin.

11.2.2.10.2 Tanks

The parameters for the tanks in the Liquid Waste Processing System are shown in Table 11.2.1-7.

All liquid process tanks are constructed of stainless steel. All tanks are provided with level indicators which alarm in the WPB control room on high level.

One reactor coolant drain tank is provided for the plant. The purpose of the reactor coolant drain tank is to store the leakoff type drains collected from inside the Containment at a control collection point for further disposition through a single penetration via the reactor coolant drain tank pumps. The tank provides surge and NPSH requirements for the reactor coolant drain tank pumps. Only water which can ultimately be directed to the recycle holdup tank is permitted to enter the reactor coolant drain tank. The contents of this tank must be compatible with reactor coolant and must contain negligible dissolved air.

The system is designed so that the reactor coolant drain tank will maintain a constant level to minimize the amount of gas sent to the Gaseous Waste Processing System. Tank level is maintained by continuous running of one pump and operation of a proportional control valve in the discharge line. This valve operates on a signal from the tank level controller to limit flow out of the system. The remainder of the flow is recirculated to the tank.

The waste evaporator condensate tank is used to collect condensate from the evaporator and is equipped with a diaphragm to isolate the liquid from the atmosphere.

The chemical drain tanks are used to collect wastes from the hot laboratory and the low activity laboratory following sample analysis.

The purpose of the spent resin storage tanks is to provide a collection point for spent resin to allow for decay of short lived radionuclides before dewatering or solidification. These tanks serve also as head tanks for the spent resin sluice pumps. Four spent resin storage tanks are provided for the Liquid Waste Processing System. These tanks are vertical cylindrical tanks which facilitate removal of resin. These tanks are designed so that sufficient pressure can be applied in the gas space of the tanks to aid in forcing the resin out of the tanks. The vents from the spent resin storage tanks are routed to the plant vent, and are filtered through a low/medium efficiency filter, HEPA filter, and a charcoal absorber.

The floor drain tanks are used to collect liquids from the floor drains, including decontamination fluids located in controlled areas of the plant, and hold these liquids until they can be processed or transferred to the waste monitor tank. When using the MFTDS, all waste streams are normally routed to the floor drain tanks from where the waste is routed to the MFTDS for processing.

The laundry and hot shower tanks are used for collection of wastes from the chemical drain tanks, fuel cask wash and fuel pool draining. Laundry wastes should be minimal due to the use of off-site laundry services.

The treated laundry and hot shower storage tanks are provided for monitoring laundry and hot shower treatment system liquid discharges from the plant site.

The waste evaporator concentrate tank is used to collect bottoms from the various evaporators.

The reverse osmosis concentrates tanks are used to collect concentrates from the reverse osmosis units. Two tanks are provided for the plant.

The filter backwash transfer tanks, filter backwash storage tank, and the filter particulate concentrate tank are used to store backwash water and particulate matter from the flushable filters. All these tanks are designed to withstand the 350 psig backflush pressure.

The low and high conductivity holding tanks are used to collect various secondary wastes and the chemical regeneration solutions from the condensate polishers before treatment.

The secondary waste sample tank is provided for monitoring secondary liquid prior to discharge.

11.2.2.10.3 Demineralizers

The parameters for the liquid waste demineralizers are shown in Table 11.2.1-7. The resins in these demineralizers will not be regenerated.

One demineralizer is provided to remove ionic contaminants from the waste evaporator condensate.

One demineralizer is provided to remove trace contaminants as necessary from the water in the Floor Drain Treatment System that is to be discharged.

One demineralizer is provided to remove trace contaminants as necessary from the Laundry and Hot Shower Treatment System that is intended to be discharged.

Two demineralizers are provided for the Secondary Waste Treatment System to remove trace contaminants from the secondary waste that is intended to be discharged.

11.2.2.10.4 Filters

Filters in the Liquid Waste Processing System are provided to remove particulate matter and undissolved solids from the waste streams. The filters are a flushable type utilizing a stack of chemically etched disks for the filter element. Filtered solids are backflushed by 350 psi nitrogen to a filter backwash transfer tank before being routed to the solidification system.

In addition to the etched disk filters, two (2) disposal bag filters used to remove particulate and resin fines are installed in the secondary waste system.

The design parameters of the filters are shown in Table 11.2.1-7.

11.2.2.10.5 Evaporators

One waste evaporator is normally used for the Liquid Waste Processing System. A spare evaporator is provided as backup to the boron recycle evaporator. These evaporators are of the natural circulation type.

Two reverse osmosis concentrate evaporators are normally used to further concentrate the reverse osmosis concentrates from both the Floor Drain Treatment System and the Laundry and Hot Shower Treatment System. These evaporators are of the forced circulation type.

11.2.2.10.6 Reverse Osmosis Units

One reverse osmosis unit is provided for the Liquid Waste Processing System for the removal of detergent and trace contaminants from the Floor Drain Treatment System. An additional reverse osmosis unit is provided for the treatment of the laundry and hot shower system waste.

The reverse osmosis units use membranes for salt rejection. A pH adjustment system and fluid coolers are provided to protect the membranes from damage. A membrane cleaning skid common to both reverse osmosis units is provided. The membrane modules are arranged in three stages. A design rejection rate of 90 percent for all salts except boron is used.

11.2.2.11 Operation

The collection of liquid wastes is monitored in the WPB Control Room. Normally, the operation of the processing equipment is remotely-controlled from the WPB Control Room. Processing is initiated manually, but does not require continuous surveillance by the operator. Instrumentation which is used to monitor system operation includes pressure, temperature, flowrate, pH, conductivity and tank level instrumentation. Interlocks are used to prevent unsafe equipment operation, to protect equipment, to ensure proper routing of water and to limit radiation exposure of plant personnel.

If the activity in the Secondary Waste Treatment System does not require processing to meet release limits, then the system may be run in a continuous discharge process. Secondary waste that requires processing is processed and released on a batch basis.

When processing the contents of a waste collection tank, a local sample is taken to determine the appropriate treatment lineup required. The discharge of the tank pump is then aligned as appropriate, to the floor drain filter, reverse osmosis unit, the evaporator, the demineralizer, and waste monitor tank. Processing is then commenced. The collection tank low-level alarm, filter ΔP alarm, or reverse osmosis alarm will interrupt normal processing. An evaporator condensate tank high-level alarm, monitor tank high-level alarm or evaporator concentrates tank high-level alarm stops the appropriate evaporator when in use by placing it in a hot standby condition.

After filling a waste monitor, secondary sample (batch mode), or treated laundry and hot shower tank, the tank is isolated from upstream equipment and the water in the tank is monitored. If the water satisfies preset criteria, the water is discharged. Processed water in the waste monitor tanks, secondary waste sample tank, or treated laundry and hot shower tanks not meeting the environmental requirements is reprocessed prior to discharge. The use of two waste monitors, or treated laundry and hot shower tanks allows processing into one tank while monitoring and transferring the water from the second tank.

In compliance with Regulatory Guide 1.21 (see Section 1.8), radiation monitors are provided before the three environmental discharge points. In the event of an off-standard radiological condition, these monitors automatically terminate the release. During plant operation, periodic testing will be done to verify that systems and components are operating as designed. Testing will include sampling inlets and outlets of process equipment to check the design decontamination factors which are given in Table 11.2.1-4. When off-standard quality exists, the fluids are sampled, analyzed and routed for further treatment.

11.2.3 LIQUID RADIOACTIVE RELEASES

The LWPS provides for the collection and processing of radioactive and potentially radioactive liquids associated with the operation of the SHNPP. Following processing these liquids are discharged to the environment. The radioactivity removed from the liquids is concentrated in filters, ion exchange resin, and concentrator bottoms. These concentrated wastes are sent to the Solid Waste Processing System for packaging and eventual shipment to an approved offsite disposal location.

Prior to discharging processed liquid wastes, the tank's contents are mixed and sampled. A pre-release calculation using sample data and expected discharge conditions shows compliance with the Offsite Dose Calculation Manual. During discharge of the liquid wastes it is monitored by the Radiation Monitoring System to ensure that activity concentrations do not exceed predetermined limits. If the limit is exceeded, the discharge will be automatically terminated. Following the release, a post-release calculation is performed, using actual discharge flowrates and cooling tower blowdown. This calculation demonstrates actual compliance with the Offsite Dose Calculation Manual.

An estimate of the annual quantity of radioactivity in liquid effluents, including anticipated operational occurrence, is presented in Table 11.2.3-1. Table 11.2.3-2 presents the assumptions used in estimating the station's releases. The values were obtained using the guidance presented in NUREG 0017, Rev. 1, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from PWRs," (March 1985).

The amount of tritium released via the liquid pathway is calculated internal to the gale code.

Release of liquid radioactivity is through the cooling tower discharge line, with an assumed discharge rate of 16.5 cfs. This activity uniformly mixes in the mean reservoir mixing volume of 2.92 x 109 ft.^{3}. Radioactive liquid effluent concentrations, for normal operation, including anticipated operational occurrences, are presented in Table 11.2.3-3, in the reservoir and the cooling tower discharge. These concentrations are within the limits of 10 CFR 20, Appendix B, Table II, Column 2. The potential doses caused by the release of radioactivity in the liquid effluents are given in Table 11.2.3-4. These exposures are within the guidance of 10 CFR 50, Appendix I, September 4, 1975 Annex. The doses were calculated in accordance with Regulatory Guide 1.109 and Regulatory Guide 1.113 (see Section 1.8).

Although it is not expected that the plant will operate for an extended period of time with design basis failed fuel, Table 11.2.3-5 presents the radioactive liquid effluents should this condition persist for an entire year. The annual average radionuclide concentrations based upon these releases, are also provided in Table 11.2.3-5, as is a comparison with the limits of 10 CFR 20, Appendix B, Table II, Column 2.

In calculating the normal annual releases of radioactivity from the LWPS, the GALE Code adjusts upward the calculated releases in order to account for anticipated operational occurrences. Regarding design basis conditions, no adjustment was made to the calculated releases. The design basis conditions represent the upper bounds of postulated releases; any further adjustment would be unnecessary.

11.3 GASEOUS WASTE MANAGEMENT SYSTEMS

This section describes the capabilities of the plant to control, collect, process, store, and dispose of gaseous radioactive wastes generated as a result of normal operation including anticipated operational occurrences. The section discusses the design and operating features of the Gaseous Waste Processing System (GWPS) and the performance of other gas treatment and ventilation systems. Total gaseous releases from the plant for normal operation and the resulting offsite doses are also presented.

11.3.1 DESIGN BASIS

The GWPS is designed to collect, process and store gaseous wastes generated due to plant operations including anticipated operational occurrences. The system is designed to assure that the release of gaseous effluents from the plant and expected offsite doses are as low as reasonably achievable (ALARA) as defined in the design objectives in the Annex to Appendix I of 10 CFR 50, September 9, 1975. An evaluation of plant conformance to Appendix I is given in Section 11.3.3. The GWPS has sufficient capacity and redundancy to control releases to within the discharge concentration limits of 10 CFR 20 during periods of design basis fuel leakage, as discussed in Section 11.3.3.

In addition, the GWPS conforms to the requirements of General Design Criterion 60 by providing holdup capacity, thus precluding the necessity of releasing radioactive effluents during unfavorable environmental conditions. All gaseous effluent discharge paths are monitored for radioactivity, in compliance with General Design Criterion 64. Monitoring of radioactive effluents is discussed in Section 11.5. The capability of the system for storage eliminates the need for frequent routine discharge of radioactive gases to the environment and thereby allows discharges to be made selectively under favorable environmental conditions.

GWPS releases will be made in accordance with the ODCM, 10 CFR 20 and 10 CFR 50 limits. Table 11.3.2-6 shows design process parameters for GWPS with 90 days of accumulation. During normal operation, the annual releases by leakage and planned discharges from the GWPS will be sufficiently low to control site boundary doses from the effluent to a small fraction of regulation requirements.

The design of the GWPS is based on continuous operation of the Plant assuming that one percent of the rated core power is generated by fuel rods containing cladding defects. This condition is assumed to exist over the life of the plant.

While the normal inflow during volume control tank purge to the GWPS is 0.7 SCFM, the GWPS can accommodate surges up to 1.7 scfm such as may result from venting the recycle holdup tank, venting the pressurized relief tank or venting the reactor coolant drain tank. If the capacity of the hydrogen recombiner package is exceeded, volume control tank purge flow is isolated (see Section 11.3.2.2.2). No other anticipated operational occurrence will cause a significant surge in GWPS process flow. However, the operator may elect to increase the volume control tank purge flow above 0.7 scfm.

When waste gases are being released to the environment, the release is automatically terminated if the radioactivity level exceeds a predetermined level (the radiological monitoring and control instrumentation is described in Section 11.5).

In order to control the release of radioactive gases resulting from equipment failure or operator error, the GWPS design has all the waste gas decay tanks isolated from each other with valves except when all influents to the Waste Gas System are secured. In this configuration, two waste gas decay tanks may be interconnected. The tanks are in separate compartments. Thus the maximum uncontrolled release would be limited to the contents of one operating or two isolated, cross-connected waste gas decay tank(s). The effects of this occurrence would be approximately the same as the postulated waste gas decay tank rupture accident which is discussed in Section 15.7. To reduce GWPS downtime resulting from equipment failures, the GWPS design includes redundant waste gas compressors and catalytic hydrogen recombiners. One of the hydrogen recombiners is in long-term shutdown.

The system is designed to preclude the possibility of an internal explosion. However, the system volume is distributed among 10 isolated tanks located in separate compartments so that the dose in the unlikely event of an explosion is approximately the same as the dose due to a waste gas decay tank rupture.

The GWPS component design parameters and instrumentation and control pararameters are provided in Section 11.3.2.

The seismic classification and safety class information for the GWPS are found in Section 3.2.

Design features incorporated in the GWPS to reduce leakage of radioactive gases are described in Section 11.3.2.

Table 11.3.2-1, based on the reactor coolant system given in Table 11.1.1-2, shows the maximum fission product inventory that was anticipated to be accumulated in the GWPS over the forty year plant life. Table 11.3.2-2, based on the reactor coolant system given in Table 11.1.2-1, shows the expected fission product inventory in the GWPS over the forty year plant life.

Figures 11.3.2-3 and 11.3.2-4, which are based on the reactor coolant system activities given in Tables 11.1.1-2 and 11.1.2-1, (Reference 11.3.1-1) respectively, show that the quantity of fission gas activity accumulated after forty continuous years of operation is about twice the activity accumulated after one year of operation for fuel with 1% defects, but for expected fission gas accumulation it is about 5 times the one-year accumulation. Most isotopes reach equilibrium activity in 30 days, but Kr-85 continues to accumulate with operation.

11.3.2 SYSTEM DESCRIPTIONS

This section describes the design, operating features and performance of the GWPS and other plant gaseous waste management systems with respect to the collection and control of radioactive gases as required by General Design Criterion 61. Detailed descriptions of the plant ventilation systems and condenser vacuum system are presented in Sections 9.4 and 10.4, respectively.

All equipment in the GWPS is controlled from the Waste Processing Building (WPB) Control Room. The GWPS consists mainly of a closed loop comprised of two waste gas compressors, two catalytic hydrogen recombiners, and ten waste gas decay tanks to accumulate the fission product gases. All pipes containing radioactive gases are shielded as necessary and no piping is run through normally occupied areas. One of the hydrogen recombiners is in long-term shutdown.

The system also includes a gas decay tank drain pump, six gas traps, and a gas decay tank drain filter to permit maintenance and normal operation drains from the system. All of the equipment is located in the WPB.

The piping and instrumentation diagram for the system is shown in Figures 11.3.2-1 and 11.3.2-2. This diagram indicates safety classes for all components and piping.

The GWPS reduces the fission gas concentration in the Reactor Coolant System which in turn reduces the escape of fission gases from the Reactor Coolant System during maintenance or through equipment leakage.

The primary source of radioactive gas is the volume control tank purge. Smaller quantities of radioactive gas are received via the vent connections from the recycle evaporator gas stripper, the reactor coolant drain tank, the pressurizer relief tank, and the recycle holdup tank. The waste evaporator will be vented to the GWPS when it is used as recycle evaporator.

Since hydrogen is continuously removed in the hydrogen recombiner, this gas is not allowed to build up in the GWPS. Nitrogen gas can be added to the GWPS from the following sources during normal plant operations; (1) volume control tank can be purged with nitrogen from the nitrogen storage system during degassing operations, (2) the pressurizer relief tank can be vented to the GWPS to maintain nitrogen purity and (3) nitrogen gas can be added under the recycle holdup tank diaphragm to prevent an explosive gas mixture buildup. Impurities in the bulk hydrogen and oxygen supplies also contribute to the buildup of gases in the GWPS. A small concentration of helium gas is also collected in the GWPS. The helium is generated by a B10 (n,a) Li7 reaction in the reactor core. Stable and long lived isotopes of fission gases also contribute small quantities to the GWPS gas volume.

The GWPS meets General Design Criterion 60 by having sufficient holdup capacity for retention of gaseous effluents containing radioactive materials, particularly where unfavorable site environmental conditions can be expected to impose unusual operational limitations upon the release of such effluents to the environment. GWPS releases will be made in accordance with the ODCM, 10 CFR 20 and 10 CFR 50 limits. Table 11.3.2-6 shows design process parameters for GWPS with 90 days of accumulation.

Operation of the system is such that fission gases are distributed throughout the gas decay tanks. Separation of the GWPS gaseous inventory into several tanks assures that the allowable site boundary dose will not be exceeded in the event any one of the gas decay tanks rupture. Radiological consequences of such a postulated rupture are discussed in Chapter 15.

The GWPS also provides sufficient capacity to hold the gases generated during reactor shutdown. Nitrogen gas from previous shutdowns is contained in the gas decay tanks. This is used to strip hydrogen from the Reactor Coolant System during subsequent shutdowns. One gas decay tank (F) is normally at low pressure and is used to accept relief valve discharges from the inservice gas decay tank, the hydrogen recombiner, and the waste gas compressors.

Provisions are made to collect any residual gases stripped out of solution by the boron recycle and waste evaporators, gases from the reactor coolant drain tank, and gases from the recycle holdup tank (refer to Section 9.3.4.2.2.2).

Process flow diagrams are shown on Figures 11.3.2-1 and 11.3.2-2. The GWPS, for the normal operating mode with the gas decay tanks at low pressure (less than 25 psig), is shown on Figure 11.3.2-5. The normal operating mode when the waste gas decay tanks are at high pressure is shown on Figure 11.3.2-6 is used from the time the inservice gas decay tank pressure is above 35 psig. Due to moisture carryover problems encountered during low pressure mode of operations, the GWPS is typically operated in the high pressure mode.

Table 11.3.2-6 gives the process parameters for key locations in the GWPS based on a 90 day holdup of the waste gases.

11.3.2.1 Component Design

The gaseous waste processing equipment design parameters are given in Table 11.3.2-6. As GWPS performs no function related to the safe shutdown of the plant, some components are classified as non-nuclear safety (NNS). Component safety classes and the corresponding code and code class are shown in Section 3.2. All materials used for pressure retaining components are allowed by Section III of the ASME Code, and no malleable wrought or cast iron or plastic pipe is used. However, materials used for compressors shall conform to ASTM Specifications or equivalent ASME Code, Section II.

11.3.2.1.1 Waste gas compressor packages

Two waste gas compressor packages are provided to circulate gases around the system loop. One compressor package is normally used with the other on a standby basis.

The compressor units are water-sealed centrifugal displacement machines which are skid-mounted in a self-contained package. The waste gas compressor package is primarily constructed of stainless steel. Mechanical seals are provided to minimize the out-leakage of seal water.

11.3.2.1.2 Catalytic hydrogen recombiner packages

Two catalytic hydrogen recombiners are provided. One recombiner is normally used to remove hydrogen from the hydrogen-nitrogen fission gas mixtures by oxidation to water vapor, which is removed by condensation. The other recombiner is in long-term shutdown. Both units are self-contained and designed for continuous operation.

11.3.2.1.3 Waste gas decay tanks

Waste gas decay tanks are described in Table 11.3.2-7. The tanks are vertical-cylindrical type and constructed of carbon steel. There are ten waste gas decay tanks. Nine are used for normal operations while one (F) is kept at a low pressure to collect relief valve discharges.

11.3.2.1.4 Valves and piping

Each valve in the hydrogen recombiner packages is designed to meet the temperature, pressure and code requirements for the specific application in which it is used. The recombiner circuits contain manual valves provided with a metal diaphragm to prevent stem leakage and control valves provided with gaseous leakoffs returned to the GWPS. Other parts of the GWPS use elastomer diaphragm valves and control valves with bellows seals. Relief valves have soft seats and operate at pressures which are normally less than two-thirds of the relief valve set pressure. The relief valves of the major components discharge to one of the gas decay tanks (F). This allows the discharge to be monitored before being released. It also provides a means of containing and detecting seat leakage across the relief valves.

All piping from the waste gas decay tanks, up to and including the isolation valves is designed to Seismic Class I requirements to preclude any accidental release of gas to the environment.

There is a relief valve in each of the catalytic hydrogen recombiner packages. Liquid seals downstream of the relief valves are not provided nor are they necessary since the lines containing the relief valves connect to the relief header which discharges to a gas decay tank. Thus, relief valve failure would not result in a continuous leakage path to the environment.

11.3.2.2 Instrumentation and Control Design

The GWPS instrumentation is described in Table 11.3.2-8 and shown on the piping and instrumentation diagram, Figures 11.3.2-1 and 11.3.2-2.

The instrumentation readout is located mainly on the waste processing system (WPS) panel in the Waste Processing Building, while some instruments are read locally.

All recombiner alarms are shown separately on the WPS panel and further relayed to one common waste processing system annunciator on the main control board.

Where suitable, instrument lines are provided with diaphragm seals to prevent fission gas outleakage through the instrument.

11.3.2.2.1 Waste gas compressor package instrumentation and control

Figure 11.3.2-7 shows the location of the instruments on the waste gas compressor package.

The compressors are interlocked with the seal water inventory in the moisture separators and trip off on either high or low moisture separator level.

During normal operation the proper seal water inventory is maintained automatically.

11.3.2.2.2 Hydrogen recombiner package instrumentation and control

The catalytic hydrogen recombiner packages are designed for automatic operation with a minimum of operator attention.

Figure 11.3.2-8 indicates the location of the instruments on the hydrogen recombiner. Process gas flowrate is measured by an orifice located upstream of the hydrogen recombiner preheater.

Local pressure gauges indicate the hydrogen recombiner process inlet pressure and the oxygen supply pressure.

The oxygen concentration is monitored and controlled to assure that a flammable hydrogen-oxygen mixture does not occur as required by General Design Criterion 3. The GWPS is provided with analyzers to monitor oxygen concentrations: one between the oxygen supply and the hydrogen recombiner package, one downstream of the hydrogen recombiner, and one between the compressor and the gas decay tanks. When the hydrogen concentration is above the lower flammability limit of 4 percent, the minimum concentration of oxygen necessary for deflagration is 5 percent. The control function assigned to these analyzers is to automatically terminate the oxygen supply before reaching GWPS oxygen concentrations favorable for hydrogen flammability. Each hydrogen recombiner package also includes dual hydrogen analyzers: one to monitor the process stream entering the hydrogen recombiner and one to monitor the discharge stream.

The controls and alarms incorporated to maintain the gas composition outside the range of flammable and explosive mixtures are described below:

1. A high flow alarm sounds at a volume control tank purge flow rate of 1.0 scfm.

2. If the hydrogen recombiner feed concentration exceeds 6 percent hydrogen by volume, a high-hydrogen alarm sounds to warn that all hydrogen entering the hydrogen recombiner is not reacted. This alarm will be followed by a second alarm indicating high hydrogen in the hydrogen recombiner discharge. These alarms warn of a possible hydrogen accumulation in the GWPS.

3. If the hydrogen concentration in the hydrogen recombiner feed reaches 9 percent by volume, a high-high hydrogen alarm sounds, the oxygen feed is terminated, and the volume control tank hydrogen purge flow is terminated. These controls limit the possible accumulation of hydrogen in the system to 3 percent by volume.

4. If the oxygen concentration in the hydrogen recombiner feed reaches 3 percent by volume, a high oxygen alarm sounds and oxygen feed flow is limited so that no further increase in flow is possible. If the oxygen concentration in the hydrogen recombiner feed reaches 3.5 percent by volume, a Hi-Hi oxygen alarm sounds and the oxygen feed flow is automatically terminated. This control maintains the system oxygen concentration at 3.5 percent or less, which is below the flammable limit for hydrogen-oxygen mixtures.

5. If hydrogen in the hydrogen recombiner discharge exceeds 1.0% (0 2% range) or 5.0% (0-10% range) by volume (Train A) or 5.0% (Train B), an alarm sounds. This alarm warns of high hydrogen feed, possible reactor malfunction, or loss of oxygen feed.

6. If oxygen in the hydrogen recombiner discharge exceeds 15 ppm (Train A) or 75 ppm (Train B), a high alarm sounds. If it exceeds 60 ppm (Train A) or 150 ppm (Train B), a high-high alarm sounds and oxygen feed is terminated. This control prevents any accumulation of oxygen in the system in case of reactor malfunction.

7. On low flow through the hydrogen recombiner, oxygen feed is terminated. This control prevents an accumulation of oxygen following system malfunction.

8. On high discharge temperature from the cooler-condenser (downstream from the catalytic reactor) oxygen feed is terminated. This protects against loss of cooling water flow in the cooler-condenser.

9. On high temperature indication at the outlet of the catalyst bed, oxygen feed is limited so that no further increase of temperature is possible.

10. On high-high temperature indication at the recombiner catalytic reactor discharge, oxygen feed to the recombiner is terminated.

11. Administrative procedures will ensure that the source of all oxygen influents are secured if either (1) the downstream oxygen concentrations from the recombiner exceeds 1 percent, while in the low pressure mode, or (2) if the oxygen concentration between the GWPS compressor and the gas decay tanks exceeds 2 percent while in the high pressure mode.

11.3.2.2.3 Gaseous waste system gas analyzers

The gaseous waste system contains nine gas analyzers to provide monitoring capability and control of the hydrogen/oxygen recombination process. The system is subdivided into separate A & B processing trains. The analyzers on the A processing train are in long term shutdown. The analyzers on both trains measure recombiner inlet oxygen, inlet hydrogen, outlet oxygen, and outlet hydrogen. The remaining analyzer in the system monitors compressor discharge oxygen and is shared by both A & B trains located in common piping.

The hydrogen analyzers use the thermal conductivity principle to measure recombiner inlet and outlet hydrogen, whereas the A train oxygen analyzers utilizes a micro-fuel cell design and the B train oxygen analyzer utilizes a luminescent design to measure recombiner inlet and outlet oxygen and common compressor discharge. Both analyzers are designed to operate between 0 and 50°C.

The Analyzer Control Units and the Digital Indicator Controller (HIC-1118) provide overall electrical control for the hydrogen recombiner inlet oxygen valve controller. An alarm and shutdown bypass control switch is provided for each analyzer.

11.3.2.2.3.1 Hydrogen analyzers

A TRAIN:

The recombiner inlet and outlet hydrogen analyzers measure and control the recombination progress in the hydrogen recombiner. Analyzer HARC-1104 A measures recombiner inlet hydrogen 0 to 10% by volume and provides an input to the recombiner oxygen controller. Analyzer HAIC-1118 A measures recombiner outlet hydrogen in two selectable ranges; 0-2%, and 0-10% by volume, depending on how the system is operated. Normally HAIC-1118 is operated in the 0-2% range. HAIC-1118 also provides an input to the recombiner oxygen controller. Both analyzers operate on the thermal conductivity principle and both use pure oxygen for dilution gas. The hydrogen analyzers also contain a carbon purifier unit that is to be used to remove gaseous iodine when iodine concentration is high due to large amounts of failed fuel. Otherwise, the carbon unit is operated in bypass.

The primary function of HARC-1104 analyzer is to maintain the hydrogen concentration entering the recombiner below 6% by volume which is the maximum the recombiner can process in a single pass.

The primary function of HAIC-1118 analyzer is to monitor the recombiner discharge for high hydrogen concentration which would indicate possible WG recombiner malfunction or loss of the oxygen feed.

B TRAIN:

The recombiner inlet and outlet hydrogen analyzers measure and control the recombination progress in the hydrogen recombiner. Analyzer HOA1118/1119B measures recombiner outlet hydrogen 0 - 10% by volume. HOA-1118/1119B also provides an input to the recombiner oxygen controller. Both analyzers operate on the thermal conductivity principle and both use pure nitrogen as a purge gas.

The primary function of HOA-1104/1112B analyzer is to maintain the hydrogen concentration entering the recombiner below 6% by volume which is the maximum the recombiner can process in a single pass.

The primary function of HOA-1118/1119B analyzer is to monitor the recombiner discharge for high hydrogen concentration which would indicate possible WG recombiner malfunction or loss of the oxygen feed.

11.3.2.2.3.2 Oxygen analyzers

A TRAIN:

The recombiner inlet and outlet oxygen analyzers measure the amount of oxygen being consumed in the catalytic recombiner.

Analyzer OAIC-1112 A measures recombiner inlet oxygen (3% Hi-Alarm, 3.5% Hi-Hi) by volume. The primary function of this analyzer is to monitor and control the oxygen feed to the hydrogen recombiner by maintaining system oxygen concentration below the flammable limit for hydrogen-oxygen mixtures. If the oxygen concentration reaches the Hi-Hi setpoint, the inlet oxygen valve controller will be automatically shut.

Analyzer OARC-1119 A measures recombiner outlet oxygen (15 ppm Hi-Alarm, 60 ppm Hi-Hi) by volume. The primary function of this analyzer is to prevent the accumulation of oxygen in the discharge cycle to the decay tanks in the event of a recombiner malfunction.

Analyzer OAI-1101 measures waste gas compressor discharge oxygen (1.6% Hi-Alarm). It is located in the common piping in the system, so it can be used for oxygen measurement in either the A or B trains. The primary function of this analyzer is to monitor the oxygen concentration between the GWPS compressor and the 10 decay tanks while operating in the high-pressure mode.

Annunciation is provided to the WPCB when the setpoint is reached.

All of the A train oxygen analyzers operate on the micro-fuel cell design and can operate without dilution gas.

B TRAIN:

The recombiner inlet and outlet oxygen analyzers measure the amount of oxygen being consumed in the catalytic recombiner.

Analyzer HOA1104/1112B measures recombiner inlet oxygen (3% Hi-Alarm, 3.5% Hi-Hi) by volume. The primary function of this analyzer is to monitor and control the oxygen feed to the hydrogen recombiner by maintaining system oxygen concentration below the flammable limit for hydrogen-oxygen mixtures. If the oxygen concentration reaches the Hi-Hi setpoint, the inlet oxygen valve controller will be automatically shut.

Analyzer HOA-1118/1119B measures recombiner outlet oxygen (75 ppm Hi-Alarm, 150 ppm Hi-Hi) by volume. The primary function of this analyzer is to prevent the accumulation of oxygen in the discharge cycle to the decay tanks in the event of a recombiner malfunction.

Analyzer HOA-1101 measures waste gas compressor discharge oxygen (1.6% Hi-Alarm). It is located in the common piping in the system, so it can be used for oxygen measurement in either the A or B trains. The primary function of this analyzer is to monitor the oxygen concentration between the GWPS compressor and the 10 decay tanks while operating in the high-pressure mode.

Annunciation is provided to the WPCB when the setpoint is reached.

All of the B train oxygen analyzers operate on the luminescent measurement technology design principle.

11.3.2.3 System Operation

11.3.2.3.1 Startup operation

The GWPS is initially purged with nitrogen to remove all air. During startup operation, one waste gas compressor, one hydrogen recombiner and one gas decay tank are in service. The reactor is at cold shutdown and the volume control tank (VCT) contains nitrogen in the gas space. Reactor coolant contains neither hydrogen nor fission gases, but it may be saturated with air. Reactor coolant can become saturated with air from either opening up the RCS for maintenance or due to RCS fill and vent activities described in Chapter 9.3.4.1.2.6. If reactor coolant is saturated with air or VCT gas space contains air, the VCT can be vented to the atmosphere with a nitrogen sparge to remove excess air or vented to the waste gas system through the degasing flowpath.

When the reactor startup procedure requires that a hydrogen blanket be established in the VCT gas space, fresh hydrogen is charged into the VCT. The hydrogen-nitrogen mixture vented from the VCT enters the GWPS circulating nitrogen stream at the waste gas compressor suction. Nitrogen added to the GWPS accumulates in the inservice gas decay tank causing the tank's pressure to rise.

Initially, the VCT vent gas will be very lean in hydrogen and almost all the gas entering the GWPS will accumulate in the inservice gas decay tank. As the operation continues, however, the vent gas hydrogen content will gradually increase until it is almost totally hydrogen at the point when all of the nitrogen has been removed from the reactor coolant. At that time, hydrogen gas is passing through the VCT and mixing with the circulating nitrogen stream to give a mixture of hydrogen in nitrogen at the hydrogen recombiner inlet. A sufficient amount of oxygen is added in the hydrogen recombiner to react with the hydrogen to yield a discharge stream with a low residual concentration of hydrogen in nitrogen. After the water vapor is condensed and removed, the gas flow is directed to the waste gas compressor and then to the inservice gas decay tank and back to the hydrogen recombiner.

The VCT will continue to be vented until the reactor coolant hydrogen concentration is within operating specifications.

11.3.2.3.2 Normal operations

During normal power operation, nitrogen gas with entrained fission gases, is circulated around the GWPS operating loop by one of the two waste gas compressors. Fresh hydrogen gas is charged to the VCT where it is mixed with fission gases which have been stripped from the reactor coolant into the VCT gas space. The contaminated hydrogen gas is vented from the VCT into the circulating nitrogen stream to transport the fission gases into the GWPS. The resulting mixture of nitrogen-hydrogen fission gas is pumped by the waste gas compressor to the hydrogen recombiner where enough oxygen is added to reduce the hydrogen to a low residual concentration by oxidation to water vapor on a catalytic surface. After the water vapor is removed, the resulting gas stream is circulated to an inservice gas decay tank and back to the waste gas compressor suction to complete the circuit.

Each gas decay tank is capable of being isolated and only one tank is valved into operation at any time the Waste Gas System is collecting influents to minimize the amount of radioactive gases which could be released as a consequence of any single failure, such as the rupture of a tank or connected piping. A gas decay tank is valved into the GWPS recirculation loop for one or two months after which time it is isolated and another tank is placed in service. By alternating the use of these tanks, the accumulated activity is distributed among nine gas decay tanks. An off line waste gas decay tank may be sampled while another waste gas decay tank is on line providing all Waste Gas System influents are secured and the curie content of the two waste gas decay tanks together (last sample may be used for the off line tank) is less than the maximum curie content used in the Chapter 15.7.1 analysis.

With continued plant operation, pressure in the gas decay tanks will gradually increase as non-removable gases accumulate in the system. The initial system equipment lineup as described above will be from the waste gas compressor to the hydrogen recombiner and then to the inservice gas decay tank. The flow rate from the recombiner into the gas decay tank, during these conditions, will be 50 scfm. As the inservice gas decay tank pressure builds up, compensation must be made by periodic adjustment of the hydrogen recombiner back pressure control valve. When the inservice gas decay tank pressure reaches 25 psig, the back pressure control valve will be full open so that no more adjustment can be made. At this time, the appropriate bypass lines are opened to line up the equipment for flow from the waste gas compressor to the inservice gas decay tank and then to the hydrogen recombiner. Here the flow rate will be 40 scfm. The hydrogen recombiner back pressure control valve is re-set as required for the new arrangement. This arrangement is suitable for operation up to 100 psig.

The low pressure mode of operation may be bypassed by pressurizing the waste gas decay tank to be placed into service to 25 psig or greater. This can either be done by pressurizing with nitrogen or by cross-connecting to a waste gas decay tank that has previously been in service and is of sufficient pressure. Using the cross-connecting method minimizes the amount of inert gas added to the Waste Gas System and thus extends the potential hold-up time prior to release. If pressurization by cross-connecting two waste gas decay tanks is performed, it must be verified that the curie content of the two waste gas decay tanks together is less than the maximum curie content used in the Chapter 15.7.1 analysis. In addition, it must be verified that the two tanks are isolated from Waste Gas System influents (VCT, PRT, RCDT, and Evaporators) during this evolution and the individual waste gas decay tanks must be re-isolated prior to being placed into service. The waste gas compressors may also be used to transfer the contents of one gas decay tank to another, if the curie content of the waste gas decay tanks together is less than the maximum curie content used in the Chapter 15.7.1 analysis and all Waste Gas System influents are isolated. Note that this high-pressure mode of operation also will normally be utilized during shutdown/startup operations.

11.3.2.3.3 Shutdown and degassing of the reactor coolant system

Plant shutdown operations are essentially startup operations in reverse sequence. The volume control tank hydrogen purge is maintained until after the reactor is shutdown and reactor coolant fission gas concentrations have been reduced to specified level. During this operation hydrogen purge flow may be increased to speed up reactor coolant degassing. At this time, the volume control tank hydrogen is stopped. Nitrogen purge from the nitrogen storage system is begun when the Unit is being shutdown and the bypass on the volume control tank vent line is opened. The 40 scfm flow of gas from the gas decay tank is split with approximately 5 scfm directed through the volume control tank and then to the waste gas compressor suction. The remaining 35 scfm flows through the hydrogen recombiner where the hydrogen is removed. The gas flow, depleted of hydrogen, then goes to the compressor suction where it combines with the purge flow from the volume control tank. The waste gas compressor discharges the gas stream back to the gas decay tank. Initially, the flow from the volume control tank will be predominantly hydrogen but, as degassing progresses, the hydrogen is removed by the recombiner and the flow will become primarily nitrogen. Multiple gas decay tanks are normally used to collect this nitrogen gas during the degassing process. Because of the difference in density between the gases, the throttle valve in the bypass line may require adjustment during the degassing operation to maintain a constant flow rate. The nitrogen purge continues until reactor coolant hydrogen concentration reaches the required level. Degassing is then complete and the Reactor Coolant System may be opened for maintenance or refueling.

11.3.2.3.4 System drains

During operation, water may accumulate in the waste gas compressor moisture separator, in the hydrogen recombiner phase separator, and in the gas decay tanks. Normally, the waste gas compressor and hydrogen recombiner drains will discharge automatically to the Equipment Drain System under motive head provided by internal component pressure. During maintenance, the drains are directed either to the recycle holdup tanks (if the drains contain dissolved fission gases), or to the waste holdup tank through the drain header (if the drains contain no dissolved fission gases). A gas trap is provided in the drain lines from the waste gas compressors and hydrogen recombiners to prevent undissolved gases from leaving the GWPS.

All drains from the waste gas decay tanks are manually operated. Depending on the internal tank pressure and on the drain routing, the waste gas decay tank drain pump is used or bypassed. Normally, the tank is drained by pumping the accumulated condensate to the recycle holdup tank. Gas traps are provided in the waste gas decay tank drain line to prevent the discharge of gases into other parts of the plant. All drains from the GWPS are filtered before entering the recycle holdup tank.

11.3.3 GASEOUS RADIOACTIVE RELEASES

Gaseous radioactive effluent will be released in accordance with the guidelines of the ODCM, 10 CFR 20 and 10 CFR 50, Appendix I, as described in Section 11.3.1. The GWPS is capable of monitoring radioactive gaseous discharge to the environment to ensure that activity concentrations do not exceed predetermined limits. If a limit is exceeded, discharge will be automatically terminated.

An estimate of the normal gaseous effluent from the facility, including anticipated operational occurrences, is presented in Table 11.3.3-1. The values were obtained using the guidance of NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from PWRs" (April, 1976) and the assumptions given in Table 11.3.3-2.

The tritium released through the ventilation exhaust systems during normal operation was also calculated. The exhaust quantity of tritium available for release was calculated using a functional relationship derived from measured liquid and vapor tritium releases at operating PWRs and the integrated thermal power output during the calendar year in which the release occurs. It is assumed that the tritium released through the ventilation exhaust systems is the total tritium available for release minus the tritium calculated to be released through the liquid pathway. The annual average concentrations of these normal operational effluents at the site boundary are given in Table 11.3.3-3. The concentrations are based on the highest annual average no decay, undepleted atmospheric dispersion factor, including terrain and recirculation correction factors, at the site boundary. Also shown in Table 11.3.3-3 is a comparison of the normal release concentrations within the limits of 10 CFR 20, Appendix B, Table II, Column 1.

The potential doses caused by the release of radioactivity in the gaseous effluent are given in Table 11.3.3-4. These exposures were calculated using the guidance of Regulatory Guide 1.109 (see Section 1.8) and are well within the limits of 10 CFR 50 Appendix I. It should be noted that Table 11.3.3-4 also demonstrates compliance with the September 4, 1975 Annex to Appendix I. Accordingly, a rigorous cost benefit analysis of compliance with Section II D of Appendix I is not provided.

Although it is not expected that the facility will operate for an extended period of time with design basis failed fuel, Table 11.3.3-5 presents the radioactive gaseous effluents should this condition persist for an entire year. The annual average radionuclide concentrations at the site boundary, based upon these releases, are also provided in Table 11.3.3-5, as is a comparison with the limits of 10 CFR 20, Appendix B, Table II, Column 1.

Section 9.4 presents the location of all gaseous release points, and provides the height and inside dimensions of each release point along with the effluent temperature and exit velocity. For additional discussion on the ventilation systems see Sections 12.2 and 12.3.

REFERENCES: SECTION 11.3

11.3.1-1 WCAP-15397, Revision 1, "Radiation Analysis Manual Model 312, Progress Energy, Harris Nuclear Power Plant Unit 1," J. I. Duo, January 2011.

11.4 SOLID WASTE PROCESSING SYSTEM

The Solid Waste Processing System (SWPS) collects, controls, processes, packages, handles, and temporarily stores radioactive waste generated as a result of normal operation of the plant, including anticipated operational occurrences. The SWPS prepares waste material for transportation to an offsite disposal facility. Provisions are provided for use of a Vendor Mobile Solid Waste Processing System.

The process technologies that are available through vendors include resin dewatering and solidification. Vendor processed wastes would be packaged in high integrity containers (HIC's), liners, or drums as appropriate. Reference to SWPS processing in the text that follows in Section 11.4 refers to the vendor-provided system(s).

Dry active waste (DAW) is now placed in appropriate transport containers and shipped to an off-site facility for volume reduction and ultimately shipped for disposal at an approved disposal site.

The abandonment of solidification system equipment does not preclude the return to service of the original liquid waste processing equipment that has been removed from service and placed in a lay-up condition. Spent resins, filter sludges, and evaporator bottoms can be processed by the currently available vendor-supplied solidification or dewatering systems. Therefore, to address the possible return to service of the original liquid radwaste process equipment, discussions on wastes produced by the LWPS is retained. These discussions are, however, augmented to include inputs from the MFTDS which is currently used to process the station's liquid radwaste.

11.4.1 DESIGN BASES

11.4.1.1 Design Objective and Design Criteria

The objective of the Solid Waste Processing System is to convert radioactive wastes into acceptable packaged forms for offsite disposal as solid waste. In addition, the SWPS is to provide a reliable means for processing the material while minimizing radiation exposure to plant personnel and the general public in compliance with the guidelines of 10 CFR 20 and 10 CFR 50. The SWPS receives wastes from LWPS, CVCS, BRS, SFPCCS, as well as solid radioactive waste such as contaminated paper, cloth, construction materials, laboratory supplies, and other non-retrievable items as are generated during the operation of the plant.

The specific design objectives are:

a) The SWPS is designed to provide for the collection, processing, packaging, and storage of solid wastes resulting from plant operations without limiting the operation or availability of the plant. Types of wastes, quantities (maximum and expected volumes), activities, and radionuclide distributions given in Tables 11.4.1-1 through 11.4.1-9 as inputs to the Solid Waste Processing System are accommodated in the system design.

In order to develop the radionuclide inventories for the SWPS, the following steps were taken:

1) The source terms (Primary Coolant-Secondary Coolant, Design Basis Normal Operation) in Section 11.1 were used,

2) A model of the LWPS was used. This model was used to obtain source terms (see Section 11.2) for the effluent of the LWPS, and

3) Used as input for the source terms for the SWPS.

b) The SWPS is designed to provide at least 60 days storage of spent resin in the spent resin storage tank during normal generation rates.

c) DELETED.

d) The SWPS is designed to hold one day of production of evaporator concentrates at normal generation rates before solidification is required.

e) The SWPS is designed to provide a reliable means of handling spent resins, evaporator concentrates, and filter particulates while maintaining the exposure levels to plant personnel within the permissible limits of 10 CFR 20.

f) The SWPS is designed to prevent the release of significant quantities of radioactive materials to the environs. This controls the radiation exposure to the public and operating personnel within the requirements of 10 CFR 20 and 10 CFR 50.

g) All radioactive waste is packaged in accordance with appropriate federal and state standards for burial in accordance with 49 CFR 170-179, 10 CFR 20, 10 CFR 61, and 10 CFR 71.

h) DELETED.

i) Design of the WPB Building and Fuel Handling Building, which houses the SWPS, to Seismic Category I requirements (Section 3.8.4) prevents uncontrolled releases of radioactivity due to anticipated operational occurrences. Foundations and adjacent walls to the WPB are designed to the Seismic Category I criteria to a height sufficient to contain the liquid inventory in the WPB. Section 3.2 lists the seismic and quality group classifications of the Solid Waste Processing System.

j) DELETED.

k) Any Vendor Solid Waste Processing System used by the plant will be designed in accordance with applicable portions of regulations, codes, and standards of the nuclear industry including 10 CFR 20, 10 CFR 61, Regulatory Guide 1.143, Regulatory Guide 8.10, ANSI Standard B31.1, and ANSI/ANS 55.1 or as stated in an NRC approved Topical Report.

l) With the exception of systems which contain, and are used to process, radioactivity at levels near to the environmental Lower Limit of Detection (LLD) (for example, sewage plant or settling basin sludge), all radioactive portions of a Vendor Solid Waste Process System will be located in the Waste Process Building or Fuel Handling Building to contain any spillage or leakage. Systems which contain and are used to process radioactivity at levels near the Environmental LLD do not need to be located within the Waste Processing Building or the Fuel Handling Building because the dose consequences from the release of this level of radioactivity is bounded by those calculated for an RWST rupture.

11.4.1.2 Process Control Program

The Vendor Solid Radwaste System will be operated in accordance with the Vendor's Process Control Program (PCP). These PCPs have been developed using the guidance of NUREG 0472 and NUREG 0133, and it shall be implemented and revised in accordance with SHNPP Technical Specifications.

The basic objectives of the PCP are as follows:

a) Waste Sampling - Representative samples of the waste to be solidified shall be taken and analyzed.

b) Waste Analysis - Samples to be solidified shall be analyzed for pH, percent solids, percent sodium sulfate, percent boron/boric acid, and activity as appropriate. At least every tenth batch of each type of waste shall have a sample solidification performed using the appropriate solidification formulas to verify that there is no free standing water.

c) Records - The appropriate solidification worksheet shall be used as a record of the solidification operation and provide documentation for the PCP.

11.4.2 SYSTEM DESCRIPTION

The SWPS dewaters or solidifies wet wastes generated during normal plant operation and packages the waste for off-site burial.

The Solid Waste Processing System consists of the following subsystems:

a) Waste collection and pretreatment subsystem

b) Waste solidification subsystem (Vendor Mobile Dewatering and Solidification)

c) Waste handling subsystem.

The waste collection and pretreatment subsystem consists of two solidification pretreatment tanks. Liquid wastes, such as evaporator concentrates (bottoms), and chemical drain solutions are processed for pH adjustment and mixing in the solidification pretreatment tank. All treated and processed wet wastes will be solidified or dewatered, as appropriate to the waste. This will be accomplished in accordance with the vendors' process control program (Subsection 11.4.1.2). The system description for the Vendor Solid Waste Process System and equipment is provided in the Vendor Topical Report.

All solidification/dewatering containers (i.e., drums, liners, and HIC's) are inspected and labeled for shipment off-site. Also, all containers are shipped and buried in accordance with 49 CFR 173-177, 10 CFR 61, and 10 CFR 71.

Of the various wet wastes that could be or are generated at the SHNPP, the current processing options that exist are as follows:

- Spent resin – Solidification or dewatering
- Filter backwash – Solidification or filter out particulate in disposable filters and encapsulate filters in cement or dewater and compaction
- Bag and Cartridge Filters – Encapsulate in cement or dewater and compaction
- Evaporator concentrates and other liquids – Solidification or incineration

The vents from the solidification system pretreatment tanks are routed to the WPB Vent, and are filtered through a low/medium efficiency filter, a charcoal adsorber, and a HEPA Filter. In addition, the vent exhaust from the following is routed through a HEPA Filter:

a) Filter Backwash Transfer Tanks

    1) Fuel handling building

    2) Secondary waste

    3) Waste processing building

b) WPB Filter Backwash Storage Tank

c) WPB Filter Particulate Concentrate Tank

d) Vendor Solid Waste Process Liners

e) Spent Resin Storage Tanks

The expected volumes of wastes to be shipped off-site are given in Table 11.4.2-1. The principal nuclides and associated curie content are given in Tables 11.4.2-2 through 11.4.2-3b. The radionuclide concentrations for the filtered particulates, spent resins, are consistent with the processing described in Sections 9.3.4 (Chemical and Volume Control System), 9.1.3 (Spent Fuel Pool Cooling and Clean-up System) and 11.2 (Liquid Waste Processing System).

11.4.2.1 System Component Descriptions

11.4.2.1.1 Tanks, Pumps, Valves and Piping

Table 11.4.2-4 summarizes the design data for the tanks and pumps which are used in the Waste Collection and Pretreatment Systems. The flushing water supplied at the suction of the pump is used to flush the piping after processing concentrates and slurries.

The piping and valves are designed, inspected, and tested according to ANSI B31.1. Materials are procured according to ASTM or ASME Section II with the welder qualification and welding procedures of ASME Section IX used where required.

Details of the resin sluice header and the waste evaporator concentrate tank are presented in Figures 11.4.2-4, 11.4.2-7, and 11.2.2-3.

11.4.2.1.2 Bridge cranes

Traveling bridge cranes located in the Waste Processing Building are designed and constructed for precise, remote handling of 55 gallon drums. All remote operations are monitored by closed circuit television cameras mounted on the bridge cranes.

Although almost all the process equipment forming the original SWPS has been removed from service and abandoned (Section 11.4), the operability of the crane accessing Room 144A is being maintained.

11.4.2.2 Design Features to Control Releases, Reduce Maintenance, and Improve Operations

The SWPS equipment remaining operable and the Vendor Solid Waste Process System are designed to provide a reliable means for processing waste by including appropriate equipment, interlocks, alarms, and fail-safe mechanisms so that the exposure of individuals to radiation in restricted areas is below the limit specified in 10 CFR 20 Section 101.

Tanks and other equipment are provided with level indication and alarms for high level conditions. The level alarms alert the operators when tanks are nearly full. Manual transfer from filled tanks to alternate tanks will then proceed. Curbing is provided in each tank cubicle to control liquid leaks and overflow. The floors in the cubicles are pitched to floor drains located at low points to facilitate floor drainage. These floor drains drain to the floor drain tanks which collect any liquid overflows and route them to the LWPS for processing.

Overflow of the waste evaporator tanks is piped to the equipment drains. Curbing prevents the spread of liquid from the cubicle. Provisions to prevent entry of the concentrates into the Floor Drain System are necessary to prevent potential solidification within the drainage system.

The system controls provide interlocks to prevent spillage from both potential operator errors and equipment malfunction. With the exception of systems which contain, and are used to process, radioactivity at levels near to the environmental LLD (for example, sewage plant or settling basin sludge), all solid waste processing equipment including Vendor Solid Waste Process System equipment containing radioactive fluids is located within the Waste Processing Building or Fuel Handling Building, any leakage or spillage resulting from operator error or equipment malfunction (single failures) is contained within the building. Thus, releases of radioactive material are prevented.

Provisions are incorporated in the layout of the system to allow for periodic inspection, using visual and monitoring instrumentation. Equipment is arranged and shielded to permit operation, inspection, and maintenance with ALARA personnel exposure. Tanks and processing equipment, which contain large quantities of radwaste, are shielded. Ventilation air flows from low activity areas to higher activity areas.

Pressure-retaining components or process systems utilize welded construction to the maximum practicable extent. Process piping systems include the first root valve on sample and instrument lines. Flanged joints or suitable rapid disconnect fittings are used only where maintenance or operational requirements clearly indicate that such construction is preferable. Screwed connections in which threads provide the only seal are not used except for instrumentation connections where welded connections are not suitable. Process lines are not less than 3/4 in.

Completed process systems are pressure tested to the maximum practicable extent. Piping systems are hydrostatically tested in their entirety except at atmospheric tank connections where no isolation valves exist. Testing of piping systems is performed in accordance with ANSI B31.1. The test pressure is held for a minimum of 30 minutes with no leakage indicated. Vendor Solid Waste System hoses will be pressure tested prior to use.

Materials for the pressure-retaining components conform to materials specifications of Section II of the ASME Boiler and Pressure Vessel Code or ASTM materials. Specific materials for each piece of equipment is shown in Table 11.4.2-4. Malleable, wrought, and cast iron materials have not been used. Manufacturer's material certificates of conformance with material specifications or certified materials test reports are required.

A quality assurance program has been established to assure that the design, construction, and testing requirements are met. The overall quality assurance program applied to the items listed in the component summary data tables, except those items listed as manufacturer's standard, is in accordance with the Engineering and Construction Quality Assurance Program which was approved by the NRC during the construction permit review.

11.4.2.3 Dry Waste Processing

Dry active waste (DAW) processing is now performed by an off-site vendor that utilizes the most effective type of volume reduction for the various types of DAW shipped from the Harris Station. The DAW is collected in shipping containers which are retained on site until a sufficient quantity of waste has been collected for shipment. This waste is then shipped to the off-site DAW processing facility where it is processed, packaged for disposal, and ultimately shipped to the low-level waste disposal facility. Provided in Table 11.4.2-1 is a projection of the annual quantity of DAW shipped for disposal from the SHNPP (i.e., from the SHNPP either directly or via the off-site DAW processing facility).

ndling and packaging of large waste material or equipment which become activated during reactor operation will be handled by personnel following appropriate radiation protection measures. Since each such item handled would have unique problems, the personnel, the methodology, and the packaging are determined for each case separately.

11.4.2.4 Containers for Waste

Several types of containers are used for waste shipping. If necessary these containers can be placed in shielded transportation casks for offsite shipment. The quantity and type of radioactivity shipped will determine if shielding is required and the strength of the shielding cask or overpack. The exact containers used for shipment are in compliance with 10 CFR 20, 10 CFR 71 and 49 CFR 170 through 49 CFR 179.

The projected maximum volumes of solid wastes are given in Table 11.4.2-1 with isotopic content of the wastes shipped offsite provided in Tables 11.4.2-2 through 11.4.2-3b.

All radioactive waste shipments from SHNPP will meet applicable state regulations.

11.5 PROCESS AND EFFLUENT RADIOLOGICAL MONITORING AND SAMPLING SYSTEMS

The Process and Effluent Radiological Monitoring and Sampling Systems monitor and furnish information to operators concerning activity levels in selected process systems and plant effluents.

The systems consist of permanently installed continuous off-line type monitoring devices together with provisions for specific routine sample collections and laboratory analyses. The overall systems are designed to assist the operator in providing information for evaluating and controlling the radiological consequences of normal plant operation, anticipated operational occurrences, and postulated accidents such that resultant radiation exposures and releases of radioactive materials in effluents to unrestricted areas are maintained as low as reasonably achievable (ALARA).

These systems are supplemented by the Area and Airborne Radioactivity Monitoring Systems described in Section 12.3.4.

11.5.1 DESIGN BASES

11.5.1.1 Process Radiological Monitoring System

The continuous Process Radiological Monitoring System, supplemented by the Process Sampling System, is designed to perform the following functions:

a) Provide assistance to operators to ensure the proper functional performance of the selected systems being monitored.

b) Provide for early detection of radioactivity leakage into normally nonradioactive systems, including primary-to-secondary leakage, and process system leakage into normally nonradioactive systems.

c) Provide information to plant personnel of radiation levels in liquid and gaseous process lines to permit proper control.

d) Provide information to plant personnel of any abnormal increase in normally radioactive or potentially radioactive process lines.

The process monitoring system complies with the design guidance of Appendix 11.5-A to Standard Review Plan 11.5 and the recommendations of ANSI 13.10-1974.

11.5.1.2 Effluent Radiological Monitoring System

11.5.1.2.1 Normal operations and anticipated operational occurrences

The Effluent Radiological Monitoring System is designed to perform the following functions in order to meet the requirements of 10 CFR 20, 10 CFR 50, General Design Criteria (GDC) 60 and 64, and to follow the recommendations of Regulatory Guides 1.21 and 1.97 (see Section 1.8 for the extent of compliance). All major and potentially significant paths for release of radioactive material are monitored in order to:

1. Provide representative sampling, monitoring, storage of information, indication and if necessary, alarm of liquid and gaseous radioactivity levels.

2. Provide the capability, during the release of radioactive liquid waste (treated laundry and hot shower tank, waste monitor tanks, and secondary waste sample tank) to alarm and initiate automatic closure of the appropriate waste discharge valves before effluent release limits are approached or exceeded.

3. Provide radiation level indication and alarm annunciation to the control room operators whenever radioactive effluent release limits are approached or exceeded.

4. Provide capability to detect non-condensable fission product gases so that the gases can be redirected to HEPA and charcoal filters before release to the environment.

5. Provide capability for automatically terminating the discharge to the normal discharge path (turbine building drains and tank area drains) and manually redirecting the discharge to the Waste Management System in the event of a high radiation content.

Section 11.5.2.3.1 discusses the techniques used to implement Regulatory Guide 1.21 for the Radiation Monitoring System.

The effluent monitoring system complies with the design guidance of Appendix 11.5-A to Standard Review Plan 11.5 and the recommendations of ANSI 13.10-1974.

All radioactive effluent pathways will be operated in accordance with approved procedures which require monitoring and grab sampling of all continuous effluent releases, as well as grab sampling of batch release effluent pathways prior to release. In addition, procedures will require the appropriate review and approval of each batch release. The control of monitoring, sampling, analysis, and accountability of each potential radioactive effluent pathway complies with the guidelines of Regulatory Guides 1.21 and 4.15.

11.5.1.2.2 Postulated accidents

The design objectives and use of the Process and Effluent Radiological Monitoring Systems for post-accident monitoring purposes are discussed in Section 11.5.2 and 12.3.4.

11.5.1.3 Process Sampling System

11.5.1.3.1 Normal operations and anticipated operational occurrences

The Process Sampling System provides grab samples to supplement the Process and Effluent Radiological Monitoring Systems, and in particular is designed to provide specific information regarding specific radionuclide composition of process and effluent streams. Additionally, each local monitor has provisions for obtaining manually a grab sample. Frequency of grab samples is discussed in the Offsite Dose Calculation Manual. A discussion of the Sampling System for radiological inputs to the Radiation Monitoring System (RMS) is found in Section 11.5.2.3.1.

Representative grab sampling from radioactive process tanks is done in the following tanks:

1. Waste Hold-up Tank
2. Waste Evaporator Condensate Tank
3. Waste Monitor Tank
4. Laundry and Hot Shower Tank
5. Reverse Osmosis Concentrate Tank
6. Recycle Hold-up Tank
7. Recycle Monitor Tank

The liquid waste tanks identified in Table 11.5.1-1 are designed with pumps, valving, and piping to assure representative sampling of the tank contents.

The recirculation pumps for these liquid waste tanks are capable of recirculating the liquid inventories at a rate of two tank volumes in at least eight hours and are designed so that they can be operated at two different points on their performance curve, respectively, for the process or recirculation mode. The corresponding flow rate capacities for the above mode are stated in Table 11.5.1-1. The tanks are provided with level switches which actuate lo/hi alarms that alert the operators to take necessary actions to prevent overfilling. During system operation, the liquid inventory in the tanks will be less than the design capacity; therefore, considering the margin between the design pump capacity and the pump run-out capacity, a representative sample of the various tank contents can be obtained in accordance with the criteria stated in SRP 11.5, II.2.a, excluding the recycle holdup tank.

Representative sampling of the recycle hold-up tank will be accomplished by recirculating the tank and taking samples. The recirculation time will vary based on: the liquid volume in a tank, the recirculation capability, the trending of the sample results taken during recirculation, and the uncertainty that can be tolerated. These considerations will be included in administrative controls for the sampling of the tank.

All of the vent systems indicated below exhaust into their respective vent stacks where, if required due to high radioactive concentrations, the off gas is filtered by a low/medium filter, charcoal adsorber, and HEPA filter before release to the environment.

1) Deleted per Amendment 62.

2) Various evaporator vent systems such as the RO concentrates evaporator.

3) Pre-treatment liquid radwaste tank vent systems.

4) Boron recycle system vent.

The turbine gland seal condenser exhaust is routed to the turbine building vent stack which is sampled and monitored by a wide range noble gas monitor as described in Section 11.5.2.7.2.18.

11.5.2 SYSTEM DESCRIPTION

11.5.2.1 Continuous Process and Effluent Radiological Monitoring

The requirements of the system design bases for continuous monitoring are satisfied by a system of off-line type monitoring channels for the in-plant liquid and gaseous process and effluent lines.

Continuous monitoring means that the monitor operates uninterrupted for extended periods during normal plant operation. The monitor may occasionally be out of service for maintenance, repair, calibration, etc., during which time the frequency of sampling of the particular stream may be increased, depending on the past history of the radioactivity level of the stream.

Off-line radiation detection instrumentation is associated with liquid and gaseous process and effluent streams, in order to monitor trends in radionuclide concentrations in such streams. As trend-measuring devices, such instrumentation will furnish information on type and rates of changes in radiation levels. Type and rate of change measurements can be obtained through measurements of gross gamma or beta activity and/or a select energy basis dependent upon the isotopic composition of a particular stream. The monitoring system is operated in conjunction with regular and special radiation surveys and with radiochemical information for continued operation. Continual indication of radiation levels for normal operation, for anticipated operational occurrences and for a reasonable range of accident conditions is maintained for each channel associated with the monitoring system. Alarm annunciation and alarm setpoint adjustment will be centralized within the Control Room, the WPB Control Room, and the Radiological Control Center.

Tables 11.5.2-1 and 11.5.2-2 are tabulations of basic information describing each of the continuous process and effluent radiological monitors and samples, including monitor location, type of monitor and measurement made, sampler and/or detector type, range of activity concentrations to be monitored, typical alarm setpoint, provisions for power supplies, and automatic actions initiated.

The basis for the ranges listed in Tables 11.5.2-1 and 11.5.2-2 are as follows:

1. Process Monitors

   a. Maximum expected concentrations during normal operations and anticipated operational occurrences, as well as range of expected concentrations.

b. The highest sensitivity commercially available when purchased in order to detect process system leakage contamination as early as possible.

2. Effluent Monitors

a. Range of expected concentrations during normal operations and anticipated operational occurrences.

b. Sufficient sensitivity to detect gross gamma or beta activities below the limits specified in 10 CFR 20 prior to dilution in the atmosphere or water discharge canal.

The actual high alarm values are determined in accordance with the Off-site Dose Calculation Manual (ODCM); therefore, the values listed in Tables 11.5.2-1 and 11.5.2-2 should be interpreted as typical values.

11.5.2.1.1 General system description

The Process and Effluent Radiological Monitoring Systems provide the means for monitoring the major liquid and gaseous paths by which radionuclides may be released to the environment either under normal operating conditions or under abnormal plant accident conditions, and as such are an integral part of the Radiation Monitoring System, which is described in detail in Section 11.5.2.3.

The Process and Effluent Radiological Monitoring Systems consist of cabinet or skid mounted individual liquid or gaseous monitors. These are composed of individual channels, with a channel consisting of a sampling chamber, check source, and detector. The detector assembly consists of a gamma or beta sensitive scintillation crystal, a photo-multiplier tube and local amplifier. All channels associated with a monitor are served by a local, dedicated microprocessor, and all channel information is processed through this microprocessor, which is then polled by the appropriate radiation monitoring system computer for further processing, indications on cathode ray tubes, storage, remote alarming and hard copy production if so desired.

All liquid effluent and process radiation monitors are of the side-stream type and are isolable, by isolation valves, from the process stream which they monitor. Each liquid radiation monitor is provided with demineralized water flushing capability. Each liquid monitor is also designed to allow removal of the detector without breach of the process liquid boundary (i.e. Detection Systems are of the well-type.)

The monitors used to monitor the gaseous paths of the Process and Effluent Radiological Monitoring Systems have the capability to be replaced or decontaminated without opening the process systems or losing the capability to isolate the effluent stream. Each gaseous radiation monitor skid has manually-operated ball valves at the skid inlet and outlet for isolation during monitor servicing. During monitor servicing, effluent grab sampling will be conducted in accordance with the Offsite Dose Calculation Manual.

The Process and Effluent Monitoring System will conform with Regulatory Guide 4.15.

11.5.2.1.2 Power supplies

Each channel is provided with an independent power supply, designed such that a failure in that channel does not affect any other channel. Monitors that are identified as safety related are redundant where redundancy is required and are supplied power from the station 120V AC safety related buses. The power supplies for these channels are identified in Tables 11.5.2-1 and 11.5.2-2. Power to the channels that monitor only normal operations is supplied from the station regulated 120V AC instrumentation bus.

11.5.2.2 DELETED BY AMENDMENT NO. 44

11.5.2.3 Radiation Monitoring System

11.5.2.3.1 System function and operation

The description which follows applies to all radiation monitoring equipment discussed in Section 5.2.5, 11.5, and 12.3.4.

The major function of the Radiation Monitoring System (RMS) is to provide plant operations personnel and health physics personnel with both current and historical measurements of radiological conditions in certain areas and plant systems during both normal and design basis conditions. In addition, this system automatically produces alarms to warn plant personnel, and in certain cases exerts control action when unusual radiological conditions or equipment malfunctions occur. All information is presented as efficiently and unambiguously as possible.

The RMS is a comprehensive, plant-wide radiation information gathering and control system encompassing the process and effluent monitors and the area and airborne monitors. The RMS is a digital, distributed microprocessor-based system in which full functional capability resides locally at the microprocessor controlling each monitor. The RMS is divided into a non-safety related portion and a safety related portion, with all equipment in the latter designed in accordance with 308-1974, 323-1974, 336-1971, 344-1975 and 384-1974. All safety related monitors are also designed in accordance with IEEE-279-1971, with the exception of the following monitors: containment leak detection monitor, main steam line monitors, plant vent stack wide range gas monitor, and control room area monitor. Equipment critical to safety is qualified in accordance with NUREG-0588 and Regulatory Guide 1.89.

The non-safety related portion of the RMS is composed of the local monitors (Section 11.5.2.4) and four operator's consoles, one located in the Control Room, Computer Room as well as the Radwaste Control Room, and the Radiological Control Center.

Each operator's console is associated with a dedicated minicomputer, CRT, and printer. Each monitor is part of a loop, each loop connecting two minicomputers. The minicomputers which are so connected are: Control Room and Computer Room and the WPB Control Room and the Radiological Control Center.

Communication is in either direction along the loop, thereby assuring redundancy in the event of any single failure. Each microprocessor in a loop is controlled by either of the two minicomputers with which it is associated.

Information from the monitors is displayed at the CRT. Since all four minicomputers are interconnected, the information is shared among all four minicomputers and available to all four operator's consoles. Information includes radiation level in the proper engineering units or counts per minute (cpm), effluent release rate, monitor status and alarm status. Each monitor has two upscale trips for alert and high radiation, and one downscale trip to indicate monitor failure. Monitor failure includes: low flow, torn filter paper, and detector failure (low count). Controlled functions include monitor setpoints, purging, checksource activation, and monitor testing.

The safety related portion is composed of the local monitors (Section 11.5.2.4) and two safety related panels, one for each of two electrical divisions A and B. Each monitor is remotely controlled by its own dedicated display and control module located in the appropriate panel. Information is displayed digitally using LED displays.

Additionally, the safety related monitors are grouped into loops, each between two non-safety operators' consoles, similar to those of the non-safety monitors. All communication loops between the safety monitors and non-safety related operators' consoles have properly qualified 1500V, optical isolation buffers, and are used solely for the purpose of transmitting information from the monitor. No control can be exercised by the non-safety related portion of the RMS over the safety related monitors. With this technique, information from all the monitors is normally available at the operators' consoles' CRT. The dedicated display and control modules provide the same annunciation/control capabilities for safety related monitors as the non-safety operators' consoles provide for non-safety monitors.

A schematic of the Radiation Monitoring System is shown on Figure 11.5.2-1.

11.5.2.4 RMS equipment description

11.5.2.4.1 Monitor (cabinet/skid)

Each fluid monitor is a skid mounted self-contained instrument package consisting of the requisite number and type of channels, and sampling pumps, valves, interconnecting piping, fittings, flow and pressure indicators, controls and local annunciators, and process fluid pre-conditioners, as required. All skid mounted monitors obtain for analysis a suitable continuous fluid sample of the process or effluent stream and return the sample to the process or effluent stream in a closed loop. Each skid mounted monitor is located as close as practical to the process or effluent stream, such that sample line losses or transit time is minimized.

Cabinet mounted monitors consist of remote ambient detector assemblies connected to a cabinet mounted electronics package.

11.5.2.4.2 Sample chamber (fluid monitors)

The sample chamber is sized and shielded in a 4-pi geometry as required to achieve the specified minimum system sensitivities. Each sample chamber is constructed of 300 series stainless steel. The sampling chamber is designed to operate within the environmental conditions for the area in which they are located. Sample chamber decontamination is provided through the use of removable chambers.

11.5.2.4.3 Detector assembly

11.5.2.4.3.1 Fluid monitor detector assembly

The detector assembly associated with a skid mounted fluid sample monitor is a completely weatherproof assembly, housing a detector, photomultipliers, and radiation check source. The assembly is capable of withstanding the design pressure of the piping system of which it is a part, without leakage, collapse of the tube walls, or damage to the detector. Sample temperature is controlled, where required, within the design limits of the detector.

11.5.2.4.3.2 Ambient detector assembly

The ambient detector assembly is an assembly housing two detectors. One detector is shielded against Beta to provide an indication about background effects. The assembly is capable of withstanding the maximum ambient temperature, pressure, and radiation required of the intended service.

11.5.2.4.4 Check source

Each detector assembly is provided with a solenoid operated check source to be used for operational and gross calibration checks of the detector and readout equipment. All check sources have half-lives greater than seven years. In addition a recalibration of the detectors will be performed at periodic intervals.

11.5.2.4.5 Microprocessor

The functions of each monitor are controlled by a local dedicated microprocessor mounted in its own NEMA-12 cabinet. The microprocessor performs all required communications, calculations, data logging, and validity checking, control and annunciation: The microprocessor shall receive, process, and transmit system information upon request. Alarms will be generated and displayed following the exceeding of alarm setpoints or whenever a channel becomes inoperative. The microprocessor also has the capacity to activate the check source into position, control sampling, and purging as appropriate for the monitor.

Each microprocessor, which is part of the non-safety related portion of the RMS can be controlled locally by a plug-in readout and control unit which can perform all the display and control functions which the panel mounted display and control module of the safety related portion can perform.

Each microprocessor of the safety related portion of the RMS has a local dedicated display module mounted on the front of the microprocessor cabinet. This is similar to the remote, panel mounted display and control modules which are located in the Control Room except that no provisions exist for microprocessor data-base access. This access, if required, is provided by the portable plug in readout and control units. This is done to prevent unauthorized changes of monitor data-base. Otherwise local annunciation is as described for each system.

Access to all control functions in the control room is via a numerical security code and/or key available to authorized personnel only.

All microprocessors are designed to operate at 32°F to 131°F, 0 to 95 percent humidity, and are designed for an integrated lifetime radiation dose of 1000 rads.

Information stored in the microprocessor includes radiation histories, expressed in the proper engineering units, and effluent release rates as required for effluent monitors in accordance with Regulatory Guide 1.21 (see Section 1.8). Data files will be grouped into 24-10 minute, 24-one hour, and 28-one day history averages.

All information is protected in random access memory (RAM) for eight hours in the event of power interruption; all microprocessors are capable of self-initialization and reload from their own data base within this eight-hour period; following these eight hours re-initialization requires a reload from the appropriate minicomputer with which the microprocessor is associated, or as in the case of the safety related monitors, via manual entry from the portable control device or the safety related readout and control device in the control room.

11.5.2.5 RMS Detector Types

11.5.2.5.1 Low range GM tube detector

The detector is constructed from a halogen-quenched GM tube operated in the pulse mode. A charge amplifier is used to provide the necessary charge amplification and impedance matching to drive these pulses up to 1000 ft. over a standard twisted shielded pair. Output pulse rates range from 10 to 10^6 cpm in response with radiation over a range of 10^{-1} to 10^4 mR/hr.

At radiation levels above the pulse mode range of the detector, the GM tube saturates. A special circuit detects this and actuates an oscillator circuit which drives the signal line at the maximum pulse rate corresponding to a full-scale indication.

Energy dependence is $\pm$ 20 percent over a range of 80 Kev to 2.5 Mev; operating at 600V DC the response to ionizing radiation is $\pm$ 2 percent from 40°F to 131°F; maximum operating temperature is 131°F; and maximum operating humidity is 100 percent. Operating life equals 1010 tube discharges.

A 1.0 micro-Ci C1-36 beta check source actuated by a spring return solenoid is used to provide a one-decade response indication of actuation. In the non-actuated position, this source will provide an artificial background indication corresponding to the beginning range of the unit.

11.5.2.5.2 Extended low range GM tube detector

The detector is a modified version of the GM detector mentioned in Section 11.5.2.5.1. The only difference between the two units is that the GM tube of this detector has been modified to increase the sensitivity of the unit to give an operating range of 10^{-2} - 10^3 mR/hr.

11.5.2.5.3 High range ion chambers

The detector is constructed from an ion chamber. Gamma photons strike the detector and form ion pairs in the filter gas of the detector. These ion pairs are collected and integrated by an external circuit forming a current output which is displayed on a logarithmic scale. The output current is conducted to the signal processor over the coaxial cable.

At radiation levels above the range of the detector, the ion chamber no longer continues to increase output current linearly with absorbed dose. Instead, the output current reaches a maximum value and remains at that level until the gamma flux intensity diminishes to a level back in the operating range of the unit.

11.5.2.5.3.1 Ion chamber (10^1 to 10^7mR/hr)

Energy dependence is $\pm$ 15 percent over a range of 100 Kev to 2.5 Mev; output sensitivity is approximately 1 x 10^{-9} A/R/hr.; the operating range of the ion chamber is from 10^1 - 10^7 mR/hr. No check source is needed.

11.5.2.5.3.2 Digital high range ion chamber

Operating range is from 1 to 1 x 10^8 R/hr with a typical sensitivity of 1 x 10^{-11} AMP/R/hr. It is designed to withstand post LOCA conditions and will operate in temperatures up to 350 degrees (F). No check source is needed.

11.5.2.5.4 Beta sensitive detector

This beta sensitive detector monitors beta emitting samples within its solid angle sensitive volume. The detector is constructed from a 0.625 in. thick, 2 in. diameter plastic beta scintillator coupled to a photomultiplier tube.

The minimum detectable beta energy is 150 Kev. Per ANSI N13.10-1974, and using the microprocessor software for signal processing, the minimum detectable concentration for Kr-85 is 3.1 x 10^{-8} μCi/cc, with a sensitivity for Kr-85 of 2.81 x 10^8 cpm/μCi/cc, and a background count of 200 cpm. A 1 μCi C1 36 beta check source is provided.

11.5.2.5.5 Noble gas detector

The noble gas detector is constructed from a 3 in. thick, steel-jacketed, horizontal, cast-lead cylinder which provides a 4-pi shield around an easily removable 3.2-liter stainless steel sample canister. Inside the canister the gas is viewed by an aluminum-foil-covered 2 in. diameter beta scintillation phosphor coupled to a 2-in. diameter photomultiplier tube through a pressure boundary light pipe.

The minimum detectable beta energy is 150 Kev. Per ANSI 13.10-1974, and using the microprocessor software for signal processing, the minimum detectable concentration for Xe-133 in a 2.5 mR/hr 1.0 Mev gamma background is 1.4 x 10^7 μCi/cc, with a sensitivity for Xe-133 of 4.3 x 10^7 cpm/ μCi/cc, and a background count of 133 cpm. Maximum operating temperature is 131°F. Maximum operating pressure is 15 psia. A < 0.05 μCi C1-36 beta check source actuated by a spring return solenoid is used to provide a one-decade response indication on actuation.

11.5.2.5.6 Noble gas detector

This detector is a shielded gamma scintillation detector assembly designed to measure gamma emissions in gas samples in a gamma flux background. It is constructed from a steel jacketed, horizontal, 3 in. cast lead cylinder capped at one end by a lead plug. A lead door provides access to the detector and is designed to permit entry and exit of the sample flow line. The lead provides a 3 in. 4 pi shield around a removable stainless steel sample well. The sample gas activity level is monitored by a 1 1/2 x 1 in. NaI (T1) scintillator crystal optically coupled to a photomultiplier (PM) tube.

A solenoid operated checksource to verify detector operation is mounted on the shield assembly. The sensitive volume is 1.5 gal. with a typical sensitivity of 2.18 x 10^7 cpm/uCi/cc. The operating temperature is 35 to 130°F with an operating pressure of -2 to 5 psig. The checksource is a 9 microcuries Cs 137 gamma source.

11.5.2.5.7 Liquid detector

The detector is constructed from a 3 in. thick, steel-jacketed, horizontal cast lead cylinder which provides a 4-pi shield around a removable 6.2-liter polished stainless steel sample canister. Inside the canister, the fluid is viewed from a detector well by a 1.5 in. thick by 1.0 in. diameter NaI gamma scintillation crystal coupled to a 1.5 in. diameter photomultiplier tube.

The minimum detectable gamma energy is 70 Kev. Per ANSI N13.10 1974, and using the microprocessor software signal processing, the minimum detectable concentration for a liquid Cs-137 sample in a 2.0-mR/hr., Co-60 gamma background, is 4.1 x 10^{-7} µCi/cc, with a sensitivity Cs-137 of 1.28 x 10^8 cpm/µCi/cc, and a background count of 1172 cpm. Maximum operating temperature is 131°F. Maximum operating pressure is 150 psia except for the service water and component cooling water monitors whose maximum operating pressure is 300 psig. The sample flowrate is approximately 6 gpm.

Actual background will of course vary from this reference condition and will depend on the particular location of the liquid detector for the locations located in Table 11.5.2-1. Background radiation is expected to be less than 1.0 mR/hr during normal operation.

A 9 micro-Ci Cs-137 gamma check source actuated by a spring return solenoid is used to provide a one-decade response indication on actuation.

11.5.2.5.7.1 Adjacent to line liquid detector

The RD-64-511 adjacent to line liquid detector is a high temperature, gamma sensitive detector. The radiation detector sensor is a 2 inch thick by 2 inch diameter NaI (TI) gamma scintillation crystal coupled to a 2 inch diameter photomultiplier tube. The shielded detector is situated perpendicular to the liquid line and is provided with a near 4π, 5 inch lead shield.

The minimum detectable gamma energy is 70 Kev. Per ANSI N13.10-1974, and using the microprocessor software signal processing constant, the minimum detectable concentration for a liquid Cs-137 sample in a 1.0 mR/hr Co-60 gamma background is 1.5 x 10^{-6} µCi/cc, with a sensitivity of 4.56 x 10^7 cpm per µCi/cc, and a background count rate of 179 cpm. The maximum operating temperature is 140°F.

Actual background will vary from this reference condition and is expected to be less than 1.0 mR/hr during normal operation. A Cs-137 gamma checksource actuated by a spring return solenoid is used to verify detector response to radiation.

11.5.2.5.8 Moving filter particulate detector

The detector uses a rotary solenoid to advance a 2.75 in. wide filter paper across a 1.7 in. length sample point aperture. The filter advance rate can be varied or stopped entirely, and operated as a fixed filter. Typical speed is 1.00 in. per hour. Particulate-laden air enters the assembly through the sample inlet and is deposited on the face of the filter (dropout is onto the filter). The point of deposition is viewed by a 0.625 in. by 1.125 in. side window beta scintillation detector which, together with the aperture port and filtering point, is surrounded by 2.5 in. of 4-pi lead shielding.

The minimum detectable beta energy is 150 Kev. Per ANSI 13.10-1974, and using the microprocessor software signal processing the minimum detectable concentration for Cs-137 is 6.2×10^{-12} μCi/cc in a 2.5-mR/hr., Co-60 gamma background (after equilibrium) with a filter speed of 1.0 in./hr.; a filter efficiency of 99 percent for particulates 0.3 microns or larger; with a sensitivity for Cs-137 of 1.08×10^{5} cpm/ μCi deposited, and a background count of 74 cpm. Maximum operating temperature is 131°F. Maximum operating pressure is 2 psia.

A < 0.05 μCi C1-36 beta check source actuated by a spring return solenoid is used to provide a one-decade response indication on actuation.

11.5.2.5.9 Deleted by Amendment No. 46

11.5.2.5.10 Iodine and noble gas detector

The detector is constructed from a single, cast block of solid lead which provides 3 in. of 4-pi lead shielding around the two detectors. Each detector is inserted into a steel-lined sampler bore case into the shield. In the iodine channel, the sample enters the sampler bore between the scintillation detector and the filter cartridge assembly. Iodine is absorbed into the filter as the sample passes through the filter and exits through the outlet downstream of the filter. Radioactive iodines, absorbed into the filter, are viewed by a 2 in. x 2 in. NaI gamma scintillation crystal.

In the noble gas channel the sample enters the sampler bore in front of the scintillation detector and exits a few inches farther away. The free volume element viewed by the 3 in. diameter beta scintillation phosphor coupled to a 2 in. diameter photomultiplier tube is 410 cc.

The minimum detectable gamma energy for the iodine detector is 100 Kev. The minimum detectable beta energy for the gas detector is 150 Kev. Per ANSI 13.10-1974, and using the microprocessor software for signal processing, the minimum detectable concentration with the iodine detector for I-131 in a 0.1 mR/hr, Co 60 gamma background, after two hour of flow, using a TEDA impregnated charcoal cartridge, at 3 scfm is 1.05×10^{-12} μCi/cc. The minimum detectable concentration with the radiogas detector for Xe-133 in the same gamma background conditions is 1.53×10^{-7} μCi/cc. Maximum operating temperature is 131°F. Maximum operating pressure is 15 psia. The sensitivity for I-131 is 1.01×10^{5} cpm/μCi. The sensitivity for Xe-133 is 1.84×10^{7} cpm/μCi/cc with a background count of 40 cpm.

A < 9 micro-Ci Ba-133 gamma check source actuated by a spring return solenoid is used to provide a one-decade response indication from the iodine detector on actuation. A < 0.05 micro-Ci C1-36 beta check source mounted in a similar fashion to the iodine detector is used to provide a one-decade response to the radiogas detector when actuated.

11.5.2.5.11 Wide range noble gas monitor

In adherence to NUREG 0737 and Regulatory Guide 1.97, Rev 3 Wide Range Noble Gas Monitors are provided to monitor the range of activities that may exist during normal and post-accident operations.

These wide range Noble gas monitors shall make use of separate isokinetic nozzles for isokinetic sampling in the normal flow range of the stack.

In order to assure that plant personnel have access to certain assemblies of the monitor (such as the particulate and iodine sample filters) during a high-range release condition, the monitor is divided into separate assemblies that are located in such a way as to minimize personnel exposure to the postulated high levels of radiation.

There are five assemblies: (a) Isokinetic Nozzles; (b) Sample Conditioner; (c) Wide-Range Gas Detectors; (d) Electronics; and (e) Readouts. Each of these assemblies are described below. Skid assemblies (b) and (c) are of open design to allow access to parts and to allow cooling by natural convection. All plumbing and piping are stainless steel and all connections are leak tested prior to shipment. All electrical power needed is distributed from the Wide-Range Gas Detector assembly.

1. Isokinetic Nozzles - Two sets of isokinetic nozzles are normally used - one for normal and one for high-range conditions. These two nozzles are located inside an isokinetic sampling skid. An isokinetic nozzle array is located in the sampled stack to obtain and deliver the isokinetic sample to the skid through a single tube. Isokinetic nozzles are used to ensure representative particulate and iodine grab samples (see below). Both isokinetic nozzles are mounted inside the sample stream coming from the duct-mounted nozzle array. The normal isokinetic nozzles operate at 1.6 ft^3/min, whereas the high-range isokinetic nozzle operates at 0.06ft^3/min to minimize activity build-up. The sample acquisition rate is controlled by a dedicated micro-processor for each sampling skid to assure an isokinetic sample is taken. The location for the nozzle assembly in the effluent stacks was chosen in accordance with ANSI N13.1-1969.

2. Sample Conditioner - This skid assembly is located downstream from the isokinetic sampling skid. Its purpose is to provide representative particulate and iodine grab samples for laboratory analysis (in accordance with NUREG 0737), and to prevent contamination of the gas monitor by filtering out large concentrations of radioiodines and particulates. Without the sample conditioner, the monitor would become contaminated and remain upscale even when actual radioactive gas levels decreased. To provide enough filtering material to contain the radioiodines and particulates for the duration of the measured period, special multiple filters are used. Filters on the high-activity flowpath have full 4 pi solid lead shielding to minimize personnel exposure. Fast disconnect fittings are provided for the grab sample filters. Grab sample actuation and duration are non-safety RMS control room panel functions (see below). The sample conditioning assembly shall be accessible during a high-range condition to retrieve grab samples. Based on the Design Basis Shielding envelope assumptions presented in Table II.F.1-2 of NUREG-0737, the radiation exposures of personnel retrieving the samples will not exceed GDC 19 criteria.

Particulate and iodine filter efficiencies are typically 99 percent.

3. Wide-Range Gas Detectors - This skid assembly contains the three radioactive gas detectors that monitor radioactivity concentrations from 10^{-7} to 10^{5} μCi/cc. This assembly also contains the necessary pumps, flow control valves, flowmeters, etc. Each detector has a solenoid-actuated, checksource to verify proper operation and is full 4 π cast-lead shielded to reduce background effects. The twelve decades of Noble gas concentrations are monitored continuously by the three detectors with at least one decade overlap between ranges of the individual detectors. Table 11.5.2 2 shows the ranges of the three detectors for Xe-133. The low-range detector utilizes a plastic scintillator, whereas the mid- and high-range detectors are solid-state. As above, there are two flow paths through the detectors. During normal operation, only the low-range detector is used and the mid-range and high range detectors are bypassed. As the low-range detector begins to saturate, the flow path is automatically changed to the mid and high range detectors and the low range detector is purged. This prevents contamination of the low-range detector so that it will be available when it is automatically returned to service to measure radioactive gas concentrations as they return to low levels. The only solid-state electronics mounted on the skid are the detector preamplifiers which are provided with full 4 π lead shielding to minimize radiation exposure. Without shielding, these electronics could not survive accident levels of background radiation for the duration of the accident condition.

4. Electronics - The monitor is controlled by a microprocessor. The microprocessor performs flow control, valve actuations, engineering conversions, and other calculations and control functions, in addition to data storage. It shall be remotely located from the detectors, near the control room in a low radiation area. It contains the microprocessor, memory, high-voltage power supplies, preamplifiers, battery back up, etc. Mounted adjacent the microprocessor is a junction box for termination of user cables between the RM-80 and other assemblies of the monitor.

5. Readouts - There are four readouts available. One readout is in the control room and three are in the hot chemistry lab. They are microprocessor based and provide a display of all monitored parameters. These include channel activity in μCi/cc, effluent release rates (μCi/Sec), alarm status, etc. The local microprocessor also maintains history files of twenty four 10 min., twenty four 1 hour, and twenty eight 1 day averages of channel activity that are available for recall via the CRT. Purge and grab sample control as well as effluent activity indication shall be provided for via labeled control switches and display modules, which will be located in a control cabinet. From the control cabinets located in either the main control room or the hot chemistry lab, the operator is able to select clean prefilters, should one set be loaded to the point where appreciable concentrations of xenon off gas is produced by iodine decay. Remote selection is dependent upon the selected path being valved "open" locally. In this manner, the Noble gas detector will not interpret iodine daughter xenon as Noble gas going out the stack. Additionally from the control cabinet the operator may also take grab samples of 1 to 99 minutes duration for the low range flow path and 0 to 99 seconds for the high-range flow path.

An isokinetic sampling skid and an associated Flow Rate Monitor control system are utilized to achieve isokinetic flow conditions for isokinetic sampling of the effluent for WPB Vent Stack 5, WPB Stack 5A and PVS. The Flow Rate Monitor calculates stack flow by monitoring auxiliary contacts from each running fan that feeds the vent stack. As fans are started, their respective design flow rates are summed to calculate total stack flow. For the PVS Flow Rate Monitor, flow transmitters for some of the exhaust fans are used to provide actual flow signals in lieu of individual design flow rates for the calculation of total stack flow. Total stack flow is then converted by the Flow Rate Monitor using an isokinetic sampling ratio to determine the skid flow rate that is required to maintain isokinetic flow through the Isokinetic Sampling Skid. To maintain isokinetic flow through the skid, the Flow Rate Monitor positions a flow control valve to restrict air flow to the sampling pump.

11.5.2.5.12 Extended range area monitor (ERAM)

This monitor uses two detector assemblies with overlapping ranges to provide a full extended range for the monitor of 10^{-1} to 10^{7} mR/hr.

One of the detectors is a GM tube with a dose rate range of 10^{-1} to 10^{4} mR/hr. The GM tube produces an output pulse for each gamma photon striking the tube. If the number of photons detected by the GM tube exceeds the saturation level, indicated output remains at full scale as long as the saturation condition persists.

Output pulse rate ranges from 10^{1} to 10^{6} cpm (10^{-1} to 10^{4} mR/hr). Operating limits are 32°F to 131°F and 0 percent to 100 percent humidity (weatherproof).

The other detector is an ion chamber with a range of 10^{2} to 10^{7} mR/hr and a sensitivity of 1.2 x 10^{-10} A/R/hr. Energy dependence is $\pm$ 20 percent from 80 keV to 3 Mev.

Operating limits are 30°F to 131°F and 0 percent to 100 percent humidity. Radiation lifetime is 5 x 10^{5} rads integrated dose.

The full ERAM is constructed of five subassemblies: the two detectors described above, a microprocessor assembly (described into Section 11.5.2.4.5), a customer interface junction box and a local annunciator assembly described in Section 12.3.4.1.5.

11.5.2.6 Monitor Equipment Configuration

11.5.2.6.1 Ambient gas monitor

Each ambient gas monitor uses the beta sensitive detector described in Section 11.5.2.5.4. This monitor has two detectors per channel, one of which is shielded against betas thereby yielding active background information. The unit is inserted into a duct or plenum, attached to the duct wall, and pointed at the free volume to be monitored.

11.5.2.6.2 Liquid radiation monitors (L)

Each liquid radiation monitor uses the liquid detector described in Section 11.5.2.5.7. Each monitor skid is supplied with one centrifugal pump used to obtain a continuous fluid sample, demineralized water for purging, heat exchanger where the sample temperature may exceed 120 F, and drain connection to the appropriate waste system. A sample connection to which a sample bomb may be attached is provided.

11.5.2.6.3 Adjacent to Line Radiation Monitors (ATL)

The ATL liquid monitor uses the detector described in Section 11.5.2.5.7.1. The radiation monitor looks at the process stream directly with no sampling required.

11.5.2.6.4 Airborne particulate, iodine and noble gas monitor (PIG)

Each particulate, iodine, and noble gas monitor uses the moving filter particulate detector and the iodine and noble gas detector described in Sections 11.5.2.5.8 and 11.5.2.5.10, respectively.

Each non-safety related monitor skid is supplied with one pump and each safety related monitor skid is supplied with two parallel pumps for redundancy; flow is from the particulate detector to the iodine detector and then to the noble gas detector. All PIGs are supplied with automatic flow control, and sample probes used to obtain isokinetic samples in accordance with ANSI N13.1-1969.

A sample connection from which grab samples of particulates and iodines can be obtained is provided.

11.5.2.6.5 Airborne particulate and noble gas monitor (PG)

Each particulate and noble gas monitor uses the particulate detector and noble gas detector described in Sections 11.5.2.5.8 and 11.5.2.5.6. Particulate and noble gas monitors are used for the Containment Leak Detection Monitor and the Containment Pre entry Purge Monitor. Each monitor skid is supplied with two parallel pumps for redundancy; flow is from the particulate detector to the noble gas detector. All PGs are supplied with automatic flow control, and sample probes used to obtain isokinetic samples in accordance with ANSI N13.1-1969.

Sample connections to which a flow through sample chamber can be attached is provided for grab sampling.

11.5.2.6.6 Noble gas monitor (G)

The noble gas monitor uses the noble gas detector described in Section 11.5.2.5.5. The monitor skid is supplied with one pump, heat exchanger when the sample temperature can exceed 120°F, and heat tracing to prevent condensation where sample humidity is near condensation. A sample connection to which an evacuated sample bomb may be attached is provided. The heat exchanger, in addition to cooling the sample also removes moisture from the sample stream. Therefore, heat tracing downstream of this heat exchanger is unnecessary. Heat exchange and moisture condensation collection occurs on a separate skid.

11.5.2.7 Process and Effluent Radiological Monitors

See Table 11.5.2 1 for operating information on the process radiological monitors.

11.5.2.7.1.1 Component cooling water system monitors

The component cooling water system monitors are part of the safety related portion of the RMS (Section 11.5.2.3) and provide an indication to operations personnel whenever the activity in the

Component Cooling Water System reaches or exceeds a pre-established level. These monitors detect inleakage to the system from equipment that may contain radioactivity. Each of the two component cooling water loops is monitored using the high pressure version of the liquid monitors described in Section 11.5.2.6.2.

The monitors provide a high radiation alarm when concentration levels reach preset limits. The receipt of these alarms will alert the operator to the presence of leakage so that additional radiation surveys, sampling, and equipment isolation can be effected in order to locate and repair the leakage source. The system does not discharge to the environment and is a closed loop system.

11.5.2.7.1.2 Auxiliary steam condensate tank liquid monitor

The auxiliary steam condensate tank monitor provides an indication to operations personnel of inleakage in the Auxiliary Steam System from the boron recycle evaporator and from the boric acid batch tanks. This is done by monitoring the auxiliary steam radioactive contamination levels at the common header for the auxiliary steam condensate tank exhausts with the low pressure (150 psig) version of the liquid monitor described in Section 11.5.2.6.2. This monitor provides a high radiation alarm when concentration levels reach preset limits. The receipt of this alarm will alert the operator to the presence of leakage so that additional radiation surveys, sampling, and equipment isolation can be effected in order to locate and repair the leakage source.

11.5.2.7.1.3 Steam generator blowdown monitor

The primary function of the steam generator blowdown radiation monitor is to provide indication of the gross gamma activity of the steam generator blowdown whenever the blowdown system is in operation. The monitoring for activity of the secondary side of the steam generators provides indication of a possible primary to secondary system leak. The monitor is located downstream of the flash tank common to all three steam generators. The monitor is a low pressure version of the liquid monitor described in Section 11.5.2.6.2. The monitor is provided with a heat exchanger.

The monitor provides a high radiation alarm when concentration levels reach preset limits. The receipt of the alarm alerts the operator to the presence of primary-to-secondary leakage so that grab sampling can be performed on steam generator sample fluid at points P-11, P-12, and P-13 on sample panel 1A as shown on Figure 9.3.2-1. The grab samples can then be transported to the hot lab for radiological analysis. This will permit the operator to determine which of the three steam generators has a radiation leak.

11.5.2.7.1.4 Auxiliary steam condensate waste processing system monitor

The auxiliary steam condensate tank waste processing system monitor provides an indication to operations personnel of inleakage into the Auxiliary Steam System from the reverse osmosis concentrator evaporator and the waste evaporator package. The auxiliary steam condensate concentrates are monitored on a common header using the low pressure version of the liquid monitor described in Section 11.5.2.6.2.

The monitor provides an alert and high radiation alarm when concentration levels reach preset limits. The receipt of these alarms will alert the operator to the presence of leakage so that additional radiation surveys, sampling, and equipment isolation can be effected in order to locate and repair the leakage source.

11.5.2.7.1.5 Waste Processing Building (WPB) cooling water system monitor

The WPB cooling water system monitor provides an indication to operations personnel of radioactive inleakage into the WPB Cooling Water System. The liquid monitor is described in Section 11.5.2.6.2.

The monitor provides an alert and high radiation alarm when concentration levels reach preset limits. The vent valve on the WPB cooling water surge tank automatically closes on a radiation alarm from the WPB cooling water monitor.

11.5.2.7.2 Effluent radiological monitoring system

See Table 11.5.2-2 for operating information on the effluent radiological monitors.

11.5.2.7.2.1 Service water system monitors

The service water radiation monitors are used to detect leakage of radioactivity into service water that cools systems which may become contaminated with radioactivity. The service water system will not be a source of routine radioactivity release. The service water system is separated from potentially contaminated systems by at least one barrier and one other monitored cooling system (i.e., CCW and WPCCW System) or one barrier and a positive pressure differential (i.e., containment fan coolers and WPC HVAC chiller, liquid radiation monitors). Both the CCW and WPCW Systems are monitored. To ensure that any potential radioactive contamination into the service water system is monitored prior to release to the environment, the service water from the WPB and RAB will be continuously monitored before normal operational discharge into the circulating water system. The monitors are located downstream of all potential radioactive inputs to the system. Grab sampling capability is provided on the monitors as described in Section 11.5.2.6.2.

The monitors provide alert and high radiation alarms when concentrations reach preset limits. These limits are determined in accordance with the SHNPP Offsite Dose Calculation Manual (ODCM). The receipt of these alarms will alert the operator to the presence of leakage. Under accident conditions the RAB and WPB service water are not continuously monitored. Monitoring of effluent under accident conditions is accomplished by periodic grab sampling of effluent streams.

11.5.2.7.2.2 Fuel Handling Building (FHB) normal exhaust monitors

The FHB normal exhaust monitors provide an indication to operations personnel of the activity in the fuel pool ventilation system serving the operating floor, new fuel pools, and spent fuel pools. These exhausts contribute to release point 1 shown on Figure 9.4.0-2. Each of the two normal exhausts is monitored using the airborne particulate, iodine and noble gas monitor described in Section 11.5.2.6.4.

These monitors provide a high radiation alarm when concentration levels reach preset limits. The receipt of these alarms will alert the operator to the presence of low level leakage so that additional radiation surveys and sampling can be effected in order to locate the leakage source.

11.5.2.7.2.3 Fuel Handling Building (FHB) emergency exhaust monitors

The FHB emergency exhaust monitors are part of the safety related portion of the RMS (Section 11.5.2.3) and are located downstream of the HEPA-charcoal filter units of each of the two emergency exhaust ducts. These monitors measure effluent releases during and after a fuel handling accident. These exhausts contribute to release point 1 as shown on Figure 9.4.0-2. Each of the two emergency exhausts is monitored using noble gas monitor described in Section 11.5.2.6.4.

11.5.2.7.2.4 Plant vent stack monitor

With exception of isokinetic sampling panels PNL-21AV-3509 and PNL-21AV-3509-1, the plant vent stack monitor is part of the safety related portion of the RMS (Section 11.5.2.3), and provides an indication to operations personnel of the activity of release point 1 as shown on Figure 9.4.0-2. The release point is monitored with a Wide Range Noble Gas Monitor as described in Section 11.5.2.5.11.

The plant vent radiation monitor is designed to representatively sample, monitor, indicate and store the radioactivity levels in the plant effluent gases being discharged from the plant vent stack. It provides a continuous indication of the activity levels of radioactive materials released to the environment so that determination of the total materials released can be made.

11.5.2.7.2.5 Turbine building drain monitor

The turbine building drain monitor provides an indication to operations personnel of the activity in the effluent from the industrial waste sump to the cooling tower blowdown via the yard oil separator, waste neutralization basin, and settling basin. The liquid monitor is described in Section 11.5.2.6.3.

During normal operation, effluent from the Industrial Waste Sump Pumps is pumped to the yard oil separator. When the effluent concentration exceeds a preset value, determined in accordance with the SHNPP ODCM, a high radiation alarm signal is generated and the effluent path to the environment will be isolated by automatically closing the valve to the oil separator and automatically tripping the Industrial Waste Sump Pumps. A high radiation alarm is initiated by the radiation monitoring system to alert the main control room operator. In addition, if the water level in the sump continues to rise, an alarm is actuated on the waste processing control board when the high-high level is reached. The response to the alarms is to investigate and isolate the source of contaminated leakage in order to prevent discharge of radioactive effluents to the environment. Upon loss of power to the motor operated diversion valve to the oil separator, the associated industrial waste sump pumps will be tripped thereby preventing discharge of radioactive effluent to the environment.

The monitor is not equipped with a record of effluent flow releases because radioactivity exceeding preset limits will not be sent to the environs but instead will be processed by an appropriate radiological waste processing system.

11.5.2.7.2.6 Tank area drain transfer pump monitor

The tank area drain transfer pumps monitor provides an indication to operations personnel of the activity in the effluent from the tank area. The liquid monitor is described in Section 11.5.2.6.2.

The monitor provides a high radiation alarm, determined in accordance with the ODCM, when concentrations reach a preset limit. Ordinarily, this effluent is rainwater, which flows to the Storm Water Drainage System; however, in the event of a major spillage of either the condensate storage tank or the refueling water storage tank this may be contaminated. When the radiation level exceeds the high alarm value, the monitor sends an automatic shutoff signal to the drain transfer pump. Flow can then be diverted to the floor drain tanks by local manual closure of the flow control valve to the Storm Water Drainage System, local manual opening of the flow control valve to the floor drain tanks and restarting of the drain transfer pumps.

The monitor is not equipped with a record of effluent flow releases because the radioactivity exceeding preset limits is not sent to the environs but instead to the respective waste processing systems.

11.5.2.7.2.7 DELETED

11.5.2.7.2.8 Reactor Auxiliary Building (RAB) emergency exhaust monitors

The RAB Emergency Exhaust System is monitored for effluent releases using the airborne particulate, iodine and noble gas monitor described in Section 11.5.2.6.4. The particulate and iodine channels have been abandoned in place. Activity released from the critical components of the Containment Spray System and RHR System during post-accident conditions will be sampled downstream of the HEPA-charcoal filter units provided for each RAB Emergency Exhaust System. This monitor provides a high radiation alarm when concentrations reach preset limits. This exhaust contributes to release point 1 as shown on Figure 9.4.0 2.

11.5.2.7.2.9 Condenser Vacuum Pump Effluent Monitor

The condenser vacuum pumps effluent monitor measures noncondensable fission product gases in the condenser vacuum pump discharge during normal operations. The presence of radioactivity in this line would indicate a primary to secondary leak in the steam generators. The monitor provides a high radiation alarm. Predominant isotopes would be Kr-85 and Xe-133 with the presence of iodine. The condenser vacuum pump discharge is monitored using the noble gas monitor described in Section 11.5.2.5.5 as shown in Figure 9.4.4 1. The condenser vacuum pump effluent is then routed to the turbine building vent stack which has sampling and monitoring capability as discussed in Section 11.5.2.7.2.18.

During hogging operations at plant startup and prior to turbine operation, if the reactor has been shutdown for less than 30 days, the effluent pathway is monitored as described above for normal operations. During hogging operations when the reactor has been shut down for greater than 30 days, the condenser vacuum discharge may be routed directly to the Turbine Building area. This discharge will be monitored by the condenser vacuum pump effluent monitor described above since normally open valve 7AE-B3-1 will remain open creating dual exit paths for the discharge.

11.5.2.7.2.10 Treated Laundry and Hot Shower Tank Pumps Monitor

The treated laundry and hot shower tank pumps monitor provides an indication to operations personnel of the activity in the effluent from the treated laundry and hot shower tank to the cooling tower blowdown. The liquid monitor is described in Section 11.5.2.6.2.

The monitor provides alert and high radiation alarms when concentrations reach preset limits. These limits are determined in accordance with the SHNPP ODCM. On high alarm, the effluent discharge is terminated automatically by shutting the automatic flow control valve on the discharge line.

11.5.2.7.2.11 Waste Monitor Tanks Discharge Monitor

The waste monitor tanks discharge monitor provides an indication to operations personnel of the activity in the effluent from the waste monitor tanks to the cooling tower blowdown. The liquid monitor is described in Section 11.5.2.6.2.

The monitor provides alert and high radiation alarms when concentrations reach preset limits. These limits are determined in accordance with SHNPP ODCM. On high alarm, the effluent discharge is terminated automatically by shutting the automatic flow control valve on the discharge line.

11.5.2.7.2.12 Secondary Waste Sample Tank

The secondary waste sample tank monitor provides an indication to operations personnel of the activity in the effluent from the secondary waste sample tank to the cooling tower blowdown. The liquid monitor is described in Section 11.5.2.6.2.

The monitor provides alert and high radiation alarms when concentrations reach preset limits. These limits are determined in accordance with the SHNPP ODCM. On high alarm, the effluent discharge is terminated automatically by shutting the automatic flow control valve on the discharge line.

11.5.2.7.2.13 Waste Processing Building (WPB) exhaust system monitors

The WPB exhaust monitors provide an indication to operations personnel of the overall airborne activity in the Waste Processing Building effluent at release points 5 and 5A as shown on Figure 9.4.0-2. Both WPB Exhaust Stack 5 and WPB Exhaust Stack 5A are monitored by a separate Wide Range Noble Gas Monitor, as described in Section 11.5.2.5.11. WPB Exhaust Stack 5 is also monitored by an airborne particulate, iodine and noble gas monitor (PIG), as described in Section 11.5.2.6.4; however, the particulate and iodine channels have been abandoned in place.

The monitors provide a high radiation alarm when concentration levels reach preset limits. Also, a WPB exhaust monitor (REM-1WV-3546) serves to detect radioactivity passing through WPB vent stack 5 from the gas decay tanks to atmosphere and serves to trip the flow control valve in the waste decay tank discharge line when the radiation level exceeds the high alarm value, which is determined in accordance with the SHNPP ODCM. Waste gas release is an operator decision based on meteorological conditions and activity contained in the waste gas. When the operator has decided to release waste gas, he first samples the gas to determine its activity concentration. With this information and total pressure in the tank, the operator knows the quantity of activity to be released as well as the rate at which the gas can be released.

To make the actual release, he must unlock and then open the manual isolation valve at the tank discharge and then unlock and set the discharge flow control valve at the desired rate based on the vent stack activity monitor. Discharge flow is maintained at a constant rate by a pressure regulator upstream of the flow control valve. If the discharge flowrate results in an excessive radiation release rate, the flow control valve is tripped shut by the vent stack monitor.

11.5.2.7.2.14 Intentionally Deleted by Amendment 20

11.5.2.7.2.15 Containment pre-entry purge monitor

The containment pre-entry purge monitor provides an indication to operations personnel of the activity of the effluent being exhausted from the containment through the containment pre-entry purge line as shown on Figure 6.2.2-3. The pre-entry purge effluent is contributory to release point 1 shown on Figures 6.2.2-3 and 9.4.0-2. The monitor is an airborne particulate and noble gas detector as described in Section 11.5.2.6.5 and listed in Table 11.5.2-2.

The monitor provides a high radiation alarm when concentration levels reach preset limits. The receipt of an alarm will alert the operator to the presence of leakage so that additional radiation surveys and sampling can be effected. The monitor provides additional assurance that radioactivity will not be released undetected from the plant.

An automatic control feature is included to terminate the containment purge if the radiation monitor detects activities high enough to cause offsite concentrations in excess of those permissible under SHNPP effluent specifications.

The SHNPP has two modes of containment purge operation. In one mode the normal containment purge is mixed with the plant stack flow prior to discharge. The second mode is a pre-entry purge mixed into the plant stack flow prior to discharge. The SHNPP has a radiation monitor on the pre entry purge line upstream of the filtration units. No dedicated radiation monitor is provided for the normal purge line.

An interlock from the high alarm contact of the containment leak detection monitor is provided to isolate normal purge when containment radiation concentrations are such that site boundary limits can be exceeded if system operation is continued (See Section 12.3.4.2.8.1).

At a level of activity 10-3 μCi/cc, the containment leak detection monitors described in FSAR Section 12.3.4.2.8.1 will terminate normal purge operation. Grab sampling is provided by the Containment Leak Detection Monitor as described in Section 11.5.2.6.5.

11.5.2.7.2.16 Main steam line monitors

In order to estimate the releases which may occur as a result of the actuation of steam generator Safety Relief Valves (SRV) and Atmospheric Steam Dump Valves (ASDV), one collimated GM tube is installed to view the activity of each main steam line over the range of from 10^{-1} μCi/cc to 10^{3} μCi/cc. The detector reading is in mR/hr and shall be recorded by the microprocessor as ten 10-minute, 24-hour and 28-day averages. Calculational methods are employed to quantify radiological releases based on monitor dose rates. In order to obtain concentrations of 10^{-1} to 10^{3} μCi/cc of Xe-133 in the main steam line, a large primary-to-secondary leak must be present coincident with a large amount of cladding failure. Present with Xe-133 will be other nuclides. Based on the Postulated Primary System Accident scenarios (e.g., cladding failure, fuel failure) and on the assumed steam generator isotope partition factors, isotopic concentrations in the main steam line can be calculated, however, on-site isotopic analysis capability will be available for follow up analysis. Provisions for limiting occupational doses to personnel in the dilution and analysis of samples will be made in the sampling system design and plant procedures. This analysis capability will rely upon sample dilution or reduction of the amount of material analyzed for those accident conditions (highly radioactive grab samples) where the routine grab sample size cannot be analyzed directly. The ISOSHLD computer code (ISOSHLD, "REMAL INTEGRATION CODE, GENERAL PURPOSE ISOTOPE SHIELDING ANALYSIS," CCC-79, OAK RIDGE RSIC, 1973) is used to determine monitor response to the various isotopic concentration levels under three postulated accident scenarios when delayed isotopic information becomes available. Additional calculations can be performed after the release to quantify the amount more accurately. This model accounts for the thickness of the main steam line wall and the presence of insulating material.

Estimating radiological releases through the SRV and ADVs are calculated by summing the products of the concentrations, and mass of the steam released. Main steam concentrations are obtained from a calculated conservative conversion factor which will convert the detector's mR/hr reading to μCi/cc of steam of Xe-133 dose equivalent concentrations.

Steam line pressure, steam line flow, and status of the relief valves provide the information necessary to determine the mass of steam released. The main steam line radiation monitors provide a measure of the radioactivity levels in the main steam line. Therefore, the amount of activity released can be determined by multiplying the radioactivity in the main steam by the mass of steam released.

Main steam line pressure indicators (P1-474, 484, 494, 475, 485, 495, 476, 486, 496), with ranges of 0-1300 psig, provide direct indication should over pressurization occur in the main steam lines (MSLs). The MSL pressures are recorded on a recorder whose range also covers 0-1300 psig. The recorder has one pen per MSL and records MSL pressure as a function of time. This information provides an indication of when the SRVs and/or PORVs are open based on their setpoints. Status lights for the ADVs are provided on the Main Control Board to determine their valve position.

When the Main Steam Isolation Valves (MSIVs) are closed, the release of steam to the atmosphere with the PORVs and/or SRVs open can be measured by the MSL flow transmitters (FT-474, 484, 494, 475, 485, 495). The MSIVs close upon manual actuation or automatically on Hi-2 containment pressure, low steam pressure, or high steam pressure rate. Indication of the steam flow in the range of 0-5 MPPH is provided on the Main Control Board (MCB) and the Emergency Response Facilities Information System (ERFIS) computer and is recorded on recorders UR-478, 488, and 498. A description of the main steam line flow monitors is contained in FSAR Table 7.5.1-11, Figure 10.1.0-1, and Section 10.3.2.

When the MSIVs are open, the mass of steam released through either the PORVs, the SRVs or the ADVs would be estimated assuming design rate flow through each open valve.

11.5.2.7.2.17 High range containment monitors

Two high range in containment detectors are located directly inside the containment at reactor building azimuth 0° and 180° at 350 ft. elevation. Each High-Range Radiation Monitor consists of a detector, as described in Section 11.5.2.5.3.2, and cable suitable for use in a containment environment, and support electronics including a readout located in the Control Room. The detector is encased in stainless steel to protect it from containment sprays and high temperatures. The monitor is a safety monitor (Class 1E) and is qualified under LOCA conditions to IEEE 323-1974. Radiation levels of up to 10^8 R/hr are displayed in the control room on a front panel meter. Two level trips are provided for alert and high radiation levels and are independently adjustable over the full range. A failure trip is provided to actuate upon loss of power, high voltage, or signal from the detector. Automatic self-testing is provided to continuously verify detector operation. Outputs are provided for remote alarm relays, and meters. Energy response is uniform ($\pm$ 20 percent) for photons in the range of 60 Kev to 3 Mev. The monitors will comply with NUREG 0737, Table II.F.1 3.

Readout and control for these monitors is provided for as described for Class 1E area monitors in FSAR Section 12.3.4. The monitors are located in containment in a manner as to provide a reasonable assessment of area radiation conditions inside containment. The monitors are separated so as to provide independent measurements and shall "view" a large fraction of containment volume. Monitors are not placed in areas which are protected by massive shielding and are accessible for replacement, maintenance and calibration.

A sustaining signal is generated within the detector corresponding to 1 R/hr. A failure alarm will occur if the signal from the detector falls below this value. This feature assures knowledge of the monitor's integrity at all times.

Calibration of those decades above 10R/hr will be by electronic calibration via the injection of a DC signal to simulate detector response to radiation. Electronics calibration check is via an internal current source corresponding to 10^{+5} R/hr. In situ calibration for at least one decade below 10R/hr shall be provided by means of calibrated radiation sources. Calibration and type testing of representative specimens of the detector will be provided at a sufficient number of points to demonstrate linearity through all scales up to 10^6 R/hr.

NRC Information Notice 97-45 Supplement 1 documents a potential impact on the Containment High Range Radiation Monitors during rapid temperature changes inside Containment, such as after a Loss of Coolant Accident or Main Steam Line Break. This rapid temperature change can cause CHRRM readings outside of normal accuracy ranges for a period of time immediately following an accident. This phenomenon, commonly called “Temperature Induced Current,” has been evaluated. The impact of TIC is accounted for in Harris operating procedures as to not significantly impact the site’s response to either a LOCA or MSLB. Note also that diverse indication, particularly from the Containment Ventilation Isolation Radiation Monitors, will also be available.

11.5.2.7.2.18 Turbine building vent stack monitor

The Turbine Building Vent Stack Effluents are monitored by the wide range noble gas monitor described in Section 11.5.2.5.11. The turbine building vent stack monitor provides an indication to operations personnel of the overall airborne activity in the turbine building vent stack, effluent release point 3 as shown on Figures 1.2.2-72, 1.2.2-76 and 9.4.0-2. The monitor provides a high radiation alarm when concentration levels in the exhaust effluent reach a preset limit, which is determined in accordance with the Off-site Dose Calculation Manual. The receipt of alarms will alert the operator to the presence of activity leakage so that additional radiation surveys and sampling can be initiated in order to locate and correct the source leakage. The monitoring of the turbine building vent stack will provide assurance that radioactivity will not be released undetected from the plant. The monitor provides representative sampling of particulates and iodines downstream of all inputs as shown on Figure 9.4.4-1. During times when activities exceed the range of the low range detector, isokinetic sampling for particulates is not provided. Multiple sample points assure representative noble gas sampling. This is because the only source of activities in excess of the lower bound detector is from the condenser vacuum pump discharge, which vents into this exhaust point. Due to high partitioning, only a small amount of particulates and iodines are expected from the condenser discharge.

11.5.3 EFFLUENT RADIOLOGICAL MONITORING AND SAMPLING SYSTEM

11.5.3.1 Implementation of General Design Criterion 64

Sections 11.5.1 and 11.5.2 contain a detailed description of the means which are provided for monitoring effluent discharge paths for radioactivity that may be released for normal operations, including anticipated operational occurrences, and from postulated accidents.

11.5.4 PROCESS MONITORING AND SAMPLING SYSTEM

11.5.4.1 Implementation of General Design Criterion 60

Sections 11.5.1 and 11.5.2 contain a detailed description of the means which are provided for automatic closure of isolation valves in gaseous and liquid effluent paths.

11.5.4.2 Implementation of General Design Criterion 63

Sections 11.5.1 and 11.5.2 contain a detailed description of the means which are provided for monitoring of radiation levels in radioactive waste process systems.

TABLE 11.1.1-1

PARAMETERS USED IN THE CALCULATION OF DESIGN BASIS FISSION AND CORROSION PRODUCT SPECIFIC ACTIVITIES

1. Ultimate core thermal power (MWt)	2958(h)
2. Reactor coolant liquid volume ($ft.^3$)	9406(g)
3. Reactor coolant full power average temperature (F)	593
4. Purification flow rate, normal (gpm)	106
5. Effective cation demineralizer flow (gpm)	10.6
6. Volume control tank	
a. Vapor volume ($ft.^3$)	150
b. Liquid volume ($ft.^3$)	150
c. Pressure (psig)	25
d. Temperature (F)	109
7. Nuclide release coefficients: The nuclide release coefficient is the product of the failed fuel fraction and the fission product escape rate coefficient.	
a. Failed fuel fractions: Equivalent fraction of core power produced by fuel rods containing small cladding defects	0.01
b. Fission product escape rate coefficients during full power operation (sec^{-1}):	
Kr and Xe isotopes	6.5×10^{-8}
Br, Rb, I, and Cs isotopes	1.3×10^{-8}
Mo, Tc, and Ag isotopes	$2.0 \times 10\text{-}^{9}$
Te isotopes	1.0×10^{-9}
Sr and Ba isotopes	1.0×10^{-11}
Y, Zr, Nb, Ru, Rh, La, Ce, and Pr isotopes	1.6×10^{-12}
8. CVCS mixed bed demineralizers	
a. Resin volume ($ft.^3$)	30
b. Demineralizer isotopic decontamination factors[b]	
Kr and Xe isotopes	1
Br and I isotopes	10
Sr and Ba isotopes	10
Other isotopes	1
9. CVCS cation bed demineralizer	
a. Resin volume ($ft.^3$)	20
b. Demineralizer isotopic decontamination factors[b]	
Kr and Xe isotopes	1
Sr and Ba isotopes	1
Rb-86, Cs-134, and Cs-137	10
Rb-88, Rb-89, Cs-136, and Cs-138	1
Other isotopes	1

Table 11.1.1-1 (Continued)

10. Volume control tank noble gas stripping fractions
(based on no purge to the Gaseous Waste Management System)

Isotope	Stripping Fraction[c]
Kr-83m	0.59
Kr-85m	0.37
Kr-85	2.8×10^{-5}
Kr-87	0.67
Kr-88	0.48
Kr-89	0.98
Xe-131m	0.0061
Xe-133m	0.032
Xe-133	0.014
Xe-135m	0.87
Xe-135	0.16
Xe-137	0.96
Xe-138	0.88

11. Pressurizer volumes ($ft.^3$)

a. Liquid volume	840
b. Vapor volume	560

12. Initial boron concentrations (ppm)

a. Equilibrium cycle	1530

13. Operation times (effective full-power hours)

a. Equilibrium cycle	11930

14. Secondary Coolant Parameters[d]

a. Total steam generator water mass (lb.)	3.3×10^5
b. Total steam flow rate (lb/hr)	1.29×10^7
c. Total blowdown rate (gpm) [a]	360
d. Total primary-to-secondary leak rate (lb/day)	1.2×10^4

Notes to Table 11.1.1-1:

a) Flow measured at charging pump discharge at 2250 psia and 130F.

b) For all isotopes, except the isotopes of Kr, Xe, Br, I, Rb, Cs, Sr, and Ba, a removal decontamination factor (as distinct from demineralizer DF) of 10 was assumed. This is done to account for removal mechanisms other than ion exchange; such as plateout, etc.

c) The nuclide stripping fractions are calculated using the following equation:

$$\psi i = 1 - \frac{[KQ]}{KQ + \lambda\,(\mathrm{KL+V}) + P}$$

where:

ψ = nuclide volume control tank stripping fraction

K = $\frac{RT}{MH}$

R = gas constant = $45.59 \, \frac{\frac{atm}{cm^3}}{gm\frac{mole}{°R}}$

Table 11.1.1-1 (Continued)

T	=	nominal volume control tank temperature (°R)
M	=	molecular weight of water = 18.0 gm/gm mole
H	=	Henry's Law Constant
H	=	2.89×10^4 atm/mole fraction for krypton, at 109F
H	=	1.91×10^4 atm/mole fraction for xenon, at 109F
Q	=	letdown or purification flowrate (gm/sec)
λ	=	nuclide decay constant (1/sec)
L	=	volume control tank liquid mass (gm)
V	=	volume control tank vapor volume (cm^3)
P	=	volume control tank purge rate to the gaseous waste management system, at volume control tank conditions (cm^3/sec.)

d) Moisture carryover of 0.10 percent is used to determine steam concentration of all nuclides except iodine, krypton, xenon, and tritium.
e) Flow assumed to be at 440F and 839 psig.
f) Flow assumed to be at 590F and 2250 psig.
g) The RCS volume reflects a conservatively minimum volume, assuming 10% steam generator tube plugging.
h) The core power is 102% of the licensed core power for conservatism.

TABLE 11.1.1-2

DESIGN BASIS REACTOR COOLANT FISSION AND CORROSION PRODUCT SPECIFIC ACTIVITY

Nuclide	Specific Activity (µCi/gm)	Nuclide	Specific Activity (µCi/gm)
Kr-83m	4.17E-01	Co-58	1.50E-02
Kr-85m	1.73E+00	Co-60	1.90E-03
Kr-85	1.06E+01	Sr-89	2.53E-03
Kr-87	1.10E+00	Sr-90	1.13E-04
Kr-88	3.21E+00	Sr-91	4.26E-03
Kr-89	9.32E-02	Sr-92	1.10E-03
Xe-131m	3.41E+00	Y-90	3.07E-05
Xe-133m	4.86E+00	Y-91m	2.30E-03
Xe-133	2.76E+02	Y-91	5.85E-04
Xe-135m	4.36E-01	Y-92	9.80E-04
Xe-135	8.52E+00	Y-93	2.95E-04
Xe-137	1.75E-01	Zr-95	3.81E-04
Xe-138	6.30E-01	Nb-95	3.93E-04
Br-83	8.08E-02	Mo-99	4.70E-01
Br-84	4.39E-02	Tc-99m	4.35E-01
Br-85	5.30E-03	Ru-103	3.25E-04
I-127 (a)	5.81E-11	Ru-106	1.22E-04
I-129	3.83E-08	Rh-103m	3.69E-04
I-130	3.28E-02	Rh-106	1.22E-04
I-131	1.71E+00	Ag-110m	1.03E-03
I-132	2.47E+00	Te-125m	3.76E-04
I-133	7.23E+00	Te-127m	1.81E-03
I-134	5.67E-01	Te-127	1.16E-02
I-135	1.84E+00	Te-129m	6.18E-03
Rb-86	1.97E-02	Te-129	1.04E-02
Rb-88	7.93E+00	Te-131m	1.61E-02
Rb-89	1.90E-01	Te-131	1.21E-02
Cs-134	1.55E+00	Te-132	2.09E-01
Cs-136	3.21E+00	Te-134	2.79E-02
Cs-137	1.61E+00	Ba-140	2.39E-03
Ba-137m	1.52E+00	La-140	8.90E-04
Cs-138	9.77E-01	Ce-141	3.93E-04
H-3	3.50E+00	Ce-143	3.61E-04
Cr-51	5.50E-03	Ce-144	2.69E-04
Mn-54	4.00E-04	Pr-143	3.50E-04
Fe-55	2.30E-03	Pr-144	2.69E-04
Fe-59	5.80E-04		

(a) Gram of I-127 per gram of coolant.

The above concentrations are based on the following assumptions:
* RCS Mass = 1.87E+08 g
* Operation with small defects in the cladding of fuel rods generating 1 percent of the core rated power
* Reactor coolant purification of letdown rate = 106 gpm at 130°F and 2250 psia
* No volume control tank purge. Reactor coolant gaseous fission product activities with the GWPS operating are provided in Table 11.3.2-3.

TABLE 11.1.1-3

PRESSURIZER ACTIVITIES

Liquid Phase Specific Activity
(865 ft.^{3} liquid phase, operating conditions)

Nuclide	Specific Activity (µCi/gm)
I-132	2.5E+00
KR-88	3.2E+00
KR-89	9.3E-02
I-133	7.2E+00
XE-133	2.8E+02
I-135	1.8E+00
XE-135	8.5E+00
RB-88	7.9E+00
CS-134	1.5E+00
CS-136	3.2E+00
CS-138	9.8E-01

Steam Phase Concentration
(577 ft.^{3} steam phase, operating conditions)

Nuclide	Concentration (µCi/cm^3)
KR-83M	1.7E-02
KR-85M	2.0E-01
KR-85	3.2E+01
KR-87	2.6E-02
KR-88	2.1E-01
KR-89	7.8E-09
XE-131M	7.5E+00
XE-133M	7.3E+00
XE-133	6.1E+02
XE-135M	4.2E-04
XE-135	2.1E+00
XE-137	1.0E-07
XE-138	4.8E-04
I-129	3.8E-10
I-130	3.3E-04
I-131	1.7E-02
I-132	2.5E-02
I-133	7.2E-02
I-134	5.7E-03
I-135	1.8E-02

TABLE 11.1.1-4*

VOLUME CONTROL TANK ACTIVITIES

Liquid Phase Specific Activity

(150 ft.^{3} liquid phase)

Nuclide	Specific Activity (µCi/gm)
Kr-83m	1.73E-01
Kr-85m	1.10E+00
Kr-85	1.06E+01
Kr-87	3.62E-01
Kr-88	1.68E+00
Kr-89	1.86E-03
Xe-131m	3.39E+00
Xe-133m	4.70E+00
Xe-133	2.73E+02
Xe-135m	5.52E-02
Xe-135	7.14E+00
Xe-137	6.16E-03
Xe-138	7.46E-02
(a)	5.81E-12
I-129	3.83E-09
I-130	3.28E-03
I-131	1.71E-01
I-132	2.47E-01
I-133	7.23E-01
I-134	5.67E-02
I-135	1.84E-01

(a)Gram of I-127 per gram of coolant

Vapor Phase Concentration
(150 ft.^{3} vapor phase)

Nuclide	Concentration (µCi/cm^3)
Kr-83m	4.49E+00
Kr-85m	2.47E+01
Kr-85	2.38E+02
Kr-87	1.08E+01
Kr-88	3.52E+01
Kr-89	4.84E-02
Xe-131m	4.81E+01
Xe-133m	6.88E+01
Xe-133	3.88E+03
Xe-135m	1.33E+01
Xe-135	1.16E+02
Xe-137	8.75E-02
Xe-138	1.22E+00

* Based on parameters given in Table 11.1.1-1.

TABLE 11.1.1-5 DESIGN BASIS SECONDARY COOLANT SPECIFIC ACTIVITIES (µCi/gm)

	Secondary Coolant	
Nuclide	Water	Steam
KR-83M	nil	1.8E-05
KR-85M	nil	6.7E-05
KR-85	nil	4.1E-04
KR-87	nil	4.3E-05
KR-88	nil	1.2E-04
KR-89	nil	3.5E-06
XE-131M	nil	1.3E-04
XE-133M	nil	1.9E-04
XE-133	nil	1.1E-02
XE-135M	nil	6.4E-05
XE-135	nil	3.4E-04
XE-137	nil	6.7E-06
XE-138	nil	2.4E-05
BR-83	1.6E-04	1.7E-06
BR-84	3.7E-05	4.1E-07
BR-85	5.4E-07	6.0E-09
I-129	1.2E-10	1.3E-12
I-130	9.0E-05	9.9E-07
I-131	5.2E-03	5.7E-05
I-132	4.9E-03	5.4E-05
I-133	2.1E-02	2.3E-04
I-134	6.9E-04	7.6E-06
I-135	4.7E-03	5.1E-05
RB-86	1.1E-04	1.1E-07
RB-88	4.6E-03	4.6E-06
RB-89	9.7E-05	9.7E-08
CS-134	8.6E-03	8.6E-06
CS-136	1.8E-02	1.8E-05
CS-137	8.9E-03	8.9E-06
CS-138	9.6E-04	9.6E-07
H-3	3.5E+00	3.5E+00
CR-51	1.7E-05	1.7E-08
MN-54	1.2E-06	1.2E-09
MN-56	4.4E-05	4.4E-08
FE-55	7.1E-06	7.1E-09
FE-59	1.3E-06	1.3E-09
CO-58	4.6E-05	4.6E-08
CO-60	5.9E-06	5.9E-09
SR-89	1.4E-05	1.4E-08
SR-90	6.3E-07	6.3E-10
SR-91	1.9E-05	1.9E-08
SR-92	3.2E-06	3.2E-09
Y-90	1.1E-07	1.1E-10
Y-91M	9.4E-06	9.4E-09

TABLE 11.1.1-5 DESIGN BASIS SECONDARY COOLANT SPECIFIC ACTIVITIES (µCi/gm)

	Secondary Coolant	
Nuclide	Water	Steam
Y-91	1.8E-06	1.8E-09
Y-92	3.1E-06	3.1E-09
Y-93	8.0E-07	8.0E-10
ZR-95	1.2E-06	1.2E-09
NB-95	1.2E-06	1.2E-09
MO-99	1.4E-03	1.4E-06
TC-99M	1.3E-03	1.3E-06
RU-103	1.0E-06	1.0E-09
RU-106	3.8E-07	3.8E-10
RH-103M	1.1E-06	1.1E-09
RH-106	3.8E-07	3.8E-10
AG-110M	3.2E-06	3.2E-09
TE-125M	1.2E-06	1.2E-09
TE-127M	5.6E-06	5.6E-09
TE-127	3.2E-05	3.2E-08
TE-129M	1.9E-05	1.9E-08
TE-129	2.1E-05	2.1E-08
TE-131M	4.7E-05	4.7E-08
TE-131	1.5E-05	1.5E-08
TE-132	6.3E-04	6.3E-07
TE-134	2.9E-05	2.9E-08
BA-137M	8.3E-03	8.3E-06
BA-140	7.3E-06	7.3E-09
LA-140	2.9E-06	2.9E-09
CE-141	1.2E-06	1.2E-09
CE-143	1.1E-06	1.1E-09
CE-144	8.3E-07	8.3E-10
PR-143	1.1E-06	1.1E-09
PR-144	8.3E-07	8.3E-10

TABLE 11.1.2-1 NORMAL OPERATIONAL PRIMARY AND SECONDARY COOLANT RADIONUCLIDE SPECIFIC ACTIVITIES (µCi/gm)

Nuclide	Primary Coolant Activity	Secondary Water Activity
Kr-85m	1.4E-01	3.6E-08*
Kr-85	3.3E+00	8.0E-07*
Kr-87	1.5E-01	3.5E-08*
Kr-88	2.6E-01	6.5E-08*
Xe-131m	8.6E-01	2.1E-07*
Xe-133m	6.7E-02	1.7E-08*
Xe-133	2.7E+00	6.5E-07*
Xe-135m	1.5E-01	3.5E-08*
Xe-135	8.0E-01	2.0E-07*
Xe-137	3.9E-02	9.6E-09*
Xe-138	1.3E-01	3.3E-08*
Br-84	1.8E-02	9.7E-08
I-131	2.8E-02	6.3E-07
I-132	2.1E-01	2.7E-06
I-133	1.0E-01	2.1E-06
I-134	3.7E-01	2.8E-06
I-135	2.2E-01	4.0E-06
Rb-88	2.2E-01	7.4E-07
Cs-134	4.1E-03	9.5E-08
Cs-136	5.2E-04	1.2E-08
Cs-137	5.5E-03	1.3E-07
N-16	4.0E+01	1.4E-06
H-3	1.0E+00	1.0E-03
Na-24	3.5E-02	7.0E-07
Cr-51	1.8E-03	4.2E-08
Mn-54	9.3E-04	2.1E-08
Fe-55	7.0E-04	1.6E-08
Fe-59	1.8E-04	3.9E-09
Co-58	2.7E-03	6.2E-08
Co-60	3.1E-04	7.1E-09
Zn-65	3.0E-04	6.8E-09
Sr-89	8.2E-05	1.8E-09
Sr-90	7.0E-06	1.6E-10
Sr-91	7.6E-04	1.5E-08
Y-90	8.8E-07	2.1E-11
Y-91m	5.0E-04	3.8E-09
Y-91	3.0E-06	6.8E-11
Y-93	3.3E-03	6.2E-08
Zr-95	2.3E-04	5.2E-09
Nb-95	1.6E-04	3.6E-09
Mo-99	4.0E-03	8.9E-08
Tc-99m	4.0E-03	6.8E-08
Ru-103	4.4E-03	1.0E-07
Ru-106	5.2E-02	1.2E-06

TABLE 11.1.2-1 NORMAL OPERATIONAL PRIMARY AND SECONDARY COOLANT RADIONUCLIDE SPECIFIC ACTIVITIES (µCi/gm)

Nuclide	Primary Coolant Activity	Secondary Water Activity
Rh-103m	4.4E-03	1.0E-07
Rh-106	5.2E-02	1.2E-06
Ag-110m	7.6E-04	1.7E-08
Te-129m	1.1E-04	2.5E-09
Te-129	2.5E-02	2.4E-07
Te-131m	1.0E-03	2.1E-08
Te-131	8.6E-03	3.9E-08
Te-132	1.1E-03	2.3E-08
Ba-137m	5.2E-03	1.2E-07
Ba-140	7.7E-03	1.7E-07
La-140	1.6E-02	3.5E-07
Ce-141	8.8E-05	2.0E-09
Ce-143	1.9E-03	3.9E-08
Ce-144	2.3E-03	5.1E-08
Pr-143	2.1E-03	3.9E-08
Pr-144	2.3E-03	5.1E-08
W-187	1.7E-03	3.6E-08
Np-239	1.4E-03	3.1E-08

* Specific activity in steam exiting steam generator

TABLE 11.1.2-2

PARAMETERS USED TO DESCRIBE THE REACTOR SYSTEM - REALISTIC BASIS

Parameter	Symbol	Units	SHNPP Value	ANSI/ANS 18.1-1984 VALUE Nominal Value
Thermal power	P	MWt	2949	3400
Steam flowrate	FS	lb/hr	1.3×10^7	1.5×10^7
Weight of water in reactor coolant system	WP	lb	4.1×10^5	5.5×10^5
Weight of water in all steam generators	WS	lb	3.3×10^5	4.5×10^5
Reactor coolant letdown flow (purification)	FD	lb/hr	5.4×10^4	3.7×10^4
Reactor coolant letdown flow (yearly average for boron control	FB	lb/hr	5.2×10^1	5.0×10^2
Steam generator blowdown (total)	FBD	lb/hr	1.5×10^5	7.5×10^4
Fraction of radioactivity in blowdown stream which is not returned to the secondary coolant system.	NBD	-	0.9	1.0
Flow through the the purification system cation demineralizer	FA	lb/hr	5.4×10^3	3.7×10^3
Ratio of condensate demineralizer flowrate to the total steam flowrate	NC	-	0.0078	0.0

TABLE 11.1.4-1

REACTOR COOLANT N-16 SPECIFIC ACTIVITY

Position in Loop	Loop Transit Time (sec)	N-16 Specific Activity (µCi/gram)
Leaving core	0	247
Leaving reactor vessel	1.5	216
Entering steam generator	1.8	207
Leaving steam generator	7.3	122
Entering reactor coolant pump	7.9	115
Entering reactor vessel	8.7	105
Entering Core	10.8	92
Leaving core	11.8	247

TABLE 11.1.6-1

TRITIUM PRODUCTION

Tritium Source	Total Produced[1,2] (Curies/cycle)	Design Release to Reactor Coolant[3] (Curies/cycle)	Expected Release to Reactor Coolant[4] (Curies/cycle)
Ternary fissions Projected Cycles [a]	14,900	1490	299
Coolant soluble boron Projected Cycles	950	950	950
Coolant soluble lithium Projected Cycles	984	984	984
Coolant deuterium Projected Cycles	9.77	9.77	9.77
Total Projected Cycles	16,844	3,434	2,243

[a] Refers to current projected core cycle parameters and assumptions beyond the onset of Measurement Uncertainty Recapture power uprate.

Notes:

1. Equilibrium cycle during which the maximum expected release of tritium is expected.
2. Power level, 2949 MWt.
3. Release fraction from fuel, 10 percent.
4. Release fraction from fuel, 2 percent.
5. Operating time for equilibrium cycle of 507 days Mtu.
6. Initial RCS boron concentration of 1529ppm @ 150 Mwd/Mtu
7. RCS average lithium concentration, 2.2 ppm. 1390 ppm at initial full power, hot temperature, equilibrium.

TABLE 11.1.7-1

SPENT FUEL POOL SPECIFIC ACTIVITY (µCi/ml)
NORMAL ACTIVITY

NUCLIDE	OPERATING CONCENTRATION*
Cr-51	1.27 E-1
Mn-54	4.30 E-3
Co-58	3.65 E-3
Co-60	1.47 E-3
I-131	9.80 E-3
Cs-134	2.24 E-3
Cs-137	5.74 E-3

The normal activity operating concentrations for the spent fuel pool liquid are based on a calculation for each nuclide which if allowed to reach this concentration would produce a dose rate of 2.5 MR/hr above the fuel pool.

*Reference: Dosimetry Technical Report 91-02.

DESIGN ACTIVITY**

NUCLIDE	DESIGN CONCENTRATION
H-3	3.54 E0
C-14	1.45 E-4
Fe-55	1.63 E1
Co-60	3.23 E0
I-131	3.21 E-2

NOTES:

1) These design activities are applicable at the RWST as per the accident described in FSAR 2.4.12 and Section 2.4.13.
2) All nuclides contributing less than one percent of the 10 CFR 20 concentration limits are not listed.

**Except where noted, analysis and terms used in this section are based on "pre-1993 10 CFR 20" (see Section 12.0).

TABLE 11.1.8-1

EQUIPMENT LEAKAGE ASSUMPTIONS

Valves	
Seat Leakage	10 cc/hr/in. Seat Diameter
Stem Leakage	10 cc/hr/in. Stem Diameter
Pumps	
Centrifugal	50 cc/hr.
Positive Displacement	1 gal./hr.
Pump Flanges	30 cc/hr.

TABLE 11.1.9-1

EXPECTED SPENT RESIN VOLUME RESULTING FROM PROCESSING REACTOR COOLANT LETDOWN

Item	Number	Each ($ft.^3$)	(number/year)
CVCS mixed bed demineralizers	2	30	1
CVCS cation bed demineralizer	1	20	1
Recycle evaporator feed demineralizers	2	30	1
Recycle evaporator condensate demineralizer	1	30	1
Thermal regeneration[a] demineralizers	4	75	1

[a]These demineralizers will be used when beneficial to station operation.

TABLE 11.2.1-1

PROJECTED EXPECTED ANNUAL AND DAILY AVERAGE
INPUTS TO THE LWPS SUBSYSTEMS

		AVERAGE INPUTS [(3)]		FRACTION OF RCS
Subsystem	Source	Gal/Year	Gal/Day	Spec. Activities
Equipment Drain System (EDS)	Equipment Drains & Leakoffs	141,200	387	0.14
Floor Drain System (FDS)	Floor Drain System	446,000	1,222	0.02
Recycle Holdup Tank	Boron Control Letdown	220,000	603	Note [(4)]
Laundry & Hot Shower System (L&HSS)[(1)]	Chemical Drains	3,000	8	0.05
	Fuel Cask Wash	1,000	3	0.008
	Fuel Pool Drains	100,000	274	0.008
		911,200	2,479	

(1) Laundry is sent off site for processing; therefore, there are no laundry wastes.

(2) If waste is nonradioactive, it is directed to the waste neutralization basin from the Secondary Waste Sample Tank.

(3) Average inputs are based on 1998 & 1999 experience. Current inputs are lower than these values. However, the net results based on fraction of RCS and specific activities are the same.

(4) Boron Control Letdown is RCS activity but is first processed through 2 mixed bed demineralizers before entering the MFDS demineralizer skid in the LWPS. Volume is conservatively based on not recycling boric acid using an evaporator.

(5) Secondary waste does not appear in this table since Condensate Polisher resin and Seam Generator Blowdown Demineralizer resin, the source of this waste steam, will not be regenerated if significant radioactivity is present in the resin.

TABLE 11.2.1-2

ANTICIPATED OPERATIONAL OCCURRENCES
ADDRESSED IN THE DESIGN OF THE ORIGINAL
LWPS SUBSYSTEMS AND OFF-STANDARD VOLUMES

A. The Floor Drain Treatment System will process the wastes which are detailed in Table 11.2.1-1.
B. Total processing capability of CVCS and FDS water is maintained assuming failure of or required maintenance on either the Boron Recycle Evaporator or the RO concentrates evaporator.
C. Total processing capability of CVCS and FDS water could be maintained for simultaneous failure or required maintenance of the boric acid concentrator and the RO concentrates evaporator if one evaporator is returned to service within sixty (60) days. However, holdup tanks must be near minimum level at the time both evaporators are removed from service. Load following operations or cold shutdown and startup could result in waste in excess of storage capacity of holdup tanks and floor drain tanks.
D. To maintain total process capability:
   1) Condenser leaks must be isolated quickly and repaired.
   2) Primary-to-secondary leakage must be low to prevent radioactive buildup in excess of technical specifications for steam generator activity.
   3))The plant could not be started up from a cold shutdown condition without the availability of at least one of the BRS evaporators or with the specified available capacity in the waste holdup tank.
E. Total process capability of detergent waste water is maintained provided chemical discharges are acceptable for release to the environment.

TABLE 11.2.1-3

SUMMARY - LIQUID WASTE PROCESSING SYSTEM CAPABILITIES

Subsystem	Influent Waste Volumes Gallons/Yr(14)	Proc. Cap. gpm	Process Capacity Gallons/Yr	Fraction of Process Capacity Used	Tank's Name	Tank Qty	Volume Per Tank (Gallons)	No. of Days Storage Waste Input(1)	Redundant Process Subsystem
MFD System(13)	911,200(3)	15	6.3 E+06(4)	0.14	Floor Drain Tank	2	25,000	8	(10)

(1)Based on 80% tank volume.

(2)1 spare evaporator gives 365 day availability.

(3)This is the combined input from the Equipment and Floor Drain Systems, and from the BRS for approximately 2 months (Note 13).

(4)Based on 80% equipment availability (292 days) when system does not have a dedicated spare.

(5)A vendor demineralizer system can be used as an alternative means of processing the waste

(6)Storage per Floor Drain Tank.

(7)Installed redundancy does not exist. However, greater process capacity does exist in that this system was designed to process waste at rates of up to 30 gpm. Also, failure of one component does not disable the entire system. In addition, the size and transportability of the system components would permit rapid replacement of any failed component.

(8)Should radioactivity appear in the secondary side, both the high conductivity and low conductivity wastes may be processed via the low conductivity filter and demineralizer. All secondary waste outside the pH range of 6 to 9 are first neutralized.

(9)Storage per Low Conductivity Holding Tank.

(10)For approximately two months a year there is an additional input of about 180,000 gallons (total) from the BRS.

(11)Input volumes are based on 1998 & 1999 experience.

TABLE 11.2.1-4

LIQUID RADWASTE PROCESSING SYSTEM
DECONTAMINATION FACTORS (DF)

	Design/Normal Operation		
Subsystem	I	Cs, RB	Others
MFDS[1]	100	2000[2]	100,000[2]
Secondary Waste	1	1	1
SG Blowdown	100	1,000	10,000

Notes:

(1) Assumes that during normal operation three cation and one mixed bed demineralizer are used.

TABLE 11.2.1-5

GALE CODE RADIONUCLIDE SPECIFIC ACTIVITIES
IN INPUTS TO THE WASTE PROCESSING SYSTEM

Nuclide	Normal MFDS Subsystem (μCi/g)	Normal Secondary Subsystem (μCi/g)
H3	4.30 E-02	1.00 E-08
Na-24	1.50 E-03	3.48 E-10
Cr-51	8.00 E-05	1.86 E-11
Mn-54	4.10 E-05	9.53 E-12
Fe-55	3.07 E-05	7.15 E-12
Co-58	1.18 E-04	2.75 E-11
W-187	7.48 E-05	1.74 E-11
Np-239	6.11 E-05	1.42 E-11
Y-93	1.42 E-04	3.30 E-11
Mo-99	1.75 E-04	4.07 E-11
Tc-99m	1.73 E-04	4.02 E-11
Ru-103	1.93 E-04	4.49 E-11
Ru-106	2.30 E-03	5.36 E-10
Ag-110m	3.33 E-05	7.75 E-12
Te-131m	4.39 E-05	1.02 E-11
I-131	1.19 E-03	2.76 E-10
Te-132	4.60 E-05	1.07 E-11
I-132	8.86 E-03	2.06 E-09
I-133	4.27 E-03	9.94 E-10
I-134	1.56 E-02	3.62 E-09
Cs-134	1.98 E-04	4.60 E-11
I-135	9.42 E-03	2.19 E-09
Cs-136	2.48 E-05	5.77 E-12
Cs-137	2.61 E-04	6.08 E-11
Ba-140	3.38 E-04	7.86 E-11
La-140	7.10 E-04	1.65 E-10
Ce-143	8.08 E-05	1.88 E-11
Ce-144	9.98 E-05	2.32 E-11

Notes:
(1)These are concentrations at the inlet to the collection tanks and do not account for decay while the tank is filling.

(2)Secondary waste is normally not radioactively contaminated. The values in this table are based on an assumed primary to secondary leakage of 75 lbs/day.

TABLE 11.2.1-6

DESIGN BASIS RADIONUCLIDE SPECIFIC ACTIVITIES IN INPUTS TO THE WASTE PROCESSING SYSTEM(1)

NUCLIDE	DESIGN BASIS MFDS SUBSYSTEM (μCI/g)	DESIGN BASIS SECONDARY SUBSYSTEM (μCi/g)
H3	1.51 E-01	3.50 E-08
Na 24	1.50 E-03	3.48 E-10
Cr 51	2.37 E-04	5.50 E-11
Mn 54	1.72 E-05	4.00 E-12
Fe 55	9.89 E-05	2.30 E-11
Co 58	6.45 E-04	1.50 E-10
W 187	7.48 E-05	1.74 E-11
Np 239	6.11 E-05	1.42 E-11
Y 93	1.27 E-05	2.95 E-12
Mo 99	2.02 E-02	4.70 E-09
Tc 99m	1.87 E-02	4.35 E-09
Ru 103	1.40 E-05	3.25 E-12
Ru 106	5.25 E-06	1.22 E-12
Ag 110m	4.43 E-05	1.03 E-11
Te 131m	6.92 E-04	1.61 E-10
I 131	7.35 E-02	1.71 E-08
Te 132	8.99 E-03	2.09 E-09
I 132	1.06 E-01	2.47 E-08
I 133	3.11 E-01	7.23 E-08
I 134	2.44 E-02	5.67 E-09
Cs 134	6.67 E-02	1.55 E-08
I 135	7.91 E-02	1.84 E-08
Cs 136	1.38 E-01	3.21 E-08
Cs 137	6.92 E-02	1.61 E-08
Ba 140	1.03 E-04	2.39 E-11
La 140	3.83 E-05	8.90 E-12
Ce 143	1.55 E-05	3.61 E-12
Ce 144	1.16 E-05	2.69 E-12

Notes:
(1)These are concentrations at the inlet to the collection tanks and do not account for decay while the tank is filling.

TABLE 11.2.1-7 LIQUID WASTE PROCESSING SYSTEM COMPONENT SUMMARY DATA

Tank Designation	Quantity	Volume Each Tank	Design Code	Material	Design Temp (F)	Design Pressure
Reactor Coolant Drain	1	350 gal.	ASME Section VIII Division I	304SS	250	100 psig
Laundry & Hot Shower	2	25,000 gal.	ASME Section VIII Division I	304SS	200	16 psig
Chemical Drain	2	600 gal.	ASME Section VIII Division I	304SS	200	16 psig
Waste Hold-Up	1	25,000 gal.	ASME Section VIII Division I	304SS	200	16 psig
Spent Resin Storage[1]	4	500 ft3	ASME Section VIII Division I	304SS	200	150 psig
Waste Evaporator Condensate	2	10,000 gal.	ASME Section VIII Division I	304SS	200	16 psig
Floor Drain	4	25,000 gal.	ASME Section VIII Division I	304SS	200	16 psig
Waste Monitor	2	25,000 gal.	ASME Section VIII Division I	304SS	200	16 psig
Recycle Hold-Up	1	84,000 gal.	ASME Code Section III Class 3	304SS	200	16 psig
Waste Evaporator Concentrates	1	5,000	ASME Section VIII Division I	Incoloy 825	200	16 psig
Treated Laundry and Hot Shower	2	25,000	ASME Section VIII Division I	304SS	200	16 psig
Reverse Osmosis Concentrates	2	5,000	ASME Section VIII Division I	304SS	200	16 psig
High Conductivity Holding	1	15,000	ASME Section VIII Division I	316SS	200	16 psig
Low Conductivity Holding	3	15,000	ASME Section VIII Division I	304SS	200	16 psig
Secondary Waste Sample	1	25,000	ASME Section VIII Division I	304SS	200	16 psig
Secondary Waste Concentrate	2	4,000	ASME Section VIII Division I	Incoloy 825	200	16 psig
Backwash Transfer	4	600	ASME Section VIII Division I	304SS	200	350 psig
Backwash Storage	1	2,000	ASME Section VIII Division I	304SS	200	350 psig
Filter Particulates Conc. Tank	1	1,000	ASME Section VIII Division I	304SS	200	350 psig
Solidification System & Pretreat	2	5,000	ASME Section VIII Division I	316SS	200	16 psig

[1] The spent resin storage capacity of each tank is 120 ft.^{3}

Table 11.2.1-7 (Continued)

Pumps	Quantity	Design Code	Type	Design Pressure (psig)	Design Temp (F)	Design Flow (gpm)	Wetted Material
Reactor Coolant Drain Tank	2	ANSI B73.1	Centrifugal	150	250	100	SS
Floor Drain	4	ANSI B73.1	Centrifugal	150	200	35	SS
Laundry & Hot Shower	2	ANSI B73.1	Centrifugal	150	200	35	SS
Waste Monitor	2	ANSI B73.1	Centrifugal	150	200	35	SS
Treated Laundry & Hot Shower	2	ANSI B73.1	Centrifugal	150	200	100	SS
Waste Evaporator Feed	1	ANSI B73.1	Centrifugal	150	200	35	SS
Chemical Drain	2	ANSI B73.1	Centrifugal	150	200	35	SS
Waste Evaporator Condensate Tank	2	ANSI B73.1	Centrifugal	150	200	35	SS
Spent Resin Sluice (Total No-3)	3	ANSI B73.1	Centrifugal	150 150	200 200	140 150	SS SS
Waste Evaporator Concentrates	2	ANSI B73.1	Centrifugal	150	200	35	SS
Reverse Osmosis Concentrates	2	ANSI B73.1	Centrifugal	150	200	35	SS
Spent Resin Transfer	2	ANSI B73.1	Centrifugal	150	200	100	SS
Floor Drain Mixing	2	ANSI B73.1	Centrifugal	150	200	200	SS
Laundry & Hot Shower Mixing	1	ANSI B73.1	Centrifugal	150	200	200	SS
Filter Backwash Transfer	4	ANSI B73.1	Centrifugal	150	200	35	SS
Filter Backwash Storage	2	ANSI B73.1	Centrifugal	150	200	35	SS
Filter Particulate Concentrates	2	ANSI B73.1	Centrifugal	150	200	35	SS
Low Conductivity Holding	2	ANSI B73.1	Centrifugal	150	200	100	SS
High Conductivity Holding	2	ANSI B73.1	Centrifugal	150	200	35	SS
High Conductivity Holding Mixing	1	ANSI B73.1	Centrifugal	150	200	200	SS
Secondary Waste Concentrates	2	ANSI B73.1	Centrifugal	150	200	35	SS
Secondary Waste Sample	2	ANSI B73.1	Centrifugal	150	200	100	SS
Gas Decay Tank Drain	1	ANSI B73.1	Centrifugal	150	200	10	SS
Recycle Evaporator Feed	2	ASME Section III Class 3	Centrifugal	150	200	30	SS

Table 11.2.1-7 (Continued)

Filter	Quantity	ASME Code	Type of Elements	Retention Size Microns	Design Pressure (psig)	Design Temp (F)	Normal Flow (gpm)	Material
Secondary Waste	2	Section VIII Division I	Etched Disc	5	400	200	100	304SS
Secondary Waste	2	Section VIII Division I	Bag	Variable	150	225	Variable[2]	316SS
Backwash Storage Tank	2	Section VIII Division I	Etched Disc	10	400	200	25	304SS
Waste Evaporator Feed	1	Section VIII Division I	Etched Disc	25	400	250	35	304SS
Gas Decay Tank	1	Section VIII Division I	Etched Disc	25	400	200	35	304SS
Waste Evaporator Condensate	1	Section VIII Division I	Etched Disc	25	400	250	35	304SS
Floor Drain Tank	4	Section VIII Division I	Etched Disc	5	400	200	35	304SS
Spent Resin Sluice	3	Section VIII Division I	Etched Disc	25	400	200	150	304SS
Laundry & Hot Shower	2	Section VIII Division I	Etched Disc	5	400	200	35	304SS
Recycle Evaporator Condensate	1	Section VIII Division I	Etched Disc	25	400	250	35	304SS
Fuel Pool Demineralizer	2	Section VIII Division I	Etched Disc	5	400	200	325	304SS
Fuel Pool & Refueling Purification	2	Section VIII Division I	Etched Disc	5	400	200	325	304SS
Fuel Pool Skimmers	2	Section VIII Division I	Etched Disc	5	400	200	400	304SS
Recycle Evap Concentrates	1	Section VIII Division I	Etched Disc	25	400	250	35	304SS
Recycle Evap Feed	1	ASME Section III Class 3	Etched Disc	5	400	250	150	304SS
Seal Water Injection	2	ASME Section III Class 2	Etched Disc	5	2755	200	80	304SS
Seal Water Return	1	ASME Section III Class 2	Etched Disc	25	400	250	150	304SS
Boric Acid	1	ASME Section III Class 3	Etched Disc	25	400	250	150	304SS
Reactor Coolant	1	ASME Section III Class 2	Etched Disc	25	400	250	150	304SS
Radwaste Demineralizer	3	Section VIII Division I	Bag	Variable	150	200	15[3]	304SS/316SS
(MFTDS)	2	Section VIII Division I	Deep Bed	250	150	200	15[(2)]	304SS

[2] The normal secondary waste filter flowrate will be governed by the micron rating of its bag filter.
[3] This rate may be increased to 30 gpm if needed.

Table 11.2.1-7 (Continued)

Demineralizer	Quantity	ASME Code	Type of Resin(1)	Design Pressure	Design Temp (F)	Material	Resin Volume $ft.^3$
Laundry and Hot Shower	1	Section VIII Division I	Mixed	150	200	304SS	50
Waste Monitor Tank	1	Section VIII Division I	Cation	150	200	304SS	50
Secondary Waste	2	Section VIII Division I	Mixed	150	200	304SS	70
Recycle Evap Feed	2	ASME Section III Class 3	Mixed	150	200	304SS	30
Recycle Evap Condensate	2	Section VIII Division I	Mixed	150	200	304SS	20
Waste Evaporator Condensate	1	Section VIII Division I	Mixed	150	200	304SS	30
MFTDS	2	Section VIII Division I	Cation	150	200	304SS	20
MFTDS	2	Section VIII Division I	Mixed	150	200	304SS	20

(1) The type of resin listed is for design calculations and the type of resin may be changed based on process requirements.

Evaporators	Quantity	ASME Code	Type	Design Pressure (psig)	Maximum Design Temp (F)	Operating Pressure	Design Flow (gpm)	Approx. Heat Transferred Btu/hr.	Approx. Steam Required @50 psig (lb/hr)
Waste**	2	Section VIII Division I	Natural Circulation	65	290	3 psig	15		
Reverse Osmosis Concentrates	2	Section VIII Division I	Forced Recirculation	30	270	13 psia	10	$5.8x10^6$	6,000

RO Units	Quantity	ASME Code	Type	Design Pressure (psig)	Maximum Design Temp* (F)	Operating Pressure	Design Flow (gpm)
Laundry and Hot Shower	1	Section VIII Division I	Cellulose Acetate Membrane	600	80	500 psig	30
Floor Drain	1	Section VIII Division I	Cellulose Acetate Membrane	600	80	500 psig	30

* Temperature Limitation for RO Membrane
** One waste evaporator has been dedicated to supporting BRS operation.

TABLE 11.2.3-1

TOTAL PROJECTED ANNUAL RELEASE OF RADIOACTIVITY IN LIQUID EFFLUENTS

Nuclide	TOTAL [Curies/y]
H3	9.4 E+02
Corrosion & Activation Products	
Na 24	3.2 E-04
Cr 51	4.5 E-05
Mn 54	2.7 E-05
Fe 55	2.0 E-05
Co 58	7.3 E-05
W 187	1.9 E-05
Np 239	1.9 E-05
Fission Products	
Y 93	2.5 E-05
Mo 99	5.6 E-05
Tc 99m	4.9 E-05
Ru 103	1.1 E-04
Ru 106	1.5 E-03
Ag 110m	2.2 E-05
Te 131m	1.2 E-05
I 131	1.4 E-01
Te 132	1.5 E-05
I 132	5.4 E-04
I 133	1.3 E-02
I 134	3.0 E-05
Cs 134	4.1 E-03
I 135	2.5 E-03
Cs 136	2.4 E-04
Cs 137	5.5 E-03
Ba 140	1.6 E-04
La 140	2.7 E-04
Ce 143	2.2 E-05
Ce 144	6.5 E-05
All Others	6.9 E-03
TOTAL (Except H3)	1.7 E-01

TABLE 11.2.3-2

ASSUMPTIONS USED TO CALCULATE RADIOACTIVE LIQUID EFFLUENTS

STREAM	FLOW RATE (GAL/DAY)	FRACTION OF PCA(1)	FRACTION DISCHARGED	COLLECTION TIME (DAYS)	DECAY TIME (DAYS)
Boron Control Letdown	6.03 E+02	1	1	55.75	1.56
Primary (MFDS)	1.89 E+03	0.043	1	26.4	2.31
Secondary Lo-Cond	0.00 E+00	0	0	0	0
SG Blowdown	4.32 E+05		0	0	0
Untreated Blowdown	0.00 E+00		0	0	0
Regenerant Solids	0.00 E+00		0	0	0

DECONTAMINATION FACTORS

STREAM	I	CS	OTHERS
Boron Control Letdown	1.00 E+04	4.00 E+04	5.00 E+06
Primary (MFDS)	1.00 E+02	2.00 E+03	1.00 E+05
Secondary-Lo Cond.	1.00 E+00	1.00 E+00	1.00 E+00
SG Blowdown	1.00 E+02	1.00 E+03	1.00 E+04
Regenerant Solids	1.00 E+00	1.00 E+00	1.00 E+00

Notes:

(1) PCA = Primary coolant activity.

TABLE 11.2.3-3

NORMAL OPERATIONAL CONCENTRATIONS
OF RADIONUCLIDES IN LIQUID EFFLUENTS

Nuclide	COOLING TOWER DISCHARGE [µCi/ml](2)	COOLING TOWER DISCHARGE [Conc./EC Limit](1)	AVERAGE DISCHARGE [µCi/ml]	AVERAGE DISCHARGE [Conc./EC limit](1)
H-3	6.38 E-05	6.38 E-02	2.18 E-05	2.18 E-02
Na-24	2.19 E-11	4.38 E-07	9.64 E-15	1.93 E-10
Cr 51	3.06 E-12	6.12 E-09	5.70 E-14	1.14 E-10
Mn-54	1.81 E-12	6.04 E-08	2.49 E-13	8.28 E-09
Fe-55	1.38 E-12	1.38 E-08	3.36 E-13	3.36 E-09
Co-58	4.97 E-12	2.48 E-07	2.21 E-13	1.10 E-08
W-187	1.28 E-12	4.25 E-08	8.94 E-16	2.98 E-11
Np-239	1.27 E-12	6.34 E-08	2.09 E-15	1.05 E-10
Y-93	1.72 E-12	8.58 E-08	5.14 E-16	2.57 E-11
Mo-99	3.82 E-12	1.91 E-07	7.47 E-15	3.74 E-10
Tc 99m	3.31 E-12	3.31 E-09	5.83 E-16	5.83 E-13
Ru-103	7.67 E-12	2.56 E-07	1.99 E-13	6.65 E-09
Ru-106	1.02 E-10	3.42 E-05	1.58 E-11	5.28 E-06
Ag-110m	1.47 E-12	2.44 E-07	1.78 E-13	2.97 E-08
Te-131m	7.94 E-13	9.92 E-08	6.98 E-16	8.72 E-11
I-131	9.30 E-09	9.30 E-03	5.20 E-11	5.20 E-05
Te-132	1.03 E-12	1.15 E-07	2.35 E-15	2.61 E-10
I-132	3.63 E-11	3.63 E-07	2.45 E-15	2.45 E-11
I-133	9.09 E-10	1.30 E-04	5.60 E-13	7.99 E-08
I-134	2.06 E-12	5.16 E-09	5.33 E-17	1.33 E-13
Cs-134	2.80 E-10	3.11 E-04	6.21 E-11	6.90 E-05
I-135	1.72 E-10	5.75 E-06	3.39 E-14	1.13 E-09
Cs-136	1.62 E-11	2.70 E-06	1.45 E-13	2.42 E-08
Cs-137	3.75 E-10	3.75 E-04	1.37 E-10	1.37 E-04
Ba-140	1.08 E-11	1.35 E-06	9.51 E-14	1.19 E-08
La-140	1.85 E-11	2.06 E-06	2.17 E-14	2.41 E-09
Ce-143	1.47 E-12	7.36 E-08	1.43 E-15	7.14 E-11
Ce-144	4.43 E-12	1.48 E-06	5.83 E-13	1.94 E-07
TOTAL Conc./EC Limit		7.39 E-02		2.21 E-02

Notes:

(1)Effluent Concentrations (EC) are based on Post-1993 "10 CFR 20".

(2)The expected concentrations through the cooling tower Blowdown Lines at the Air Relief Valves are calculated at 400,000 pCi/l. This assumes 80,000 liters with 25 curies of tritium at a 25 gpm release rate into a 20,000 gpm dilution stream. This is the highest potential for groundwater contamination from spillage.

TABLE 11.2.3-4

INDIVIDUAL DOSES FROM LIQUID RADIOACTIVE RELEASES

	Annual Dose (mrem/yr.)	
	Organ[(1)]	Total Body[(2)]
Fish	1.07 E+00	7.66 E-01
Drinking[(3)]	3.81 E-02	neg
Shoreline	neg[(4)]	neg
Swimming	neg	neg
Boating	neg	neg
Total	1.12 E+00[(5)]	8.20 E-01

(1)Based on input parameters, the highest organ dose was calculated to the Teen Liver.

(2)The total body dose to an adult is greater than the dose to any other age group.

(3)The Harris reservoir is a drinking water source for worker populations and is of limited availability to the general public. Any realistic dose available to a member of the general public via this pathway is considered insignificant. Lillington, NC is the nearest downstream public drinking water source as defined by NRC guidelines in NUREG-0472, Rev. 3.

(4)Neg is less than 1 E-02 mrem/yr.

(5)This value includes the sum of individual values reported as "neg."

NOTE: Doses are based on radioisotope concentrations calculated by the GALE Code (NUREG-0017). Primary waste streams are assumed to be processed through the MFTDS, and a primary to secondary leak rate of 75 lb/day is assumed within the GALE Code. Therefore, actual doses may be lower, depending on plant conditions and processing equipment used.

TABLE 11.2.3-5

DESIGN BASIS CONCENTRATIONS OF RADIONUCLIDES IN LIQUID EFFLUENTS

	EFFLUENT RELEASE	COOLING TOWER DISCHARGE		AVERAGE RESERVOIR DISCHARGE	
Nuclide	[Ci/Y]	[μCi/ml]	[Conc./EC limit]	[μCi/ml]	[Conc./EC limit]
H 3	3.29 E+03	1.03 E-04	1.03 E-01	7.64 E-05	7.64 E-02
Na 24	3.23 E-04	1.01 E-11	2.03 E-07	9.64 E-15	1.93 E-10
Cr 51	1.33 E-04	4.19 E-12	8.38 E-09	1.69 E-13	3.37 E-10
Mn 54	1.12 E-05	3.52 E-13	1.17 E-08	1.04 E-13	3.48 E-09
Fe 55	6.53 E-05	2.05 E-12	2.05 E-08	1.08 E-12	1.08 E-08
Co 58	3.99 E-04	1.25 E-11	6.27 E-07	1.20 E-12	6.02 E-08
W 187	1.88 E-05	5.91 E-13	1.97 E-08	8.94 E-16	2.98 E-11
Np 239	1.87 E-05	5.87 E-13	2.94 E-08	2.09 E-15	1.05 E-10
Y 93	2.26 E-06	7.10 E-14	3.55 E-09	4.59 E-17	2.30 E-12
Mo 99	6.50 E-02	2.04 E-10	1.02 E-05	8.63 E-13	4.31 E-08
Tc 99m	5.28 E-03	1.66 E-10	1.66 E-07	6.31 E-14	6.31 E-11
Ru 103	8.18 E-06	2.57 E-13	8.56 E-09	1.44 E-14	4.81 E-10
Ru 106	3.44 E-06	1.08 E-13	3.60 E-08	3.60 E-14	1.20 E-08
Ag 110m	2.87 E-05	9.02 E-13	1.50 E-07	2.37 E-13	3.95 E-08
Te 131m	1.85 E-04	5.80 E-12	7.25 E-07	1.10 E-14	1.38 E-09
I 131	8.49 E+00	2.67 E-07	2.67 E-01	3.22 E-09	3.22 E-03
Te 132	2.97 E-03	9.33 E-11	1.04 E-05	4.59 E-13	5.10 E-08
I 132	6.41 E-03	2.01 E-10	2.01 E-06	2.94 E-14	2.94 E-10
I 133	9.75 E-01	3.06 E-08	4.37 E-03	4.07 E-11	5.82 E-06
I 134	4.76 E-05	1.50 E-12	3.74 E-09	8.35 E-17	2.09 E-13
Cs 134	1.39 E+00	4.36 E-08	4.84 E-02	2.09 E-08	2.33 E-02
I 135	2.13 E-02	6.70 E-10	2.23 E-05	2.85 E-13	9.48 E-09
Cs 136	1.33 E+00	4.18 E-08	6.96 E-03	8.07 E-10	1.35 E-04
Cs 137	1.46 E+00	4.60 E-08	4.60 E-02	3.63 E-08	3.63 E-02
Ba 140	4.83 E-05	1.52 E-12	1.90 E-07	2.89 E-14	3.61 E-09
La 140	1.47 E-05	4.63 E-13	5.14 E-08	1.17 E-15	1.30 E-10
Ce 143	4.17 E-06	1.31 E-13	6.54 E-09	2.74 E-16	1.37 E-11
Ce 144	7.57 E-06	2.38 E-13	7.93 E-08	6.76 E-14	2.25 E-08
TOTAL Conc./EC limit		4.76 E-01			1.39 E-01

Note: Effluent Concentrations (EC) are based on the 1993 revisions of 10 CFR 20

TABLE 11.3.2-1

DESIGN BASIS ACCUMULATED RADIOACTIVITY IN THE GASEOUS WASTE PROCESSING SYSTEM AFTER FORTY YEARS OPERATION

Activity (Curies)

		Following Plant Shutdown	
Isotope	Zero Decay	30 Days	50 Days
Kr-85	44,400	44,160	44,010
All other noble gases			
Kr-85m	54	~0	~0
Kr-87	6.0	~0	~0
Kr-88	57	~0	~0
Xe-131m	760	132	41
Xe-133	54,800	1042	74
Xe-133m	770	~0	~0
Xe-135	500	~0	~0
Xe-135m	2.2	~0	~0
Xe-138	0.18	~0	~0

The table is based on forty years continuous operation with 1 percent of rated core power generated by fuel rods containing cladding defects. Power is assumed to be 2958 MWt. This assumed power level is 102% of the licensed core power for conservatism. The data are based on a volume control tank purge rate of 0.7 scfm and on reactor coolant concentrations given in Table 11.1.1-2.

TABLE 11.3.2-2

EXPECTED ACCUMULATED RADIOACTIVITY IN THE GASEOUS WASTE PROCESSING SYSTEM AFTER FORTY YEARS OPERATION

Activity (Curies)

Following Plant Shutdown

Isotope	Zero Decay	30 Days	50 Days
Kr-85	5300	5272	5253
All other noble gases			
Kr-85m	4.2	~0	~0
Kr-87	0.79	~0	~0
Kr-88	4.4	~0	~0
Xe-131m	190	34	10.6
Xe-133	520	10	0.7
Xe-133m	9.9	~0	~0
Xe-135	37	~0	~0
Xe-135m	0.044	~0	~0
Xe-138	0.035	~0	~0

Inventories are based on reactor coolant concentrations given in Table 11.1.2-1. The table is based on forty years continuous operation. Power is assumed to be 2949 MWt. The data are based on a volume control tank purge rate of 0.7 scfm.

TABLE 11.3.2-3

REDUCTION IN REACTOR COOLANT SYSTEM GASEOUS FISSION PRODUCTS RESULTING FROM NORMAL OPERATION OF THE GASEOUS WASTE PROCESSING SYSTEM[(1)]

	Reactor Coolant Gaseous Fission Product Activities - µc/gm	
Isotope	GWPS Operating[(2)]	GWPS Not Operating
Kr-85	0.050	10.6
Kr-85m	1.6	1.7
Kr-87	1.1	1.1
Kr-88	3.1	3.2
Xe-131m	0.35	3.4
Xe-133	57	276
Xe-133m	1.8	4.9
Xe-135	6.8	8.5
Xe-135m	0.4	0.4
Xe-138	0.63	0.63

(1) Based on operating with cladding defects in fuel generating 1 percent of the core thermal power (2958 MWt) and a purification letdown rate of 106 gpm. The core thermal power used is 102% of the licensed core power for conservatism.

(2) Volume control tank purge rate is 0.7 scfm.

TABLE 11.3.2-6

PROCESS PARAMETERS FOR GWPS - 90 DAY ACCUMULATION OF WASTE GASES (NOTES 1 & 2)

ITEM DESCRIPTION GAS STREAMS	TEMP °F	PRESS PSIG	FLOW SCFM	N_2 + He %	H_2 %	ISOTOPIC CONCENTRATION, µ C/CC (Note 3) KR85	KR85M	KR87	KR88	XE-133	XE-133M	XE-135
1. Volume Control Tank Purge	130	18	0.7	0	100	8.77E-02	4.49E-01	3.01E-01	7.26E-01	2.43E+00	1.07E-01	2.00E+00
2. Gas Decay Tank Disch.	AMB	20	40	99.9	0.1	5.34E+00	8.46E-02	1.63E-02	8.68E-02	1.29E+01	2.48E-01	7.82E-01
3. Compressor Suction	AMB	0.5	40.7	98.3	1.7	5.25E+00	9.08E-02	2.12E-02	9.79E-02	1.28E+01	2.46E-01	8.03E-01
4. Comp. Disch. 140	40	40.7	98.3	1.7	5.25E+00	9.08E-02	2.12E-02	9.79E-02	1.28E+01	2.46E-01	8.03E-01	
5. Recombiner Disch.	140	20	40	99.9	0.1	5.34E+00	9.24E-02	2.16E-02	9.96E-02	1.29E+01	2.50E-01	8.17E-01
6. Misc. Vents- Evaps. RCDT.	140	0.5	NEG.	0	100	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recycle Holdup Tank Eductor												
7 .Recombiner Oxygen Supply	AMB	50	0.35	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ITEM DESCRIPTION LIQUID STREAMS	TEMP °F	PRESS PSIG	FLOW GPD	ISOTOPIC CONCENTRATION, µ C/CC (Note 4) KR85	KR85M	KR87	KR88	XE-133	XE-133M	XE-135
1. Waste Gas Compressor Drain	140	40	0	1.27E+00	2.18E-02	5.07E-03	2.34E-02	2.52E+00	4.87E-02	1.57E+00
2. Recombiner Drain	140	30	6	1.07E+00	1.86E-02	2.39E-03	1.99E-02	2.12E+01	4.11E-02	1.33E+00
3. Gas Decay Tank Drains	AMB	20	18	5.08E-01	1.17E-02	1.54E-03	1.21E-02	1.01E+00	1.93E-02	6.06E-01
4. System Drains to Vol. Control Tank	140	30-45	24	3.18E-01	1.97E-02	3.83E-02	2.04E-02	7.46E-01	4.48E-02	1.42E-01

ITEM DESCRIPTION GAS STREAMS	TEMP °F	PRESS PSIG	VOL FT.^{3}	N_2%	H_2 %	COMPONENT INVENTORY, CURIES (Note 8) KR85	KR85M	KR87	KR88	XE-133	XE-133M	XE-135
A. Compressor	140	40	4	98.3	1.7	2.21E+00	3.83E-02	8.92E-03	4.12E-02	5.38E+00	1.04E-01	3.39E-01
B. Recombiner	140	30	4	99.9	0.1	1.84E+00	3.17E-02	7.43E-03	3.43E-02	4.07E+00	8.60E-02	2.82E-01
C. Gas Decay Tank	AMB	20	600	99.9	0.1	2.14E+02	3.40E+00	6.53E-01	3.48E+00	5.17E+02	9.92E+00	3.14E+01
TOTAL SYSTEM						2.18E+02	3.47E+00	6.70E-01	3.56E+00	5.26E+02	1.01E+01	3.20E+01

*NOTES:

1. Basis: Type of Operation = Periodic Release of Gases
   Power Level = 2949 MWt (See Note 2)
   Normal Operation Gas Decay Tanks in Rotational Use = 9
   Accumulation Period = 90 days
2. Concentrations based on GALE Code (Appendix I) Expected Reactor Coolant Radionuclide Inventories. The original calculation was performed at 2900 MWt. A multiplicative correction factor of 1.42, 2.37 and 1.66 was applied to KR-85M, KR-87 and KR-88, respectively to account for the VCT purge activity concentrations at 2949 MWt power level (Table 11.1.2-1).
4. Concentrations in µ Ci per cc at room temperature.
5. NEG - Negligible
6. AMB - Ambient
7. Pressures given for low pressure and high pressure operation (low/hi) if different.
8. These are the concentrations at the end of the third 30 day waste gas collection period. The radionuclide inventory given here does not account for any delay/holdup prior to release.

TABLE 11.3.2-7

GASEOUS WASTE PROCESSING SYSTEM
COMPONENT DESCRIPTION(1)

Waste Gas Compressor Packages

Number	2
Design pressure (psig)	150
Design temperature, (°F)	180
Normal operating temperature, (°F)	70 to 140
Normal operating pressure, psig	
Suction	0.5-2.0
Discharge	$\leq$ 100
Design flowrate (N_2 at 60°F, 0 psig) scfm	40

Waste Gas Decay Tanks

Number	10(3)
Design pressure (psig)	150
Design temperature (°F)	180
Volume, (Each) (ft^3)	600
Normal operating pressure, psig	5-100
Normal operating temperature, °F	50-140
Material of construction	Carbon Steel

Catalytic Hydrogen Recombiner Packages

Number	2(4)
Design inlet pressure, psig	35-110
Design inlet temperature, °F	40-140
Design flowrate, scfm	30-50
Design hydrogen recombiner rate, scfm	2.4
Design discharge pressure, psig	0-20
Design discharge temperature,°F	40-140
Material of construction Stainless Steel	

Note (1) The components are designed in accordance with the ASME Boiler and Pressure Vessel Code, Section III, Class 3 requirements and meet ASME Safety Class 3 criteria except for compressors which are classified as Rad-Q.

Note (2) Deleted

Table 11.3.2-7 (Continued)

Note (3) Nine gas decay tanks are used for collection and one gas decay tank is kept at a low pressure to collect effluents from relief valves.

Note (4) One hydrogen recombiner is in long-term shutdown.

TABLE 11.3.2-8

GASEOUS WASTE PROCESSING SYSTEM INSTRUMENTATION DESIGN PARAMETERS

F – Flow
T – Temperature
I – Indication
Q - Water Integrator
L – Level
C – Control
P - Pressure
R - Radiation
A - Alarm

Channel Number	Location of Primary Sensor	Design Pressure (psig)	Design Temperature (°F)	Range	Alarm Setpoint	Control Setpoints	Location of Readout
Flow Instrumentation							
FIA-1094	Volume Control Tank Purge Flow	150	250	0-1.2 scfm	1.0 scfm		WPS panel
QIA-1091	Gas Decay Tank Water Flush	150	180	0-6000 gal	3000 0		Local
Pressure Instrumentation							
PI-1031	Moisture Separator for Waste Gas Compressor 1	150	180	0-100 psig			Local
PI-1033	Moisture Separator for Waste Gas Compressor 2	150	180	0-100 psig			Local
PIA-1036	Gas Decay Tank 1A	150	180	0-150 psig	100 psig 20 psig		WPS panel
PIA-1037	Gas Decay Tank 1B	150	180	0-150 psig	100 psig 20 psig		WPS panel
PIA-1038	Gas Decay Tank 1C	150	180	0-150 psig	100 psig 20 psig		WPS panel
PIA-1039	Gas Decay Tank 1D	150	180	0-150 psig	100 psig 20 psig		WPS panel
PI-1047	Nitrogen Supply to GDT's	150	180	0-160 psig		Local	
PIA-1052	Gas Decay Tank 1E	150	180	0-150 psig	80 psig 20 psig		WPS panel
PIA-1053	Gas Decay Tank 1F	150	180	0-150 psig	80 psig 20 psig		WPS panel
PIA-1054	Gas Decay Tank 1G	150	180	0-150 psig	100 psig 20 psig		WPS panel
PIA-1055	Gas Decay Tank 1H	150	180	0-150 psig	100 psig 20 psig		WPS panel
PIA-1056	Gas Decay Tank 1I	150	180	0-150 psig	100 psig 20 psig		WPS panel
PIA-1057	Gas Decay Tank 1J	150	180	0-150 psig	100 psig 20 psig		WPS panel
PICA-1092	Waste Gas Compressor Suction Header	150	180	2-psi vac. to 2 psig	0.5 psi	0.5 psi vac.	WPS panel
PI-1093	Gas Decay Tank Makeup Water	150	180	0-150 psig			Local
PI-1094	Volume Control Tank Purge Pressure	150	250	0-30 psig			Local
Level Instrumentation							
LICA-1030	Waste Gas Compressor A Seal Tank	150	180	0-30 inches H_2O	1 inch 15 inches H_2O	10 inches 8 inches 1 inch H_2O	WPS panel and Local
LICA-1032	Waste Gas Compressor B Seal Tank	150	180	0-30 inches H_2O	1 inch 15 inches H_2O	10 inches 8 inches 1 inch H_2O	WPS panel and Local

TABLE 11.3.3-1

GASEOUS RADIOACTIVE RELEASES - ONE UNIT- NORMAL OPERATION (CURIES PER YEAR)

	WASTE GAS DECAY TANKS (1)		BUILDING VENTILATION			CONDENSER VACUUM PUMP EXHAUST	TOTAL
	SHUTDOWN	CONTINUOUS	CONTAINMENT	AUXILIARY	TURBINE		
KR-85M	0.00E+00	0.00E+00	5.60E+01	3.00E+00	0.00E+00	2.00E+00	6.10E+01
KR-85	5.00E+00	5.60E+02	2.20E+01	0.00E+00	0.00E+00	0.00E+00	5.90E+02
KR-87	0.00E+00	0.00E+00	2.00E+01	3.00E+00	0.00E+00	2.00E+00	2.50E+01
KR-88	0.00E+00	0.00E+00	7.20E+01	6.00E+00	0.00E+00	3.00E+00	8.10E+01
XE-131M	0.00E+00	1.70E+01	1.20E+02	2.00E+00	0.00E+00	0.00E+00	1.40E+02
XE-133M	0.00E+00	0.00E+00	3.10E+01	0.00E+00	0.00E+00	0.00E+00	3.10E+01
XE-133	0.00E+00	0.00E+00	7.30E+02	1.10E+01	0.00E+00	5.00E+00	7.50E+02
XE-135M	0.00E+00	0.00E+00	4.00E+00	3.00E+00	0.00E+00	1.00E+00	8.00E+00
XE-135	0.00E+00	0.00E+00	4.20E+02	1.50E+01	0.00E+00	7.00E+00	4.40E+02
XE-138	0.00E+00	0.00E+00	3.00E+00	3.00E+00	0.00E+00	1.00E+00	7.00E+00
TOTAL NOBLE GASES							2.10E+03
I-131	0.00E+00	3.60E-03	9.80E-04	8.80E-03	0.00E+00	0.00E+00	1.30E-02
I-133	0.00E+00	1.30E-02	3.40E-03	3.20E-02	0.00E+00	0.00E+00	4.80E-02
H-3	-	-	-	-	-	-	2.10E+02
C-14	-	-	-	-	-	-	7.30E+00
AR-41	-	-	-	-	-	-	3.40E+01
CR-51	0.00E+00	1.40E-07	9.10E-05	3.20E-06	1.80E-04	0.00E+00	2.70E-04
MN-54	0.00E+00	2.10E-08	5.30E-05	7.80E-07	3.00E-04	0.00E+00	3.50E-04
CO-57	0.00E+00	0.00E+00	8.10E-06	0.00E+00	0.00E+00	0.00E+00	8.10E-06
CO-58	0.00E+00	8.70E-08	2.50E-04	1.90E-05	2.10E-02	0.00E+00	2.10E-02
CO-60	0.00E+00	1.40E-07	2.60E-05	5.10E-06	8.20E-03	0.00E+00	8.20E-03
FE-59	0.00E+00	1.80E-08	2.70E-05	5.00E-07	0.00E+00	0.00E+00	2.80E-05
SR-89	0.00E+00	4.40E-07	1.30E-04	7.50E-06	2.10E-03	0.00E+00	2.20E-03
SR-90	0.00E+00	1.70E-07	5.20E-05	2.90E-06	8.00E-04	0.00E+00	8.60E-04
ZR-95	0.00E+00	4.80E-08	0.00E+00	1.00E-05	3.60E-06	0.00E+00	1.40E-05
NB-95	0.00E+00	3.70E-08	1.80E-05	3.00E-07	2.40E-03	0.00E+00	2.40E-03
RU-103	0.00E+00	3.20E-08	1.60E-05	2.30E-07	3.80E-05	0.00E+00	5.40E-05
RU-106	0.00E+00	2.70E-08	0.00E+00	6.00E-08	6.90E-05	0.00E+00	6.90E-05
SB-125	0.00E+00	0.00E+00	0.00E+00	3.90E-08	5.70E-05	0.00E+00	5.70E-05
CS-134	0.00E+00	3.30E-07	2.50E-05	5.40E-06	1.70E-03	0.00E+00	1.70E-03
CS-136	0.00E+00	5.30E-08	3.20E-05	4.80E-07	0.00E+00	0.00E+00	3.30E-05
CS-137	0.00E+00	7.70E-07	5.50E-05	7.20E-06	2.70E-03	0.00E+00	2.80E-03
BA-140	0.00E+00	2.30E-07	0.00E+00	4.00E-06	0.00E+00	0.00E+00	4.20E-06
CE-141	0.00E+00	2.20E-08	1.30E-05	2.60E-07	4.40E-07	0.00E+00	1.40E-05

(1) Waste gas decay tank releases assumed after a 90 day decay period.

TABLE 11.3.3-2

ASSUMPTIONS USED TO CALCULATE GASEOUS RADIOACTIVE RELEASES

GASEOUS WASTE INPUTS

There is Continuous Stripping of Full Letdown Flow

Flow Rate through Gas Stripper (gpm)		26.814
HOLDUP TIME FOR XENON (DAYS)		90.000
HOLDUP TIME FOR KRYPTON (DAYS)		90.000
FILL TIME OF DECAY TANKS FOR THE GAS STRIPPER (DAYS)		.000
Primary Coolant Leak to Auxiliary Bldg (lb/Day)		160.000
GAS WASTE SYSTEM	Particulate Release Fraction	.010
FUEL HANDLING BLDG	Iodine Release Fraction	1.000
	Particulate Release Fraction	1.000
AUXILIARY BLDG	Iodine Release Fraction	.100
Particulate Release Fraction		.010
CONTAINMENT VOLUME (MILLION FT^3)		2.266
Frequency of Primary Coolant Degassing (Times/Yr)		2.000

There is a Kidney Filter

Containment Atmosphere Cleanup Rate (Thousand CFM)		10.000
Purge Time of Containment (Hours)		16.000
Fraction Iodine Bypassing Condensate Demineralizer		.984
Iodine Partition Factor (Gas/Liquid) in Steam Generator		.010
Frequency of Cntmt Bldg High Vol Purge (Times/Yr)		2.000
CNTMT-HIGH VOL PURGE	Iodine Release Fraction	.100
	Particulate Release Fraction	.010
CNTMT LOW VOL PURGE Rate (cfm)		1720.000
CNTMT LOW VOL PURGE	Iodine Release Fraction	.010
	Particulate Release Fraction	.010
Steam Leak to Turbine Bldg		1700.000
FRACTION IODINE RELEASED FROM BLOWDOWN TANK VENT		.000
PERCENT OF IODINE REMOVED FROM AIR EJECTOR RELEASE		.000

There is Not an On-Site Laundry

TABLE 11.3.3-3

ANNUAL AVERAGE CONCENTRATION OF RADIOACTIVITY AT THE SITE BOUNDARY - ONE UNIT - NORMAL OPERATION

		(A)	(B)	(C)
	Release gale-gas[1] Ci/yr	Concentration µCi/ml	10CFR20[2] EC limit (µCi/ml)	Ration Conc/EC limit
KR85M	6.10E+01	1.17992E-11	1.00E-07	1.18E-04
KR85	5.90E+02	1.14124E-10	7.00E-07	1.63E-04
KR87	2.50E+01	4.83574E-12	2.00E-08	2.42E-04
KR88	8.10E+01	1.56678E-11	9.00E-09	1.74E-03
XE131M	1.40E+02	2.70802E-11	2.00E-06	1.35E-05
XE133M	3.10E+01	5.99632E-12	6.00E-07	9.99E-06
XE133	7.50E+02	1.45072E-10	5.00E-07	2.90E-04
XE135M	8.00E+00	1.54744E-12	4.00E-08	3.87E-05
XE135	4.40E+02	8.51091E-11	7.00E-08	1.22E-03
XE138	7.00E+00	1.35401E-12	2.00E-08	6.77E-05
CR-51	2.70E-04	5.2226E-17	3.00E-08	1.74E-09
MN-54	3.50E-04	6.77004E-17	1.00E-09	6.77E-08
CO-57	8.10E-06	1.56678E-18	9.00E-10	1.74E-09
CO-58	2.10E-02	4.06202E-15	1.00E-09	4.06E-06
CO-60	8.20E-03	1.58612E-15	5.00E-11	3.17E-05
FE-59	2.80E-05	5.41603E-18	7.00E-10	7.74E-09
SR-89	2.20E-03	4.25545E-16	2.00E-10	2.13E-06
SR-90	8.60E-04	1.6635E-16	6.00E-12	2.77E-05
ZR-95	1.40E-05	2.70802E-18	5.00E-10	5.42E-09
NB-95	2.40E-03	4.64231E-16	2.00E-09	2.32E-07
RU-103	5.40E-05	1.04452E-17	9.00E-10	1.16E-08
RU-106	6.90E-05	1.33467E-17	2.00E-11	6.67E-07
SB-125	5.70E-05	1.10255E-17	7.00E-10	1.58E-08
CS-134	1.70E-03	3.28831E-16	2.00E-10	1.64E-06
CS-136	3.30E-05	6.38318E-18	9.00E-10	7.09E-09
CS-137	2.80E-03	5.41603E-16	2.00E-10	2.71E-06
BA-140	4.20E-06	8.12405E-19	2.00E-09	4.06E-10
CE-141	1.40E-05	2.70802E-18	8.00E-10	3.39E-09
I-131	1.30E-02	2.51459E-15	2.00E-10	1.26E-05
I-133	4.80E-02	9.28463E-15	1.00E-09	9.28E-06
H-3	2.10E+02	4.06202E-11	1.00E-07	4.06E-04
C-14	7.30E+00	1.41204E-12	3.00E-09	4.71E-04
AR-41	3.40E+01	6.57661E-12	1.00E-08	6.58E-04

Notes:

(1) GALE output, attachment C, Gaseous Releases with Charcoal Efficiency of 90%

(2) Effluent Concentrations [EC] limits are based on the 1993 revision to 10 CFR 20.

TABLE 11.3.3-4

POTENTIAL DOSES FROM GASEOUS RADIOACTIVE RELEASES - ONE UNIT - NORMAL OPERATION

Site Boundary Air Doses[2] (mrad/year)

Gamma	3.49E-01
Beta	6.31E-01

	Maximum Individual Doses (mrem/year)			
	Adult (17+ yrs)	Teenagers (11-17 yrs)	Children (1-11 yrs)	Infant (0-1 yrs)
TOTAL BODY				
Immersion[3]	7.00E-02	7.00E-02	7.00E-02	7.00E-02
Inhalation[3]	1.90E-02	1.91E-02	1.69E-02	9.66E-03
Ground Deposition[3]	2.75E-02	2.75E-02	2.75E-02	2.75E-02
Vegetables[4]	1.52E-01	2.26E-01	4.90E-01	
Milk[5]	3.21E-02	5.44E-02	1.24E-01	2.49E-01
Meat[3]	3.97E-02	3.21E-02	5.82E-02	
TOTAL	3.40E-01	4.29E-01	7.87E-01	3.56E-01
SKIN				
Immersion[3]	2.15E-01	2.15E-01	2.15E-01	2.15E-01
Inhalation[3]	1.85E-02	1.86E-02	1.65E-02	9.47E-03
Ground Deposition[3]	3.23E-02	3.23E-02	3.23E-02	3.23E-02
Vegetables[4]	1.29E-01	1.98E-01	4.46E-01	
Milk[5]	3.09E-02	5.32E-02	1.23E-01	2.48E-01
Meat[3]	3.90E-02	3.18E-02	5.78E-02	
TOTAL	4.64E-01	5.49E-01	8.91E-01	5.05E-01
THYROID				
Immersion[3]	7.00E-02	7.00E-02	7.00E-02	7.00E-02
Inhalation[3]	3.41E-02	3.85E-02	4.02E-02	3.13E-02
Ground Deposition[3]	2.75E-02	2.75E-02	2.75E-02	2.75E-02
Vegetables[4]	1.50E-01	2.16E-01	4.73E-01	
Milk[5]	3.60E-02	6.13E-02	1.39E-01	2.89E-01
Meat[3]	4.11E-02	3.32E-02	6.00E-02	
TOTAL	3.59E-01	4.47E-01	8.10E-01	4.18E-01

[1] All doses calculated at the critical receptor location; i.e., that location for which the combination of receptor distance and direction gives the worst meteorological conditions (Chi/Q and D/Q).
[2] Calculated at 1.36 miles in the S direction using meteorological dispersion from ODCM Revision 3.
[3] Calculated at 1.80 miles in the NNE direction using meteorological dispersion from ODCM Revision 3.
[4] Calculated at 1.70 miles in the NNE direction using meteorological dispersion from ODCM Revision 3.
[5] Calculated at 2.20 miles in the N direction using meteorological dispersion from ODCM Revision 3.

TABLE 11.3.3-5

GASEOUS RADIOACTIVE RELEASES - ONE UNIT
DESIGN BASIS**

	Release (Ci/Yr)	Concentration (Micro-Ci/ml)	MPC* (Micro-Ci/ml)	C/MPC
KR 83M	2.0E+01	3.4E-12	3.0E-06	1.1E-06
KR 85M	3.0E+02	5.2E-11	1.0E-07	5.2E-04
KR 85	2.0E+05	3.5E-08	3.0E-07	1.2E-01
KR 87	5.6E+01	9.6E-12	2.0E-08	4.8E-04
KR 88	4.1E+02	7.0E-11	2.0E-08	3.5E-03
XE 131M	1.5E+03	2.6E-10	4.0E-07	6.4E-04
XE 133M	7.5E+03	1.3E-09	3.0E-07	4.3E-03
XE 133	1.4E+05	2.4E-08	3.0E-07	7.9E-02
XE 135	1.6E+03	2.7E-10	1.0E-07	2.7E-03
XE 138	1.3E+01	2.2E-12	3.0E-06	7.3E-07
I 131	4.7E-01	8.0E-14	1.0E-10	8.0E-04
I 133	6.2E-01	1.1E-13	4.0E-10	2.8E-04
MN 54	6.0E-03	1.0E-15	1.0E-09	1.0E-06
FE 59	8.8E-04	1.5E-16	2.0E-09	7.5E-08
C0 58	1.4E-02	2.4E-15	2.0E-09	1.2E-06
C0 60	6.9E-03	1.2E-15	3.0E-10	4.0E-06
S 89	4.3E-03	7.4E-16	3.0E-10	2.5E-06
S 90	7.4E-04	1.3E-16	3.0E-11	4.2E-06
CS 134	4.3E-01	7.3E-14	4.0E-10	1.8E-04
CS 134	6.5E-01	1.1E-13	5.0E-10	2.2E-04
H 3	2.0E+03	3.0E-10	2.0E-07	1.7E-03
C 14	8.0E+00	1.4E-12	1.0E-07	1.4E-05
Ar 41	2.5E+01	4.3E-12	4.0E-08	1.1E-04
Total				2.1E-01

*Calculated at 1.33 miles in the NNE direction. χ/Q = 5.4E-06 sec/m3

**Except where noted, analysis and terms used in this section are based on "pre-1993 10 CFR 20" (see Section 12.0).

TABLE 11.4.1-1

NORMAL SOLID PROCESSING SYSTEM INPUTS*

Source	Form	Quantity (ft^3/yr)
Spent Resins	Dewatered Resin	
CVCS/BRS(1)		160
Fuel Pool		140
Condensate Polishers(2)		450
Subtotal:		750
MFTDS		
Spent Resins	Dewatered Resin	1135
Filters	Bag & Activated Carbon	200
Subtotal:		1335
Dry Solids	Paper, rags, etc.	12000
Chemical Drains	Misc. Chem. Solutions	125

NOTES: (Bases for values)

1) Normally changed during annual refueling.
2) Deep bed condensate polisher resin life of three years.

*Table gives maximum annual volumes; for expected volumes delete spent resin from the condensate demineralizers. Thus, the expected volumes are those associated with primary systems and the maximum volumes include volumes associated with the secondary systems. This table is based on the normal use of the MFTDS.

TABLE 11.4.1-1a

ALTERNATE SOLID PROCESSING SYSTEM INPUTS*

Source	Form	Quantity (ft^3/yr)
Spent Resins	Dewatered Resin	
CVCS/BRS[1])		160
Fuel Pool		140
Radwaste[3]		800
Condensate Polishers[2]		450
Subtotal:		1550
Evaporator Bottoms		
Waste Evap.[4]	12% $Na_2B_4O_7$	165
Reverse Osmosis Conc Evap.[5]	22% Na_2SO_4, 5% $Na_2B_4O_7$	1250
Boron Recycle Evap.[6]	4% H_3BO_3	1025
Subtotal:		2440
Filter Particulates	3% filter sludge	1800
Dry Solids	Paper, rags, etc.	12000
Chemical Drains	Misc. Chem Solutions	125

NOTES: (Bases for values)
1) Normally changed during annual refueling.
2) Deep bed condensate polisher resin life of three years.
3) Normally changed twice a year.
4) Based on volume reduction ratio of 50, from Equipment Drain.
5) Based on volume reduction ratio of 120 from Floor Drain and Laundry & Hot Shower Drain.
6) Based on 10% disposal of evaporator bottoms, 90% recycled.
7) Based on 10% disposal of evaporator bottoms, 90% recycled.

*Table gives maximum annual volumes; for expected volumes delete spent resin from the condensate demineralizers and the bottoms from laundry and hot shower drains. Thus, the expected volumes are those associated with primary systems and the maximum volumes include volumes associated with the secondary systems. This table is based on the processing of liquid waste using the alternative waste processing subsystem consisting of reverse osmosis and evaporation.

TABLE 11.4.1-2

NUCLIDE ACTIVITY INPUTS TO THE SOLID RADWASTE SYSTEM, EVAPORATOR CONCENTRATES (µ-Ci/g) NORMAL OPERATIONS [(1)]

Isotope	Waste Evaporator Bottoms	RO Concentrate Evaporator Bottoms	Boron Recycle Evaporator Bottoms
Br 83	1.24E-03	4.69E-05	---
Br 84	1.46E-04	1.25E-06	---
I 130	2.71E-03	2.73E-04	---
I 131	5.04E+00	5.93E-01	6.70E-01
I 132	2.46E-02	8.91E-04	8.20E-02
I 133	8.07E-01	9.18E-02	6.80E-01
I 134	4.37E-03	6.11E-05	---
I 135	1.34E-01	1.05E-02	1.50E-01
Rb 86	3.13E-03	2.88E-04	---
Rb 88	6.18E-03	2.98E-05	---
Cs 134	1.92E+00	1.25E-01	2.29E-01
Cs 136	3.69E-01	3.78E-02	7.20E-01
Cs 137	1.42E+00	9.27E-02	3.70E-01
Cr 51	8.67E-03	7.23E-04	---
Mn 54	2.31E-03	1.62E-04	---
Fe 55	1.24E-01	7.87E-03	---
Fe 59	5.54E-03	4.20E-04	---
Co 58	1.00E-01	7.18E-03	---
Co 60	1.56E-02	1.09E-03	---
Sr 89	2.02E-02	1.50E-03	---
Sr 90	7.86E-04	4.96E-05	---
Sr 91	6.54E-04	6.03E-05	---
Y 90	7.66E-07	9.94E-08	---
Y 91M	3.22E-06	4.31E-08	---
Y 91	3.81E-04	2.78E-05	---
Y 93	3.68E-06	3.48E-07	---
Zr 95	3.69E-04	4.26E-05	---
Nb 95	2.53E-04	4.29E-05	---
Mo 99	5.54E-03	7.18E-04	1.60E-01
Tc 99M	3.07E-04	2.27E-05	1.50E-01
Ru 103	2.38E-04	2.01E-05	---
Ru 106	7.52E-05	3.28E-05	---
Rh 103M	4.59E-07	7.01E-09	---
Te 125M	1.73E-03	1.27E-04	---
Te 127M	1.89E-02	1.29E-03	---
Te 127	8.23E-04	7.44E-05	---
Te 129M	6.90E-02	5.53E-03	---
Te 129	1.93E-04	3.49E-06	---
Te 131M	7.24E-03	8.72E-04	4.80E-03
Te 131	4.82E-05	3.23E-07	---
Te 132	2.08E-01	2.71E-02	6.70E-02
Ba 140	6.12E-03	6.32E-04	---
La 140	6.02E-05	7.55E-06	---
Ce 141	3.43E-04	2.76E-05	---
Ce 143	1.32E-05	1.62E-06	---
Ce 144	2.45E-04	7.38E-05	--
Pr 143	1.46E-04	1.48E-05	--
Pr 144	9.78E-07	4.52E-09	--
Np 239	6.72E-03	8.68E-04	--
TOTAL	1.03E+01	1.01E+00	3.61E+00

Notes:
(1)This table contains historical information used in the original design of the radwaste system.

TABLE 11.4.1-3 NUCLIDE ACTIVITY INPUTS TO THE SOLID RADWASTE SYSTEM, EVAPORATOR CONCENTRATES (μ-Ci/g) DESIGN BASIS (1)

Isotope	Waste Evaporator Bottoms	RO Concentrate Evaporator Bottoms	Boron* Recycle Evaporator Bottoms
Br 83	2.19E-02	8.23E-04	---
Br 84	2.30E-03	1.97E-05	---
I 129	3.22E-06	2.04E-07	---
I 130	2.42E-02	2.44E-03	---
I 131	5.11E+01	6.02E+00	5.40E-1
I 132	6.31E-01	2.29E-02	6.70E-2
I 133	8.30E+00	9.49E-01	6.90E-1
I 134	4.69E-02	6.54E-04	---
I 135	1.42E+00	1.11E-01	1.40E-1
Rb 86	7.65E-01	7.05E-02	---
Rb 88	1.21E-01	5.83E-04	---
Rb 89	4.66E-03	1.87E-05	---
Cs 134	1.69E+02	1.08E+01	2.2
Cs 136	8.02E+01	8.21E+00	3.6
Cs 137	1.12E+02	7.10E+00	1.4
Cs 138	4.76E-02	4.11E-04	---
Cr 51	2.38E-02	1.99E-03	---
Mn 54	2.84E-03	2.14E-04	---
Mn 56	5.19E-04	2.08E-05	---
Fe 55	1.70E-01	1.08E-02	---
Fe 59	3.06E-03	2.32E-04	---
Co 58	8.94E-02	6.48E-03	---
Co 60	1.41E-02	1.17E-03	---
Sr 89	2.41E-01	1.79E-02	---
Sr 90	8.98E-03	5.68E-04	---
Sr 91	5.71E-03	5.25E-04	---
Sr 92	3.23E-04	1.35E-05	---
Y 90	2.08E-05	2.70E-06	---
Y 91M	3.15E-05	4.22E-07	---
Y 91	3.29E-03	2.40E-04	---
Y 92	3.97E-05	2.09E-06	---
Y 93	3.74E-05	3.54E-06	---
Zr 95	3.86E-03	3.20E-04	---
Nb 95	3.17E-03	3.12E-04	---
Mo 99	5.91E-02	7.69E-03	1.40E-1
Tc 99M	3.91E-03	2.89E-04	1.30E-1
Ru 103	2.92E-03	2.30E-04	---
Ru 106	1.00E-03	1.37E-04	---
Rh 103M	4.97E-06	7.60E-08	--
Ag 110M	9.83E-03	6.56E-04	---
Te 125M	1.59E-02	1.16E-03	---
Te 127M	1.86E-01	1.28E-02	---
Te 127	1.03E-02	9.32E-04	---
Te 129M	8.92E-01	7.15E-02	---
Te 129	1.83E-03	3.30E-05	---
Te 131M	6.92E-02	8.34E-03	4.10E-3
Te 131	4.75E-04	3.18E-06	---
Te 132	2.23E+00	2.92E-01	5.40E-2

* *Based on not being used as a backup to the waste evaporator. See Westinghouse Letter CQL-9351, 5/30/86.

TABLE 11.4.1-3 NUCLIDE ACTIVITY INPUTS TO THE SOLID RADWASTE SYSTEM, EVAPORATOR CONCENTRATES (μ-Ci/g) DESIGN BASIS (1)

Isotope	Waste Evaporator Bottoms	RO Concentrate Evaporator Bottoms	Boron* Recycle Evaporator Bottoms
Te 134	2.01E-03	2.26E-05	---
Ba 140	1.13E-01	1.17E-02	---
La 140	5.20E-04	6.52E-05	---
Ce 141	2.98E-03	2.40E-04	---
Ce 143	1.59E-04	1.95E-05	---
Ce 144	2.76E-03	3.30E-04	---
Pr 143	1.81E-03	1.83E-04	---
Pr 144	9.63E-06	4.45E-08	---
Ba 137			1.4
TOTAL	4.28E+02	3.37E+01	7.03E+01

Notes:
*Based on not being used as a backup to the waste evaporator. See Westinghouse Letter CQL-9351, 5/30/86.
(1)This table contains historical information used in the original design of the radwaste system.

TABLE 11.4.1-4 <u>NUCLIDE ACTIVITY INPUTS TO THE SOLID RADWASTE SYSTEM, SPENT RESINS (μ-Ci/Batch) NORMAL OPERATION</u> (1)

Isotope	Waste Evaporator Condensate Demin	Floor Drain Monitor Demin	Laundry & H.S. Demin**	Secondary Waste Low-Cond. Demin	CVCS Mixed Bed Demin*	CVCS Cation Bed Demin*	Boron Thermal Regen. Demin*	Boron Recycle Evap Demin*	Fuel Pool Demin
Br 83	1.14E-01	1.82E+01		7.85E-01					
BR 84	1.38E-02	2.21E+00		9.47E-02	5.5E-02			1.17B+05	
Ir130	2.46E+00	3.95E+01		1.71E+00				1.42E+04	
I 131	4.64E+03	6.96E+04	2.24E+01	3.04E+03	1.10E+03		1.40E+01	8.90E+00	3.22E+07
I 132	2.25E+01	3.61E+02		1.57E+01	1.40E+01		4.60E-01	5.70E-01	2.42E+06
I 133	7.32E+02	1.17E+04		5.08E+02			3.00E+00		3.60E+07
I 134	4.07E+00	6.52E+01		2.80E+00				4.24E+05	
I 135	1.22E+02	1.95E+03		8.45E+01	3.20E+01		1.00E+00	1.50E+00	1.11E+07
Rb 86	3.38E-01	3.69E+01		8.26E-01					
Rb 88	6.03E-01	9.67E+01		2.07E+00	2.80E+00	4.20E+00			
Cs 134	5.03E+02	1.78E+04	6.86E+02	4.11E+02	6.80E+02	1.0E+03		3.90E+02	1.70E+06
Cs 136	3.60E+01	4.66E+03		1.03E+02	6.30E+01	4.40E+01		6.90E+01	9.05E+05
Cs 137	3.86E+02	1.30E+04	1.28E+03	3.01E+02					1.21E+06
Cr 51	1.09E+01	9.55E+01		4.27E+00					2.28E+04
Mn 54	5.66E+00	2.16E+01	1.02E+01	9.86E-01					3.84E+03
Fe 55	3.26E+01	1.14E+03		5.21E+01					1.92E+04
Fe 59	8.51E+00	5.74E+01		2.58E+00					1.21E+04
Co 58	1.82E+02	1.00E+03	3.60E+01	4.51E+01					1.91E+04
Co 60	4.18E+01	1.44E+02	9.46E+01	6.55E+00	1.30E+01				2.44E+04
Sr 89	3.26E+00	2.06E+02		9.31E+00					4.21E+04
Sr 90	2.13E-01	7.19E+00		3.29E-01					1.22E+04
Sr 91	5.94E-02	9.55E+00		4.05E-01					4.63E+04
Y 90	6.94E-05	1.11E-02		4.74E-04					
Y 91M	2.99E-04	4.80E-02		2.04E-03					
Y 91	6.44E-02	3.85E+00		1.74E-01					
Y 93	3.34E-04	5.35E-02		2.27E-03					
Zr 95	6.53E-01	3.69E+00	1.26E+01	1.67E-01					
Nb 95	3.50E-01	2.70E+00	1.59E+01	1.21E-01					
MO 99	5.02E-01	8.04E+01		3.42E+00					
Tc 99M	2.79E-02	4.46E+00		1.91E-01					
Ru 103	3.47E-01	2.51E+00	1.14E+00	1.13E-01					
Ru 106	1.87E-01	7.00E-01	2.46E+01	3.19E-02					
Rh 103M	4.26E-04	6.82E-03		2.91E-04					
Te 125M	2.94E-01	1.75E+01		7.90E-01					
Te 127M	3.85E+00	1.83E+02		8.28E+00					
Te 127	7.47E-02	1.20E+01		5.09E-01					
Te 129M	9.31E+00	7.43E+02		3.33E+01					
Te 129	1.78E-02	2.86E+00		1.22E-01					

TABLE 11.4.1-4 NUCLIDE ACTIVITY INPUTS TO THE SOLID RADWASTE SYSTEM, SPENT RESINS (μ-Ci/Batch) NORMAL OPERATION [(1)]

Isotope	Waste Evaporator Condensate Demin	Floor Drain Monitor Demin	Laundry & H.S. Demin**	Secondary Waste Low-Cond. Demin	CVCS Mixed Bed Demin*	CVCS Cation Bed Demin*	Boron Thermal Regen. Demin*	Boron Recycle Evap Demin*	Fuel Pool Demin
Te 131M	6.56E-01	1.05E+02		4.47E+00					
Te 131	4.61E-03	7.38E-01		3.14E-02					
Te 132	1.88E+01	3.01E+03		1.28E+02					
Ba 140	5.96E-01	7.75E+01		3.39E+00					
La 140	5.45E-02	8.74E-01		3.72E-02	2.70E+00				
Ce 141	4.60E-01	3.71E+00		1.66E-01					
Ce 143	1.20E-02	1.93E-01		8.18E-03					
Ce 144	5.96E-01	2.29E+00	5.08E+01	1.05E-01					
Pr 143	1.45E-01	1.84E+00		8.03E-02					
Pr 144	9.56E-05	1.54E-02		6.56E-04					
Np 239	6.08E-01	9.73E+01		4.15E+00					
TOTAL	6.77E+03	1.26E+05	2.24E+03	4.78E+03	1.91E+02	1.10E+03	2.35E+01	4.70E+02	8.63E+07

Notes:
*Activity in μci/cc
**Laundry waste is no longer being generated
(1)This table contains historical information used in the original design of the radwaste system.

TABLE 11.4.1-5 NUCLIDE ACTIVITY INPUTS TO THE SOLID RADWASTE SYSTEM, SPENT RESINS (µ-Ci/Batch) DESIGN BASIS [(1)]

Isotope	Waste Evaporator Condensate Demin	Floor Drain Monitor Demin	Laundry & H.S. Demin**	Secondary Waste Low-Cond. Demin	CVCS Mixed Bed Demin*	CVCS Cation Bed Demin*	Boron Thermal Regen. Demin*	Boron Recycle Evap Demin*	Fuel Pool Demin
Br 83	2.00E+00	3.20E+02		1.38E+01					2.07E+06
Br 84	2.18E-01	3.49E+01		1.49E+00	5.50E-01				2.29E+05
I 129	8.79E-03	2.95E+02		1.38E-03					
I 130	2.20E+01	3.52E+02		1.53E+01					
I 131	4.70E+04	7.00E+05	5.85E+01	3.09E+04	1.10E+04		1.90E+02	8.90E+01	3.22E+08
I 132	5.78E+02	9.27E+03		4.00E+02	1.40E+02		4.60E+00	5.70E+00	5.91E+07
I 133	7.53E+03	1.21E+05		5.25E+03			3.00E+01		3.69E+08
I 134	4.36E+01	6.98E+02		3.00E+01					4.57E+06
I 135	1.29E+03	2.07E+04		8.99E+02	3.20E+02		1.00E+01	1.50E+01	1.17E+08
Rb 86	8.26E+01	9.02E+03		2.17E+02					
Rb 88	1.18E+01	1.89E+03		4.06E+01	2.80E+01	4.20E+01			
Rb 89	4.61E-01	7.38E+01		1.58E+00					
Cs 134	4.39E+04	1.56E+06	1.79E+03	3.61E+04	6.80E+02	1.00E+04		3.40E+02	1.49E+08
Cs 136	7.84E+03	1.01E+06		2.25E+04	6.30E+02	9.40E+02		6.90E+02	1.88E+08
Cs 137	3.05E+04	1.03E+06	3.33E+03	2.39E+04					9.96E+07
Cs 138	4.49E+00	7.20E+02		1.55E+01	1.10E+01	1.60E+01			
Cr 51	2.99E+01	2.64E+02		1.18E+01					6.34E+04
Mn 54	6.94E+00	2.65E+01	2.66E+01	1.21E+00					4.81E+03
Mn 56	4.75E-01	7.61E+00		3.24E-01					
Fe 55	4.47E+01	1.56E+03		7.14E+01					2.69E+04
Fe 59	4.70E+00	3.17E+01		1.43E+00					6.15E+01
Co 58	1.63E+02	8.89E+02	9.39E+01	4.03E+01					1.78E+05
Co 60	3.78E+01	1.30E+02	2.47E+02	5.93E+00	1.30E+02				2.18E+04
Sr 89	3.90E+01	2.46E+03		1.11E+02					5.10E+05
Sr 90	2.44E+00	8.23E+01		3.76E+00					1.41E+04
Sr 91	5.19E-01	8.31E+01		3.54E+00					4.02E+05
Sr 92	2.95E-02	4.73E+00		2.01E-01					
Y 90	1.88E-03	3.02E-01		1.29E-02					
Y 91M	2.93E-03	4.70E-01		2.00E-02					
Y 91	5.56E-01	3.33E+01		1.50E+00					
Y 92	3.62E-03	5.80E-01		2.47E-02					
Y 93	3.40E-03	5.45E-01		2.32E-02					
Zr 95	6.83E+00	3.86E+01	3.29E+01	1.75E+00					
Nb 95	4.39E+00	3.39E+01	4.14E+01	1.52E+00					
Mo 99	5.35E+00	8.55E+02		3.65E+01					
Tc 99M	3.55E-01	5.69E+01		2.42E+00					
Ru 103	4.24E+00	3.07E+01	2.98E+00	1.38E+00					
Ru 106	2.50E+00	9.36E+00	6.42E+01	4.26E-01					
Ru 103M	4.61E-03	7.39E-02		3.14E-03					

TABLE 11.4.1-5 NUCLIDE ACTIVITY INPUTS TO THE SOLID RADWASTE SYSTEM, SPENT RESINS (µ-Ci/Batch) DESIGN BASIS (1)

Isotope	Waste Evaporator Condensate Demin	Floor Drain Monitor Demin	Laundry & H.S. Demin**	Secondary Waste Low-Cond. Demin	CVCS Mixed Bed Demin*	CVCS Cation Bed Demin*	Boron Thermal Regen. Demin*	Boron Recycle Evap Demin*	Fuel Pool Demin
Ag 110M	2.36E+01	9.18E+01	1.16E+01	4.21E+00					
Te 125M	2.70E+00	1.61E+02		7.27E+00					
Te 127M	3.80E+01	1.80E+03		8.18E+01					
Te 127	9.35E-01	1.50E+02		6.38E+00					
Te 129M	1.20E+02	9.64E+03		4.31E+02					
Te 129	1.69E-01	2.71E+01		1.15E+00					
Te 131M	6.27E+00	1.01E+03		4.28E+01					
Te 131	4.54E-02	7.26E+00		3.09E-01					
Te 132	2.02E+02	3.24E+04		1.38E+03					
Te 134	1.88E-01	3.01E+01		1.28E+00					
Ba 140	1.11E+01	1.44E+03		6.29E+01					
La 140	4.71E-01	7.55E+00		3.22E-01	2.70E+01				
Ce 141	4.00E+00	3.22E+01		1.44E+00					
Ce 143	1.44E-01	2.30E+00		9.82E-02					
Ce 144	6.70E+00	2.58E+01	1.33E+02	1.18E+00					
Pr 143	1.79E+00	2.26E+01		9.92E-01					
Pr 144	9.42E-04	1.51E-01		6.41E-03					
TOTAL	1.40E+05	4.46E+06	5.84E+03	1.23E+05	1.91E+04	1.10E+04	2.35E+05	4.70E+03	1.31E+09

Notes:
*Activity in µCi/cc
**Laundry waste is no longer being generated
(1)This table contains historical information used in the original design of the radwaste system.

TABLE 11.4.1-6

NUCLIDE ACTIVITY INPUTS TO THE SOLID RADWASTE SYSTEM, FILTER SLUDGE (µCi/Batch), NORMAL OPERATION (1)

Isotope	Reactor Coolant Filter	Fuel Pool Filter	Secondary Waste Filter	Waste Evaporator Filter	Laundry & H.S. Filter*	Floor Drain Filter
Br 83	0.	0.	0.	0.		0.
Br 84	0.	0.	0.	0.		0.
I 130	0.	0.	0.	0.		0.
I 131	0.	0.	0.	0.	0.	0.
I 132	0.	0.	0.	0.		0.
I 133	0.	0.	0.	0.		0.
I 134	0.	0.	0.	0.		0.
I 135	0.	0.	0.	0.		0.
Rb 86	0.	0.	0.	0.		0.
Rb 88	0.	0.	0.	0.		0.
Cs 134	0.	0.	0.	0.	0.	0.
Cs 136	0.	0.	0.	0.		0.
Cs 137	0.	0.	0.	0.	5.47E+02	0.
Cr 51	3.62E+05	7.38E+04	6.12E-01	1.09E+05		7.26E+03
Mn 54	5.91E+04	1.23E+04	1.00E-01	5.71E+04	1.10E+02	1.52E+03
Fe 55	0.	6.18E+04	0.	0.		0.
Fe 59	1.90E+05	3.91E+04	3.22E-01	8.54E+04		4.22E+03
Co 58	3.04E+06	6.17E+05	5.16E+00	1.83E+06	4.28E+02	7.19E+04
Co 60	3.81E+05	7.82+04	6.46E-01	4.22E+05	9.90E+02	9.99E+03
Sr 89	0.	0.	0.	0.		0.
Sr 90	0.	0.	0.	0.		0.
Sr 91	0.	0.	0.	0.		0.
Y 90	2.27E+02	0.	3.74E-04	6.94E+00		9.52E-01
Y 91M	1.57E+04	0.	4.96E-03	2.99E+01		4.43E-04
Y 91	1.22E+04	0.	2.063-02	6.46E+03		2.80E+02
Y 93	5.74E+03	0.	8.23E-03	3.34E+01		2.47E+00
Zr 95	1.14E+04	0.	1.94E-02	6.56E+03	1.52E+02	2.67E+02
Nb 95	9.52E+03	0.	1.61E-02	3.51E+03	2.15E+02	2.02E+02
Mo 99	1.74E+07	0.	2.87E+01	5.52E+05		7.60E+04
Tc 99M	7.97E+06	0.	1.02E+01	3.07E+04		1.33E+03
Ru 103	8.56E+03	0.	1.45E-02	3.48E+03	1.51E+01	1.86E+02
Ru 106	1.90E+03	0.	3.23E-03	1.89E+03	2.63E+02	4.91E+01
Ru 103M	2.22E+03	0.	8.40E-04	4.26E+00		1.96E-04
Te 125M	0.	0.	0.	0.		0.
Te 127M	0.	0.	0.	0.		0.
Te 127	0.	0.	0.	0.		0.
Te 129M	0.	0.	0.	0.		0.
Te 129	0.	0.	0.	0.		0.
Te 131M	0.	0.	0.	0.		0.
Te 131	0.	0.	0.	0.		0.
Te 132	0.	0.	0.	0.		0.
Ba 140	0.	0.	0.	0.		0.
La 140	2.79E+04	0.	4.53E-02	5.45E+02		6.99E+01
Ce 141	1.33E+04	0.	2.26E-02	4.61E+03		2.78E+02
Ce 143	7.40E+03	0.	1.19E-02	1.20E+02		1.48E+01
Ce 144	6.29E+03	0.	1.07E-02	6.01E+03	5.47E+02	1.61E+02
Pr 143	9.50E+03	0.	1.60E-02	1.45E+03		1.48E+02
Pr 144	0.	0.	0.	0.		0.
Np 239	0.	0.	0.	0.		0.
TOTAL	2.95E+07	8.82E+05	4.60E+01	3.12E+06	2.77E+03	1.74E+05

Table 11.4.1-6 (Continued)

Isotope	Spent Resin Sluice Filter	Recycle Evaporator Feed Filter	Recycle Evaporator Filter	Fuel Pool Skimmer Filter	Refueling Water Filter	Waste Evaporator Condensate Filter
Br 83						
Br 84	1.47E+02					
I 130						
I 131	1.23E+05	3.31E+03	6.79E+01	8.63E-01	2.16E+00	
I 132	6.71E+03	6.61E+02	8.83E-01	0.	0.	
I 133	3.64E+04	1.90E+03	1.18E+01	1.23E+00	3.07E+00	
I 134	0.	0.	0.	0.	0.	
I 135	1.30E+04	1.33E+03	2.02E+00			
Rb 86						
Rb 88	1.12E+04					
Cs 134	1.61E+05	8.85E+04		7.72E-02	1.93E-01	
Cs 136	6.91E+03	1.57E+04				
Cs 137	1.30E+05	8.63E+01		5.45E-02	1.36E-01	
Cr 51				5.9E-04	1.48E-03	4.20E+00
Mn 54				4.54E-04	2.38E-03	1.53E+01
Fe 55						
Fe 59				5.00E-03	1.25E-02	3.04E+01
Co 58	5.76E+04	7.63E+01		2.15E+03	3.19E+03	3.74E+02
Co 60	2.40E+04	9.54E+00		2.73E+02	4.06E+02	6.16E+01
Sr 89						
Sr 90						
Sr 91						
Y 90						6.78E-05
Y 91M						3.68E-06
Y 91						2.19E-01
Y 93						5.26E-05
Zr 95						2.17E+00
Nb 95						1.32E+00
Mo 99				2.63E-01	6.59E-01	6.40E-01
Tc 99M						2.56E-03
Ru 103						1.27
Ru 106						5.00E-01
Ru 103M						6.00E-06
Te 125M						
Te 127M						
Te 127						
Te 129M						
Te 129						
Te 131M						
Te 131						
Te 132						
Ba 140						
La 140	2.76E+02					3.33E-02
Ce 141						1.74E+00
Ce 143						6.03E-03
Ce 144						1.63
Pr 143						5.16E-01
Pr 144						
Np 239						
TOTAL	5.70E+05	1.12E+05	8.26E+01	2.43E+03	3.60E+03	5.00E+02

Table 11.4.1-6 (Continued)

Isotope	Seal Water Return Filter	Seal Water Injection Filter	Recycle Evaporator Concentrate Filter	Boric Acid Filter	Gas Decay Tank Filter
Br 83					
Br 84					
I 130					
I 131			4.13E+05	5.79E+04	
I 132			7.61E+02	3.30E+03	
I 133			1.37E+04	4.04E+04	
I 134			0.	0.	
I 135			9.81E+03	2.14E+04	
Rb 86					
Rb 88					
Cs 134			4.39E+04	6.06E+03	1.81E+04
Cs 136			2.05E+04	2.74E+03	8.56E+03
Cs 137			3.12E+04	7.73E+03	
Cr 51	1.30E+06	4.27E+05			
Mn 54	2.37E+05	1.76E+05			
Fe 55					
Fe 59	7.17E+05	5.20E+05			
Co 58	1.18E+07	8.62E+06			
Co 60	1.55E+06	1.15E+06			
Sr 89					
Sr 90					
Sr 91					
Y 90	3.39E+02	1.90E+02			
Y 91M	1.58E+03	8.45E+02			
Y 91	4.66E+04	3.29E+04			
Y 93	1.71E+03	9.38E+02			
Zr 95	4.41E+04	3.22E+04			
Nb 95	3.51E+04	2.57E+04			
Mo 99	2.89E+07	1.67E+07	8.98E+04	6.58E+04	
Tc 99M	1.47E+06	4.90E+05			
7.37E+03	1.64E+04				
Ru 103	3.19E+04	2.31E+04			
Ru 106	7.65E+03	5.69E+03			
Ru 103M	2.25E+02	1.20E+02			
Te 125M					
Te 127M					
Te 127					
Te 129M					
Te 129					
Te 131M			1.35E+04	1.61E+03	
Te 131					
Te 132			2.87E+04	5.13E+04	
Ba 140					
La 140	2.84E+04	1.53E+04			
Ce 141	4.88E+04	3.50E+04			
Ce 143	6.30E+03	3.38E+03			
Ce 144	2.52E+04	1.88E+04			
Pr 143	3.04E+04	2.08E+04			
Pr 144					
Np 239					
TOTAL	4.63E+07	2.88E+07	6.73E+05	6.73E+05	2.67+04

TABLE 11.4.1-7

NUCLIDE ACTIVITY INPUTS TO THE SOLID RADWASTE SYSTEM
FILTER SLUDGE (μCi/BATCH), DESIGN BASIS (1)

Isotope	Reactor Coolant Filter	Fuel Pool Filter	Secondary Waste Filter	Waste Evaporator Filter	Laundry & H.S. Filter*	Floor Drain Filter
Br 83	0.	0.	0.	0.	0.	0.
Br 84	0.	0.	0.	0.	0.	0.
I 129	0.	0.	0.	0.	0.	0.
I 130	0.	0.	0.	0.	0.	0.
I 131	0.	0.	0.	0.	0.	0.
I 132	0.	0.	0.	0.	0.	0.
I 133	0.	0.	0.	0.	0.	0.
I 134	0.	0.	0.	0.	0.	0.
I 135	0.	0.	0.	0.	0.	0.
Rb 86	0.	0.	0.	0.	0.	0.
Rb 88	0.	0.	0.	0.	0.	0.
Rb 89	0.	0.	0.	0.	0.	0.
Cs 134	0.	0.	0.	0.	0.	0.
Cs 136	0.	0.	0.	0.	0.	0.
Cs 137	0.	0.	0.	0.	0.	0.
Cs 138	0.	0.	0.	0.	0.	0.
Cr 51	9.95E+05	2.05E+05	1.68E+00	2.99E+05		2.00E+04
Mn 54	7.25E+04	1.48E+04	1.23E-01	7.00E+04	2.86E+02	1.86E+03
Mn 56	2.00E+06	0.	1.81E+00	4.75E+03		3.69E+01
Fe 55	0.	8.65E+04	0.	0.		0.
Fe 59	1.05E+05	2.18E+04	1.78E-01	4.72E+04		2.33E+03
Co 58	2.72E+06	5.76E+05	4.61E+00	1.64E+06	1.12E+03	6.42E+04
Co 60	2.00E+06	7.0E+04	5.85E-01	3.82E+05	2.58E+03	9.04E+03
Sr 89	0.	0.	0.	0.		0.
Sr 90	0.	0.	0.	0.		0.
Sr 91	0.	0.	0.	0.		0.
Sr 92	0.	0.	0.	0.		0.
Y 90	6.15E+03	0.	1.02E-02	1.88E+02		2.58E+01
Y 91M	1.54E+03	4.85E-02	2.93E+02	2.93E+02		4.43E-03
Y 91	1.05E+05	0.	1.78E-01	5.58E+04		2.42E+03
Y 92	1.30E+05	0.	1.39E-01	3.62E+02		6.59E+00
Y 93	5.85E+04	0.	8.39E-02	3.40E+02		2.51E+01
Zr 95	1.20E+05	0.	2.03E-01	6.86E+04	3.96E+02	2.80E+03
Nb 95	1.19E+05	0.	2.02E-01	4.40E+04	5.62E+02	2.53E+03
Tc 99M	1.01E+08	0.	1.30E+02	3.90E+05		1.69E+04
Ru 103	1.05E+05	0.	1.78E-01	4.26E+04	3.94E+01	2.28E+03
Ru 106	2.54E+04	0.	4.31E-02	2.52E+04	6.86E+02	6.55E+02
Ru 103M	2.40E+04	0.	9.06E-03	4.61E+01		2.13E-03
Ag 110M	2.54E+05	0.	4.31E-01	2.38W+05	1.26E+02	6.49E+03
Te 125M	0.	0.	0.	0.	0.	0.
Te 127M	0.	0.	0.	0.	0.	0.
Te 127	0.	0.	0.	0.	0.	0.
Te 129M	0.	0.	0.	0.	0.	0.
Te 129	0.	0.	0.	0.	0.	0.
Te 131M	0.	0.	0.	0.	0.	0.
Te 131	0.	0.	0.	0.	0.	0.
Te 132	0.	0.	0.	0.	0.	0.
Te 134	0.	0.	0.	0.	0.	0.
Ba 140	0.	0.	0.	0.	0.	0.
La 140	2.41E+05	0.	3.92E-01	4.71E+03		6.04E+02
Ce 141	1.16E+05	0.	1.96E-01	4.00E+04		2.41E+03
Ce 143	8.87E+04	0.	1.43E-01	1.44E+03		1.77E+02
Ce 144	7.07E+04	0.	1.20E-01	6.76E+04	1.43E+03	1.81E+03
Pr 143	1.17E+05	0.	1.98E-01	1.79E+04		1.83E+03
Pr 144	0.	0.	0.	0.	0.	0.
TOTAL	2.57E+08	9.56E+05	3.87E+02	9.32E+06	7.23E+03	9.62E+05

Table 11.4.1-7 (Continued)

Isotope	Spent Resin Sluice Filter	Recycle Evaporator Feed Filter	Recycle Evaporator Filter	Fuel Pool Skimmer Filter	Refueling Water Filter	Waste Evaporator Condensate Filter
Br 83	---	---	---	---	---	---
Br 84	2.28E+03	---	---	---	---	---
I 129	---	---	---	---	---	---
I 130	---	---	---	---	---	---
I 131	1.23E+06	3.33E+04	6.79E+02	8.63E+00	2.16E+01	---
I 132	1.50E+05	1.49E+04	8.83E+00	---	---	---
I 133	3.75E+05	1.95E+04	1.18E+02	1.27E+01	3.18E+01	---
I 134	---	---	---	---	---	---
I 135	1.36E+05	1.38E+04	2.02E+01	---	---	---
Rb 86	---	---	---	---	---	---
Rb 88	2.16E+05	---	---	---	---	---
Rb 89	---	---	---	---	---	---
Cs 134	7.82E+05	8.94E+05	---	6.81E+00	1.7E+01	---
Cs 136	1.99E+05	1.70E+05	---	---	---	---
Cs 137	6.19E+05	6.80E+03	---	4.54E+01	1.14E+02	---
Cs 138	4.65E+04	---	---	---	---	---
Cr 51	---	---	---	1.59E-02	3.97E-02	1.15E+02
Mn 54	---	---	---	1.18E-03	2.95E-03	1.88E+01
Mn 56	---	---	---	---	---	---
Fe 55	---	---	---	---	---	---
Fe 59	---	---	---	1.73E-03	4.32E-03	1.68E+01
Co 58	3.15E+04	6.31E+01	---	2.00E+03	2.98E+03	3.22E+02
Co 60	1.30E+04	8.63E+00	---	2.44E+02	3.63E+02	6.02E+01
Sr 89	---	---	---	---	---	---
Sr 90	---	---	---	---	---	---
Sr 91	---	---	---	---	---	---
Sr 92	---	---	---	---	---	1.83E+03
Y 90	---	---	---	---	---	3.60E+05
Y 91M	---	---	---	---	---	1.89E+00
Y 91	---	---	---	---	---	1.97E-04
Y 92	---	---	---	---	---	5.36E-04
Y 93	---	---	---	---	---	2.27E+01
Zr 95	---	---	---	---	---	---
Nb 95	---	---	---	---	---	1.65E+01
Mo 99	---	---	---	2.27E+01	5.68E+01	6.82E+00
Tc 99M	---	---	---	---	---	3.26E-02
Ru 103	---	---	---	---	---	1.56E+01
Ru 106	---	---	---	---	---	6.71E+00
Rh 103M	---	---	---	---	---	6.51E-05
Ag 110M	---	---	---	---	---	6.48E+01
Te 125M	---	---	---	---	---	---
Te 127M	---	---	---	---	---	---
Te 127	---	---	---	---	---	---
Te 129M	---	---	---	---	---	---
Te 129	---	---	---	---	---	---
Te 131M	---	---	---	---	---	---
Te 131	---	---	---	---	---	---
Te 132	---	---	---	---	---	---
Te 134	---	---	---	---	---	---
Ba 140	---	---	---	---	---	---
La 140	2.75E+03	---	---	---	---	2.83E-01
Ce 141	---	---	---	---	---	1.51E+01
Ce 143	---	---	---	---	---	7.22E-02
Ce 144	---	---	---	---	---	1.83E+01
Pr 143	---	---	---	---	---	5.61E-01
Pr 144	---	---	---	---	---	---
TOTAL	3.83E+06	1.16E+06	8.26E+02	2.34E+03	3.58E+03	7.12E+02

Table 11.4.1-7 (Continued)

Isotope	Seal Water Return Filter	Seal Water Injection Filter	Recycle Evaporator Concentrate Filter	Boric Acid Filter	Gas Decay Tank Filter
Br 83	---	---	---	---	---
Br 84	---	---	---	---	---
I 129	---	---	---	---	---
I 130	---	---	---	---	---
I 131	---	---	4.19E+06	5.85E+05	---
I 132	---	---	1.45E+04	8.47E+04	---
I 133	---	---	1.41E+05	4.21E+05	---
I 134	---	---	---	---	---
I 135	---	---	1.04E+05	2.27E+05	---
Rb 86	---	---	---	---	---
Rb 88	---	---	---	---	---
Rb 89	---	---	---	---	---
Cs 134	---	---	3.84E+06	5.30E+05	1.58E+06
Cs 136	---	---	4.45E+06	5.97E+05	1.86E+06
Cs 137	---	---	2.54E+06	6.10E+05	---
Cs 138	---	---	---	---	5.54E+03
Cr 51	2.58E+06	2.55E+06	---	---	---
Mn 54	2.41E+05	2.16E+05	---	---	---
Mn 56	2.51E+02	1.34E+02	---	---	---
Fe 55	---	---	---	---	---
Fe 59	3.46E+05	2.87E+05	---	---	---
Co 58	1.05E+07	7.70E+06	---	---	---
Co 60	1.40E+06	1.04E+06	---	---	---
Sr 89	---	---	---	---	---
Sr 90	---	---	---	---	---
Sr 91	---	---	---	---	---
Sr 92	---	---	---	---	---
Y 90	9.20E+03	5.16E+03	---	---	---
Y 91M	1.55E+04	8.27E+03	---	---	---
Y 91	4.02E+05	2.43E+05	---	---	---
Y 92	1.41E+04	1.02E+04	---	---	---
Y 93	1.79E+04	9.55E+03	---	---	---
Zr 95	4.61E+05	3.37E+05	---	---	---
Nb 95	4.41E+05	3.17E+05	---	---	---
Mo 99	2.44E+08	1.41E+08	7.59E+05	5.56E+05	---
Tc 99M	1.87E+07	6.23E+06	9.38E+04	2.09E+05	---
Ru 103	3.91E+05	2.83E+05	---	---	---
Ru 106	1.02E+05	7.59E+04	---	---	---
Ru 103M	2.44E+03	1.30E+03	---	---	---
Ag 110M	1.02E+06	7.55E+06	---	---	---
Te 125M	---	---	---	---	---
Te 127M	---	---	---	---	---
Te 127	---	---	---	---	---
Te 129M	---	---	---	---	---
Te 129	---	---	---	---	---
Te 131M	---	---	1.29E+04	1.54E+04	---
Te 131	---	---	---	---	---
Te 132	---	---	3.09E+05	5.52E+05	---
Te 134	---	---	---	---	---
Ba 140	---	---	---	---	---
La 140	2.45E+05	1.32E+05	---	---	---
Ce 141	4.24E+05	3.04E+05	---	---	---
Ce 143	7.55E+04	4.05E+04	---	---	---
Ce 144	2.83E+05	2.11E+05	---	---	---
Pr 143	3.75E+05	2.56E+05	---	---	---
Pr 144	---	---	---	---	---
Te 129M	---	---	---	---	---
Te 129	---	---	---	---	---

Table 11.4.1-7 (Continued)

Isotope	Seal Water Return Filter	Seal Water Injection Filter	Recycle Evaporator Concentrate Filter	Boric Acid Filter	Gas Decay Tank Filter
Te 131M	---	---	1.29E+04	1.54E+04	---
Te 131	---	---	---	---	---
Te 132	---	---	3.09E+05	5.52E+05	---
Te 134	---	---	---	---	---
Ba 140	---	---	---	---	---
La 140	2.45E+05	1.32E+05	---	---	---
Ce 141	4.24E+05	3.04E+05	---	---	---
Ce 143	7.55E+04	4.05E+04	---	---	---
Ce 144	2.83E+05	2.11E+05	---	---	---
Pr 143	3.75E+05	2.56E+05	---	---	---
Pr 144	---	---	---	---	---
TOTAL	2.83E+08	1.62E+08	1.65E+07	4.39E+06	1.45E+06

TABLE 11.4.1-8

RADIONUCLIDE CONCENTRATIONS IN SPENT MFTDS PROCESS MEDIA NORMAL OPERATION(2)

Nuclide	Conc.(μCi/cc)
Filters(1)	
Na-24	4.32 E-04
Cr-51	4.62 E-03
Mn-54	1.53 E-02
Fe-55	1.49 E-02
Fe-59	7.33 E-04
Co-58	1.75 E-02
Co-60	7.01 E-03
Zn-65	4.47 E-03
W-187	5.36 E-05
Np-239	1.83 E-04

Nuclide	Conc.(μCi/cc)
Spent Resins	
Na-24	6.85 E-04
Cr-51	7.34 E-03
Mn-54	2.43 E-02
Fe-55	2.36 E-02
Fe-59	1.16 E-03
Co-58	2.77 E-02
Co-60	1.11 E-02
Zn-65	7.10 E-03
W-187	8.51 E-05
Np-239	2.90 E-04
Br-84	3.56 E-07
Rb-88	1.43 E-06
Sr-89	6.95 E-04
Sr-90	2.96 E-04
Y-90	2.94 E-04
Y-91m	4.91 E-06
Y-91	7.10 E-05
Y-93	3.24 E-05
Zr-95	2.41 E-03
Nb-95m	4.88 E-05
Nb-95	3.32 E-03
Mo-99	1.19 E-03
Tc-99m	1.14 E-03
Ru-103	2.84 E-02
Rh-103m	2.79 E-02
Ru-106	1.62 E+00
Rh-106	1.62 E+00
Ag-110m	2.04 E-02
Te-129m	6.14 E-04
Te-129	3.96 E-04
I-129	2.18 E-11
Te-131m	8.36 E-05
I-131	3.13 E-02
Te-131	1.54 E-05
Te-132	3.88 E-04
I-132	4.86 E-04
I-133	4.23 E-03
I-134	2.05 E-05
Cs-134	1.86 E-01
I-135	8.83 E-04
Cs-136	1.22 E-03
Cs-137	2.87 E-01
Ba-137m	2.68 E-01
Ba-140	1.50 E-02
La-140	1.82 E-02
Ce-141	4.70 E-04
Pr-143	3.76 E-04
Ce-144	6.41 E-02
Pr-144	6.41 E-02

Notes:

1) Filter effectiveness was assumed to be limited to activation and corrosion products. It was also assumed that the filters removed 10% of these influent materials and the remaining activation and corrosion products were removed in the resin beds.
2) The data provided in this table was prepared prior to SGR/PUR but remains bounding because of the lower volume of radioactive effluents demonstrated in 1998 and 1999.

TABLE 11.4.1-9

RADIONUCLIDE CONCENTRATIONS IN SPENT MFTDS PROCESS MEDIA DESIGN BASIS CONDITIONS(2)

Nuclide	Conc.(µCi/cc)
Filters(1)	
Na-24	4.32 E-04
Cr-51	7.79 E-03
Mn-54	1.53 E-02
Fe-55	2.72 E-02
Fe-59	1.35 E-03
Co-58	5.43 E-02
Co-60	2.40 E-02
Zn-65	4.47 E-03
W-187	5.36 E-05
Np-23	1.83 E-04

Nuclide	Conc.(µCi/cc)
Spent Resins	
Na-24	6.85 E-04
Cr-51	1.24 E-02
Mn-54	2.43 E-02
Fe-55	4.31 E-02
Fe-59	2.14 E-03
Co-58	8.60 E-02
Co-60	3.79 E-02
Zn-65	7.10 E-03
W-187	8.51 E-05
Np-239	2.90 E-04
Br-84	9.13 E-07
Rb-88	2.95 E-05
Sr-89	2.08 E-02
Sr-90	2.82 E-03
Y-90	2.80 E-03
Y-91m	3.77 E-05
Y-91	7.54 E-03
Y-93	3.24 E-05
Zr-95	3.88 E-03
Nb-95m	7.86 E-05
Nb-95	7.45 E-03
Mo-99	1.32 E-01
Tc-99m	1.49 E-01
Ru-103	2.84 E-02
Rh-103m	2.79 E-02
Ru-106	1.62 E+00
Rh-106	1.62 E+00
Ag-110m	2.04 E-02
Te-129m	5.83 E-02
Te-129	3.76 E-02
I-129	2.18 E-11
Te-131m	1.33 E-03
I-131	1.90 E+00
Te-131	2.17 E-05
Te-132	6.65 E-02
I-132	5.93 E-03
I-134	3.04 E-05
Cs-134	5.86 E+01
I-135	6.84 E-03
Cs-136	4.06 E+00
Cs-137	4.46 E+01
Ba-137m	2.68 E-01
Ba-140	1.50 E-02
La-140	1.82 E-02
Ce-141	1.90 E-03
Pr-143	3.76 E-04
Ce-144	6.41 E-02
Pr-144	6.41 E-02

Notes:
1) Filter effectiveness was assumed to be limited to activation and corrosion products. It was also assumed that the filters removed 10% of these influent materials and the remaining activation and corrosion products were removed in the resin beds.
2) The data provided in this table was prepared prior to SGR/PUR but remains bounding because of the lower volume of radioactive effluents demonstrated in 1998 and 1999.

TABLE 11.4.2-1

OUTPUT FROM SOLID WASTE PROCESSING SYSTEM[1]
BASED ON NORMAL OPERATION OF THE LWPS[4]

Source	Form	Quantity (cu ft/yr)	Quantity [2] (Liners/yr.)	Quantity (drums/yr)
Spent Resins	Solidified	1,125[3]	7	
	Dewatered	750	4	
Dry Solids	Compressed	3,000[2]		500
SUBTOTALS:	With Solidified Resins		7	500
	With Dewatered Resins		4	500
MFTDS				
Spent Resins	Solidified	1,705	10	0
	Dewatered	1,135	7	0
Filters	Solidified	300	2	0
	Dewatered[5]	200	≈1[5]	
SUBTOTALS:	Solidified		12	0
	Dewatered		8	0

NOTES:

1) Table gives maximum annual volumes. For expected volumes delete spent resin from the condensate demineralizers and the detergent evaporator bottoms. Thus, the expected volumes are those associated with primary systems and the maximum volumes include volumes associated with the secondary systems.

2) Assumes 195ft^3 liners/HIC's that are 95% full.

3) Based on two volumes of waste per volume of solidification agent.

4) This table is based on the normal use of the MFTDS.

5) 60 cuft/yr spent carbon shipped in wet form for offsite vendor processing is outside the SWPS scope.

TABLE 11.4.2-1a

OUTPUT FROM SOLID WASTE PROCESSING SYSTEM(1)
BASED ON THE ALTERNATIVE USE OF THE LWPS RO/EVAPORATOR SYSTEM(4)

Source	Form	Quantity (cu ft/yr)	Quantity(3) (Liners/yr.)	Quantity (drums/yr)
Spent Resins	Solidified	2,425(3)(5)	13	
	Dewatered	1,615(5)	9	
Evaporator Bottoms	Solidified	3,660(3)(4)	20	
Filter Particulates	Solidified	2,790(3)(4)	15	
Dry Solids	Compressed	3,000(2)		500
Chemical Drains	Solidified	188(3)(4)	1	
TOTALS:	With Solidified Resins	49	500	
With Dewatered Resins	45	500		

NOTES:

1) Table gives maximum annual volumes. For expected volumes delete spent resin from the condensate demineralizers and the detergent evaporator bottoms. Thus, the expected volumes are those associated with primary systems and the maximum volumes include volumes associated with the secondary systems.

2) Assumes 195ft^3 liners/HIC's that are 95% full.

3) Based on two volumes of waste per volume of solidification agent.

4) This table is based on the processing of liquid waste using the alternative waste processing subsystem consisting of reverse osmosis and evaporation.

TABLE 11.4.2-2

NUCLIDE ACTIVITY SHIPPED FROM THE SOLID RADWASTE SYSTEM
(μ Ci/g) Normal Operations[(4)]

Isotope	Evaporator Bottoms[(1)]	Back Wash Filter Sludge[(2)]	Spent Resin[(3)]
Br 83	5.05E-05	1.98E-01	1.41E-08
Br 84	1.50E-07	9.90E-03	1.23E-06
I 130	1.08E-03	0.	1.61E-07
I 131	9.97E+00	2.34E+02	9.58E+00
I 132	3.80E-02	4.47E+00	1.55E-03
I 133	8.60E-01	1.90E+02	6.97E-03
I 134	2.10E-05	2.43E-01	1.80E-08
I 135	9.20E-02	3.82E+01	1.04E-02
Rb 86	6.17E-03	0.	4.30E-06
Rb 88	4.60E-07	4.50E-01	6.86E-05
Cs 134	4.03E+00	1.98E+01	4.80E+01
Cs 136	1.05E+00	7.09E+00	1.98E+00
Cs 137	2.96E+00	1.47E+01	3.16E-03
Cr 51	1.71E-02	3.39E+01	1.34E-05
Mn 54	4.58E-03	5.92E+00	6.01E-06
Fe 55	2.42E-01	1.36E+00	2.60E-04
Fe 59	1.09E-02	1.83E+01	9.69E-06
Co 58	1.96E-01	3.00E+02	1.96E-04
Co 60	3.10E-02	3.94E+01	4.10E-01
Sr 89	3.97E-02	2.95E-01	3.66E-05
Sr 90	1.54E-03	8.61E-03	1.69E-06
Sr 91	1.92E-04	1.80E-01	2.99E-08
Y 90	1.13E-06	1.26E-02	2.30E-10
Y 91M	1.39E-08	3.55E-02	1.26E-11
Y 91	7.48E-04	1.13E+00	7.04E-07
Y 93	1.18E-06	1.22E-01	1.81E-10
Zr 95	8.08E-04	1.06E+00	1.83E-06
Nb 95	6.16E-04	8.66E-01	1.62E-06
Mo 99	8.00E-02	1.01E+03	1.73E-06
Tc 99M	6.70E-02	1.05E+02	8.76E-09
Ru 103	4.76E-04	7.81E-01	5.02E-07
Ru 106	2.96E-04	1.83E-01	2.86E-06
Rh 103M	2.80E-09	5.54E-03	2.06E-12
Te 125M	3.40E-03	0.	2.21E-06
Te 127M	3.70E-02	0.	3.37E-05
Te 127	2.30E-04	0.	3.60E-08
Te 129M	1.36E-01	0.	1.15E-04
Te 129	1.76E-06	0.	1.02E-09
Te 131M	8.70E-03	2.65E-01	9.80E-07
Te 131	1.87E-08	0.	9.47E-11
Te 132	3.60E-01	4.42E+00	7.59E-06
Ba 140	1.20E-02	0.	6.99E-06
La 140	6.92E-05	1.30E+00	4.77E-03
Ce 141	6.75E-04	1.26E+00	5.77E-07
Ce 143	1.33E-05	3.14E-01	2.07E-09
Ce 144	7.88E-04	6.04E-01	5.89E-06
Pr 143	2.87E-04	7.89E-01	1.76E-07
Pr 144	5.78E-11	0.	1.33E-12
Np 239	9.32E-03	0.	1.77E-06
TOTAL	2.03E+01	2.04E+03	5.99E+01

Table 11.4.2-2 (Continued)

NOTES:

(1) The assumed inputs consist of waste evaporator bottoms, RO concentrate evaporator bottoms, SW high conductivity evaporator bottoms and boron recycle evaporator bottoms. Note: The SW high conductivity evaporator has been removed from service.

(2) The assumed inputs consist of reactor coolant filter, fuel pool demineralizer filter, secondary waste filter, waste evaporator feed filter, laundry and hot shower filter, floor drain filter, spent resins sluice filter, recycle evaporator feed filter, recycle evaporator condensate filter, fuel pool skimmer filter, fuel pool and refueling water purification filter, waste evaporator condensate filter, seal water return filter, seal water injection filter, boric acid filter, gas decay tank filter, and recycle evaporator concentrate filter.

(3) The assumed inputs consist of waste evaporator condensate demineralizer, floor drain monitor demineralizer, laundry & hot shower demineralizer, secondary waste (SW) low conductivity demineralizer, CVCS mixed bed and cation bed demineralizers, boron thermal regeneration demineralizer and boron recycle evaporator feed demineralizer. Also six months of decay was assumed when developing these concentrations.

(4) This table contains historical information used in the original design of the radwaste system.

TABLE 11.4.2-3 NUCLIDE ACTIVITY SHIPPED FROM THE SOLID RADWASTE SYSTEM (µ Ci/g) Design Basis

Isotope	Evaporator Bottoms(1)	Back Wash Filter Sludge(2)	Spent Resin(3)
Br 83	8.91E-04	3.50E+00	2.48E-07
Br 84	2.37E-06	1.56E-01	1.23E-05
I 129	6.29E-06	0.	7.35E-05
I 130	9.65E-03	0.	1.44E-06
I 131	1.01E+01	2.34E+03	9.58E+01
I 132	3.90E-01	1.09E+02	1.55E-02
I 133	8.74E+00	1.96E+03	6.94E-02
I 134	2.26E-04	2.62E+00	1.93E-07
I 135	9.40E-01	4.02E+02	1.04E-01
Rb 86	1.51E+00	0.	1.05E-03
Rb 88	9.01E-06	8.68E+00	6.86E-04
Rb 89	1.12E-07	0.	5.47E-09
Cs 134	3.33E+02	1.19E+03	4.80E+02
Cs 136	1.60E+02	1.42E+03	1.99E+01
Cs 137	2.20E+02	8.05E+02	2.43E-01
Cs 138	5.12E-05	1.93E+00	6.90E-04
Cr 51	4.69E-02	9.32E+01	3.83E-05
Mn 54	5.71E-03	7.23E+00	8.73E-06
Mn 56	2.36E-05	9.14E+00	6.39E-09
Fe 55	3.32E-01	1.90E+00	3.62E-04
Fe 59	6.01E-03	1.01E+01	5.54E-06
Co 58	1.76E-01	2.68E+02	1.82E-04
Co 60	2.90E-02	3.54E+01	4.10E+00
Sr 89	4.73E-01	3.59E+00	4.36E-04
Sr 90	1.76E-02	9.98E-02	1.93E-05
Sr 91	1.68E-03	1.56E+00	2.61E-07
Sr 92	1.60E-05	0.	4.12E-09
Y 90	3.06E-05	3.42E-01	6.27E-09
Y 91M	1.36E-07	3.49E-01	1.23E-10
Y 91	6.46E-03	9.74E+00	6.07E-06
Y 92	3.06E-06	1.07E+00	6.69E-10
Y 93	1.20E-05	1.70E+00	1.82E-09
Zr 95	7.79E-03	1.12E+01	1.01E-05
Nb 95	6.55E-03	1.08E+01	8.25E-06
Mo 99	8.10E-01	8.79E+03	2.33E-05
Tc 99M	6.70E-01	1.34E+03	1.11E-07
Ru 103	5.76E-03	9.60E+00	5.34E-06
Ru 106	2.34E-03	2.44E+00	9.13E-06
Rh 103M	3.03E-08	5.99E-02	2.24E-11
Ag 110M	1.93E-02	2.43E+01	2.05E-05
Te125M	3.12E-02	0.	2.94E-05
Te 127M	3.65E-01	0.	3.68E-04
Te 127	2.88E-03	0.	4.51E-07
Te 129M	1.76E+00	0.	1.48E-03
Te 129	1.67E-05	0.	9.64E-09
Te 131M	8.50E-02	1.37E+00	9.34E-06
Te 131	1.85E-07	0.	9.27E-10
Te 132	3.85E+00	4.75E+01	8.16E-04
Te 134	5.25E-06	0.	6.59E-09
Ba 140	2.22E-01	0.	1.29E-04
La 140	5.97E-04	1.13E+01	4.77E-02
Ce 141	5.86E-03	1.05E+01	5.00E-06
Ce 143	1.60E-04	3.77E+00	2.48E-08

TABLE 11.4.2-3 NUCLIDE ACTIVITY SHIPPED FROM THE SOLID RADWASTE SYSTEM (μ Ci/g) Design Basis

Isotope	Evaporator Bottoms[(1)]	Back Wash Filter Sludge[(2)]	Spent Resin[(3)]
Ce 144	6.20E-03	6.76E+00	1.91E-05
Pr 143	3.55E-03	9.71E+00	2.16E-06
Pr 144	5.69E-10	0.	1.30E-11
TOTAL	8.33E+02	1.90E+04	6.00E-02

NOTES:

(1) The assumed inputs consist of waste evaporator bottoms, reverse osmosis concentrate evaporator bottoms, secondary waste high conductivity evaporator bottoms and boron recycle evaporator bottoms. Note: The SW high conductivity evaporator has been removed from service.

(2) The assumed inputs consist of reactor coolant filter, fuel pool demineralizer filter, secondary waste filter, waste evaporator feed filter, laundry & hot shower filter, floor drain filter, spent resin sluice filter, recycle evaporator feed filter, recycle evaporator condensate filter, fuel pool skimmer filter, fuel pool and refueling water purification filter, waste evaporator condensate filter, seal water return filter, seal water injection filter, boric acid filter, gas decay tank filter, and recycle evaporator concentrate filter.

(3) The assumed inputs consist of waste evaporator condensate demineralizer, floor drain monitor demineralizer, laundry & hot shower demineralizer, secondary waste low conductivity demineralizer, CVCS mixed bed and cation bed demineralizers, boron thermal regeneration demineralizer and boron recycle evaporator feed demineralizer. Also six months of decay was assumed when developing these concentrations.

TABLE 11.4.2-3a

RADIONUCLIDE CONCENTRATIONS IN SPENT MFTDS PROCESS MEDIA DEWATERED AND PACKAGED FOR DISPOSAL NORMAL OPERATION(3)

Nuclide	Conc.(μCi/cc)(2)
Filters(1)	
Na-24	4.32 E-04
Cr-51	4.62 E-03
Mn-54	1.53 E-02
Fe-55	1.49 E-02
Fe-59	7.33 E-04
Co-58	1.75 E-02
Co-60	7.01 E-03
Zn-65	4.47 E-03
W-187	5.36 E-05
Np-239	1.83 E-04

Nuclide	Conc.(μCi/cc)(2)
Spent Resins	
Cr-51	7.75 E-05
Mn-54	1.60 E-02
Fe-55	2.07 E-02
Fe-59	7.00 E-05
Co-58	4.70 E-03
Co-60	1.04 E-02
Zn-65	4.23 E-03
Sr-89	6.10 E-05
Sr-90	2.92 E-04
Y-90	2.92 E-04
Y-91	8.26 E-06
Zr-95	3.44 E-04
Nb-95m	7.29 E-06
Nb-95	6.94 E-04
Ru-103	1.16 E-03
Rh-103m	1.14 E-03
Ru-106	1.14 E+00
Rh-106	1.14 E+00
Ag-110m	1.24 E-02
Te-129m	1.49 E-05
Te-129	9.53 E-06
I-129	2.51 E-11
I-131	4.69 E-09
Cs-134	1.57 E-01
Cs-136	7.28 E-08
Cs-137	2.83 E-01
Ba-137m	2.65 E-01
Ba-140	7.65 E-07
La-140	8.80 E-07
Ce-141	1.02 E-05
Pr-143	3.62 E-08
Ce-144	4.11 E-02
Pr-144	4.11 E-02

Notes:

1) Filter effectiveness was assumed to be limited to activation and corrosion products. It was also assumed that the filters removed 10% of these influent materials and the remaining activation and corrosion products were removed in the resin beds.
2) The spent radionuclide concentrations assume six months of decay.
3) The data provided in this table was prepared prior to SGR/PUR but remains bounding because of the lower volume of radioactive effluents demonstrated in 1998 and 1999.

TABLE 11.4.2-3b

RADIONUCLIDE CONCENTRATIONS IN SPENT MFTDS PROCESS MEDIA DEWATERED AND PACKAGED FOR DISPOSAL DESIGN BASIS CONDITIONS(3)

Nuclide	Conc.(μCi/cc) (2)
Filters(1)	
Na-24	4.32 E-04
Cr-51	7.79 E-03
Mn-54	1.53 E-02
Fe-55	2.72 E-02
Fe-59	1.35 E-03
Co-58	5.43 E-02
Co-60	2.40 E-02
Zn-65	4.47 E-03
W-187	5.36 E-05
Np-23	1.83 E-04

Nuclide	Conc.(μCi/cc) (2)
Spent Resins	
Cr-51	1.31 E-04
Mn-54	1.60 E-02
Fe-55	3.78 E-02
Fe-59	1.29 E-04
Co-58	1.46 E-02
Co-60	3.55 E-02
Zn-65	4.23 E-03
Sr-89	1.83 E-03
Sr-90	2.78 E-03
Y-90	2.78 E-03
Y-91	8.77 E-04
Zr-95	5.54 E-04
Nb-95m	1.17 E-05
Nb-95	1.56 E-03
Ru-103	1.16 E-03
Rh-103m	1.14 E-03
Ru-106	1.14 E+00
Rh-106	1.14 E+00
Ag-110m	1.24 E-02
Te-129m	1.42 E-03
Te-129	9.05 E-04
I-129	2.51 E-11
I-131	2.85 E-07
Cs-134	4.95 E+01
Cs-136	2.42 E-04
Cs-137	4.39 E+01
Ba-137m	2.65 E-01
Ba-140	7.65 E-07
La-140	8.80 E-07
Ce-141	4.13 E-05
Pr-143	3.62 E-08
Ce-144	4.11 E-02
Pr-144	4.11 E-02

Notes:

1) Filter effectiveness was assumed to be limited to activation and corrosion products. It was also assumed that the filters removed 10% of these influent materials and the remaining activation and corrosion products were removed in the resin beds.
2) The spent radionuclide concentrations assume six months of decay.
3) The data provided in this table was prepared prior to SGR/PUR but remains bounding because of the lower volume of radioactive effluents demonstrated in 1998 and 1999.

TABLE 11.4.2-4

SOLID WASTE PROCESSING SYSTEM
COMPONENT SUMMARY DATA

Tanks	No/Site	Capacity	Material	Design Code	Welder Qualification and Procedures
Caustic Addition	1	800 gal.	SS	API 620	ASME IX
Solidification Pretreatment Tank	2	5000 gal.	SS	ASME VIII Div I	ASME IX

Pumps	No/Site	Capacity (gpm)	Material	Code	Approximate Design Pressure (psig)	Approximate Design Temp (F)
Solidification Pretreatment Tank Pump	2	35	SS	ANSI B73.1	150	212
Caustic	2	13	CS	Mfgr's Standard	150	212

Note: Spent Resin Storage Tank is listed in Table 11.2.1-7 located in Section 11.2 (Liquid Waste Processing System).

TABLE 11.5.1-1

RECIRCULATION PUMPS RUN-OUT CAPACITY FLOW RATES

TANK	ASSOCIATED RECIRCULATION PUMP	PUMP DESIGN PROCESS CAPACITY (gpm)	RECIRCULATION CAPACITY (gpm)	TANK CAPACITY (gal.)	ESTIMATED TIME TO RECIRCULATE TWO TANK VOLUMES (HRS.)**
Waste Hold up Tank	Waste Evaporator Feed Pump	35	100	25,000	8
Waste Evaporator Condensate Tank	Waste Evaporator	35	100	10,000	3
Waste Monitor Tank	Waste Monitor Tank Pump	35***	100	25,000	8
Laundry and H. S. Tank	L&HS Mixing Pump	200	--	25,000	4
R.O. Concentrate Tank	R.O. Concentrate Evaporator Feed Pump	35	--	5,000	5
Recycle Hold up Tank	Recycle Evaporator Feed Pump	2 @ 30	2 @ 100	84,000	14*
Recycle Monitor Tank	Recycle Monitor Tank Pump	30	112	10,800	3

*Recycle Hold-up Tanks are oversized and will rarely contain their full capacity. This is due to the fact that the tanks are designed to hold all inputs when the Boron Thermal Regeneration Process is inoperable.

**Estimated time based upon recirculation of the total tank capacity utilizing the pump(s) operating at the limit of the recirculation capacity range.

***Waste monitor tank pump capacity is increased to 100 gpm when the waste monitor tanks are used as an alternate secondary waste sample tank.

TABLE 11.5.2-1

PROCESS RADIATION MONITORS

Description	Tag # (REM)	Subsection of 11.5.2.7.1 Described in	Detector Type	Range	Typical Sensitivity	Accuracy (%)	Typical High Alarm Setpoints	Location	Power	Automatic Actuation
Component Cooling Water A	1CC-3501A SA	.1	Liquid (11.5.2.5.7)	10^1-10^7 CPM	1.28 x 10^8 CPM/ µCi/cc Cs137	± 15	9.07 x 10^{-7} µCi/cc	Off Line	‡‡	None
Component Cooling Water B	1CC-3501B SB	.1	"	"	"	"	"	"	"	None
Auxiliary Steam Condensate Tank	21AC-3525	.2	"	"	"	"	"	"	‡‡	Stops Aux. Steam Condensate Pumps 1&2A and 1&2B; Closes Valve 6AC-V345-1&2; Closes Valve 6AC-V213-1
Steam Generator Blowdown	1BD-3527	.3	"	"	"	"	"	"	‡‡	None
Auxiliary Steam Condensate-Waste Process. Sys.	21AC-3543A	.4	Liquid (11.5.2.5.7)	10^1-10^7 CPM	1.28 x 10^8 CPM/ µCi/cc Cs137	± 15	9.07 x 10^{-7} µCi/cc	Off Line	‡‡	Stops Pump 1-4A (Aux. Condensate); Closes Valve 6AC-V345-1&2; Closes Valve 6AC-V213-1
Waste Processing Building Cooling Water	1WC-3544	.5	"	"	"	"	"	"	"	Closed vent valve on WPB cooling water surge tank.

‡ Safety Related AC Bus
‡‡ Instrumentation AC Bus

TABLE 11.5.2-2 <u>EFFLUENT RADIATION MONITORS</u>

Description	Tag#(REM)	Subsection of 11.5.2.7.2 Described in	Detector Type	Range	Typical Sensitivity	Accuracy (%)	Typical High Alarm Setpoints	Location	Power	Automatic Actuation
Service Water WPB	1SW-3500A	.1	Liquid (11.5.2.5.7)	10^1-10^7 CPM	1.28 x 10^8 CPM/µCi/cc Cs-137	± 15	2.05 x 10^{-5} µCi/cc	Off Line	‡‡	None
Service Water Turbine Building	1SW-3500B	.1	“	“	“	“	2.31 x 10^{-5}	“	‡‡	“
Fuel Handling Building Norm. Exhaust South	*1FL-3506	.2	Particulate (11.5.2.5.8) Iodine (11.5.2.5.10) & Noble Gas (11.5.2.5.10)	10^1-10^7 CPM	1.08 x 10^5 CPM/µCi/cc Cs-137 1.01 x 10^5 CPM/µCi/cc I-131 & 1.84 x 10^7 CPM/µCi/cc Xe-133	± 15				
Fuel Handling Building Norm, Exhaust North	*1FL-3507	.2	“	“	“	“	“	“	“	“
*Fuel Handling Building Emerg. Exhaust Monitor, South	*1FL-3508A SA	.3	“	“	“	“	“	“	‡	“
*Fuel Handling Building Emerg. Exhaust Monitor North	*1FL-3508B SB	.3	“	“	“	“	3.4 x 10^{-4} µCi/cc	“	“	“
Plant Vent Stack	RM21AV-3509-1SA see note 2	11.5.2.5.11	Beta Sensitive Plastic Scintillator and a Cadmium Telluride Detector	Note 1	4.3 x 10^7 CPM/µCi/cc Xe-133 1.4 x 10^4 CPM/µCi/cc Xe-133 50 CPM/ Xe-133	± 15 ± 15 ± 15	2 x 10^4 µCi/cc 7 µCi/cc 2 x 10^3 µCi/cc	Stack	‡ ‡ ‡	- - -
Turbine Building Drain	1MD-3528	.5	Liquid (11.5.2.5.7.1)	10^1-10^7 CPM	4.56 x 10^7CPM/µCi/cc Cs-137	“	2.21 x 10^{-5} µCi/cc	Adjacent to Line	‡‡	Terminates Discharge to the yard oil separator
*Reactor Auxiliary Bldg. Emerg. Exhaust A	1AV-3532A	.8	Noble Gas (11.5.2.5.10)	10^1-10^7 CPW	1.84 x 10^7 CPM/µCi/cc Xe-133	± 15	3.4 x 10^{-3} µCi/cc	Duct (off Line)	‡‡	None
*Reactor Auxiliary Bldg. Emerg. Exhaust B	1AV-3532B	.8	“	“	“	“	“	“	“	“
Condenser Vacuum Pump Effluents	1TV-3534	.9	Noble Gas (11.5.2.5.5)	“	4.3 x 10^7 CPM/µCi/cc, Xe-133	“	1.02 x 10^{-6} µCi/cc	“	“	“
Secondary Waste Sample Discharge	21WS-3542	.12	Liquid (11.5.2.5.7)	“	1.28 x 10^8 CPM/µCi/cc Cs-137	“	2.32 x 10^{-5} µCi/cc	Off Line	“	Effluent Discharge Terminated
*Waste Processing	*1WV-3546	.13	Noble Gas (11.5.2.5.10)	“	1.08 x 10^5 CPM/µCi Cs-137 1.01 x 10^5 CPM/µCi I-131	“	1.36 x 10^9 µCi/cc 7.7 x 10^{-9} µCi/cc &	Stack	“	Discharge from Gas

TABLE 11.5.2-2 EFFLUENT RADIATION MONITORS

Description	Tag#(REM)	Subsection of 11.5.2.7.2 Described in	Detector Type	Range	Typical Sensitivity	Accuracy (%)	Typical High Alarm Setpoints	Location	Power	Automatic Actuation
Building Exhaust 5					1.84 x 10^{7} CPM/µCi/cc Xe-133		8 x 10^{-4} µCi/cc			Decay Tanks Terminated
Waste Processing Building Stack 5	RM1WV-3546-1	11.5.2.5.11	Beta Sensitive Plastic Scintillator and a Cadmium-Telluride Detector	Note 1	4.3 x 10^{7} CPM/µCi/cc Xe-133 1.4 x 10^{4} CPM/µCi/cc Xe-133 50CPM/µCi/cc Xe-133	±20 ±20 ±20	2 x 10^{-4} µCi/cc 7 µCi/cc 2 x 10^{3} µCi/cc	Stack	‡‡	“
Waste Processing Building Stack 5a	RM1WV-3547-1	11.5.2.5.11	Beta Sensitive Plastic Scintillator and a Cadmium-Telluride Detector	Note 1	4.3 x 10^{7} CPM/µCi/cc Xe-133 1.4 x 10^{4} CPM/µCi/cc Xe-133 50CPM/µCi/cc Xe-133	±20 ±20 ±20				
Treated Laundry & Hot Shower Tank Pumps	*1WL-354D	-10	Liquid (11.5.2.5.7)	10^{1}-10^{7} CPM	1.28 x 10^{8} CPM/µCi/cc Cs-137	“	7.44 x 10^{-6} µCi/cc	Off Line	‡‡	Effluent Discharge Terminated
Turbine Building Vent Stack	RM1TV-3536-1	11.5.2.5.11	Beta Sensitive Plastic Scintillator and a Cadmium-Telluride Detector	Note 1	4.3 x 10^{7} CPM/µCi/cc Xe-133 1.4 x 10^{4} CPM/µCi/cc Xe-133 50CPM/µCi/cc Xe-133	±20 ±20 ±20	2 x 10^{-4} µCi/cc 7 µCi/cc 2 x 10^{3} µCi/cc	Stack	‡‡	None
Waste Monitor Tanks Discharge	21WL-3541	.11	Liquid (11.5.2.5.7)	10^{1}-10^{7} CPM	1.28 x 10^{8} CPM/µCi/cc Cs-137	“	2.08 x 10^{-5} µCi/cc	Off Line	‡‡	Effluent Discharge Terminated
Tank Area Drain Transfer Pumps	1MD-3530	.6	“	“	“	“	2.31 x 10^{-5} µCi/cc	“	“	Shuts off Drain Transfer Pumps
Containment Pre-Entry Pumps	1LT-3502B	.15	Particulate (11.5.2.5.8) & Noble Gas (11.5.2.5.6)	“	1.08 x 10^{5} CPM/µCi/cc Cs-137 2.18 x 10^{7} CPM/µCi/cc Xe-133	±10	1.5 x 10^{-8} µCi/cc	Outside Containment	“	Isolation of Pre-Entry Purge
Main Steam Line Monitors Line A Line B Line C		.16	G-M Tube	10^{0}-10^{5} mR/hr	3 x 10^{3} CPM/mR/hr	±20 ±20 ±20	5 mR/hr 5 mR/hr 5 mR/hr	Pipe	‡ ‡ ‡	None “ “

FIGURE 11.3.2-3

GWPS FISSION GAS ACCUMULATION BASED ON CONTINUOUS CORE OPERATION OF ONE UNIT AT 2958 MWT WITH 1% FUEL DEFECTS

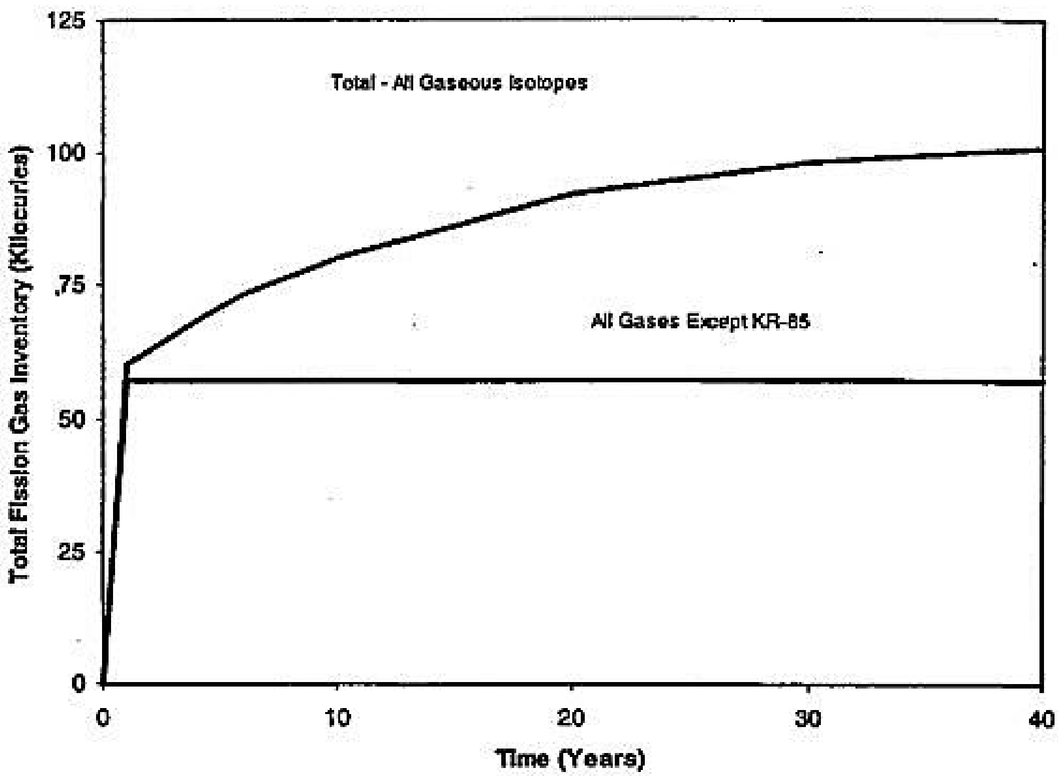


FIGURE 11.3.2-4

EXPECTED GWPS FISSION GAS ACCUMULATION BASED ON TABLE 11.1.2-1 AND FULL POWER OPERATION OF ONE UNIT AT 2949 MW_T

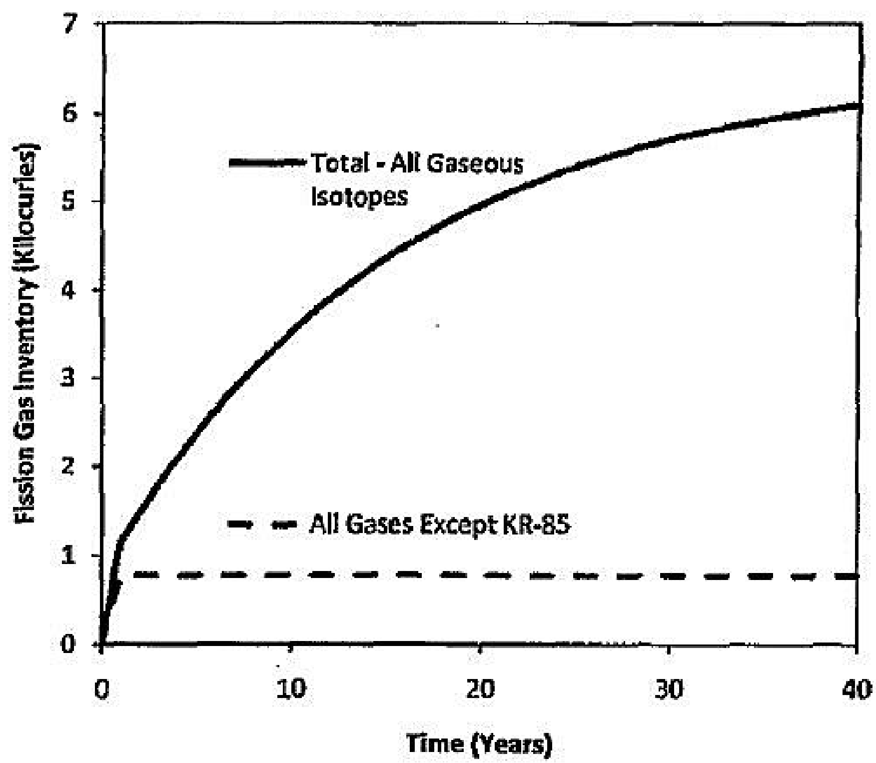


FIGURE 11.3.2-5

GASEOUS WASTE PROCESSING SYSTEM PROCESS FLOW DIAGRAM

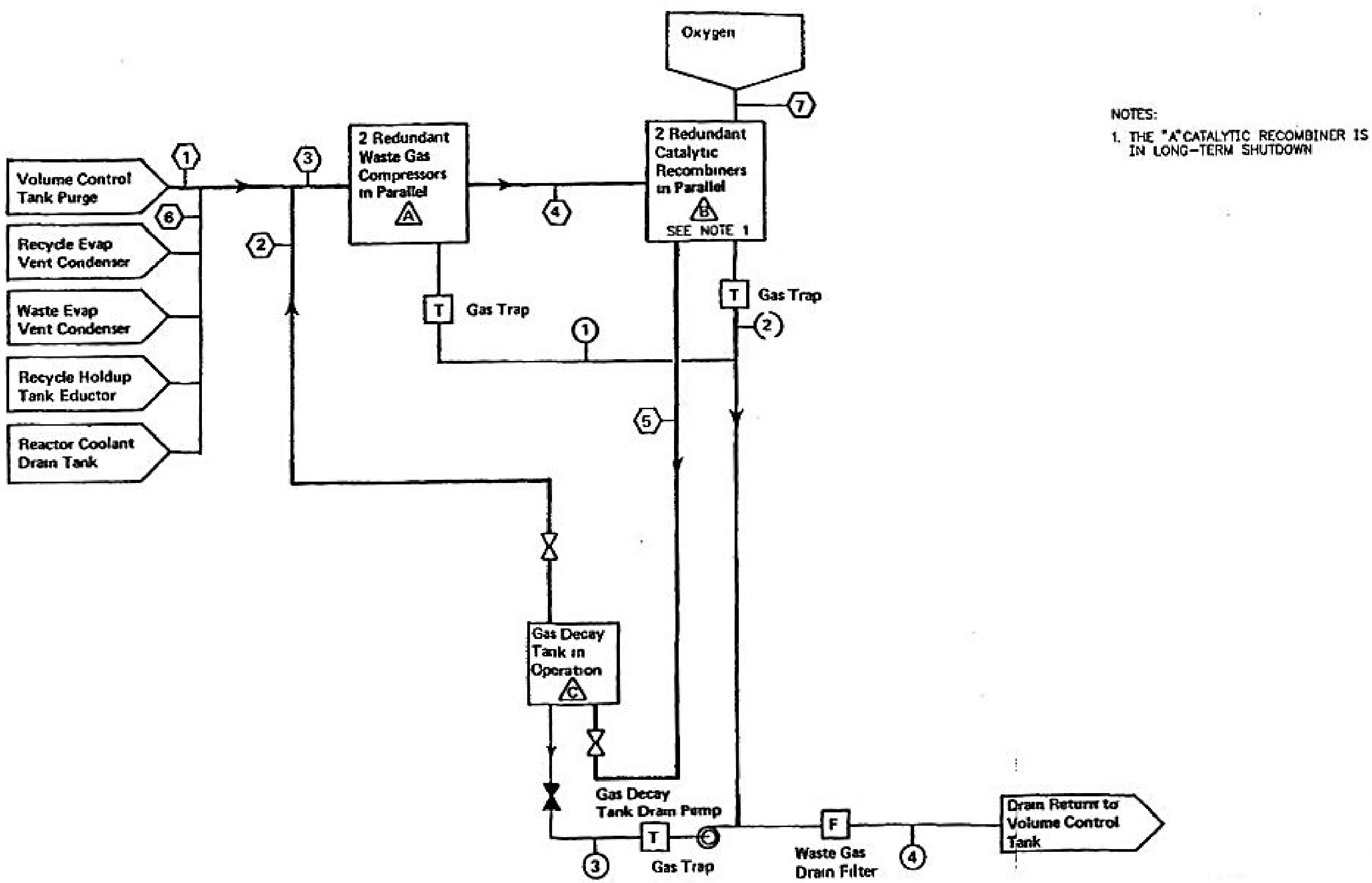


FIGURE 11.3.2-6

GASEOUS WASTE PROCESSING SYSTEM PROCESS FLOW DIAGRAM

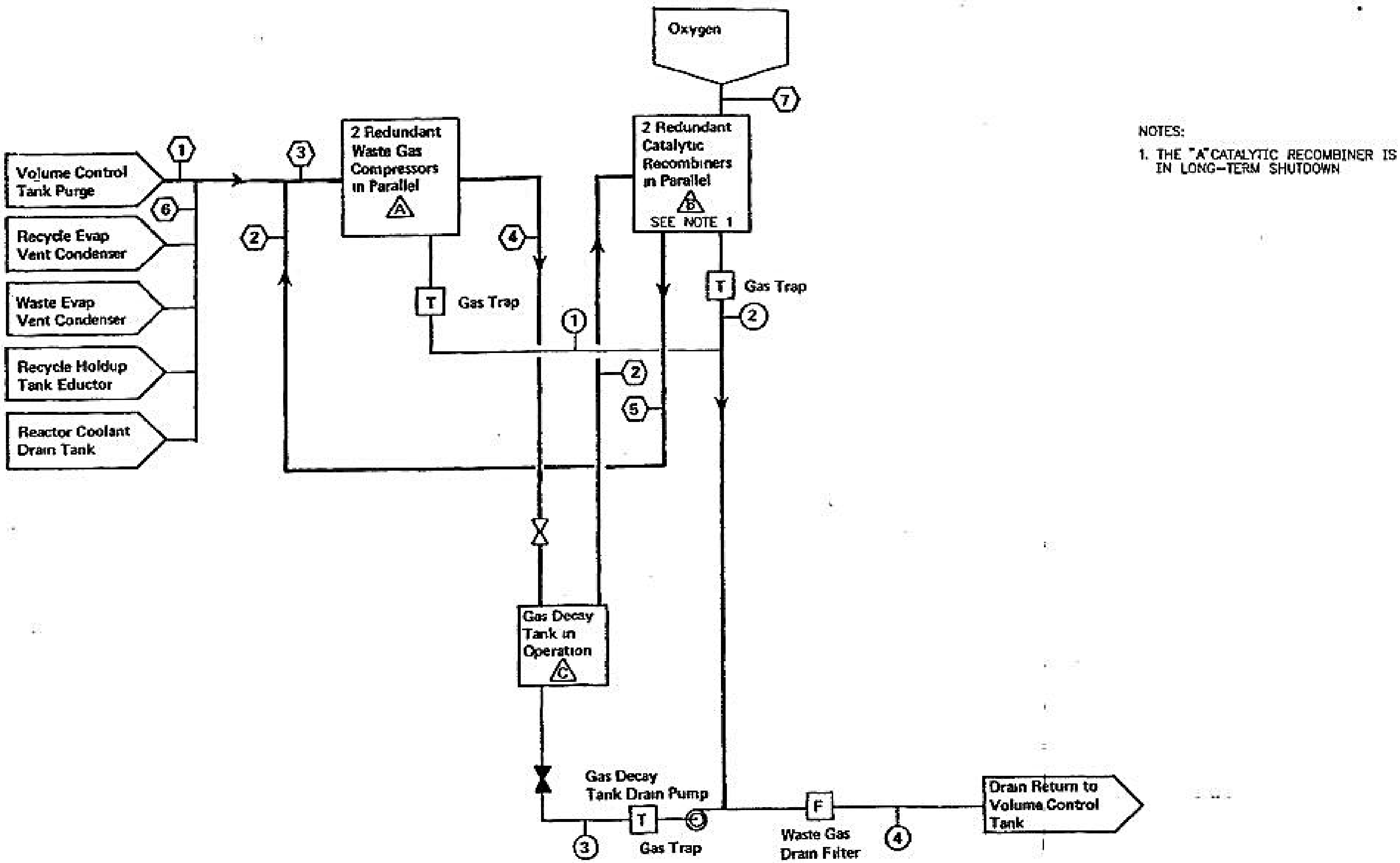


FIGURE 11.3.2-7

WASTE GAS – COMPRESSOR PACKAGE

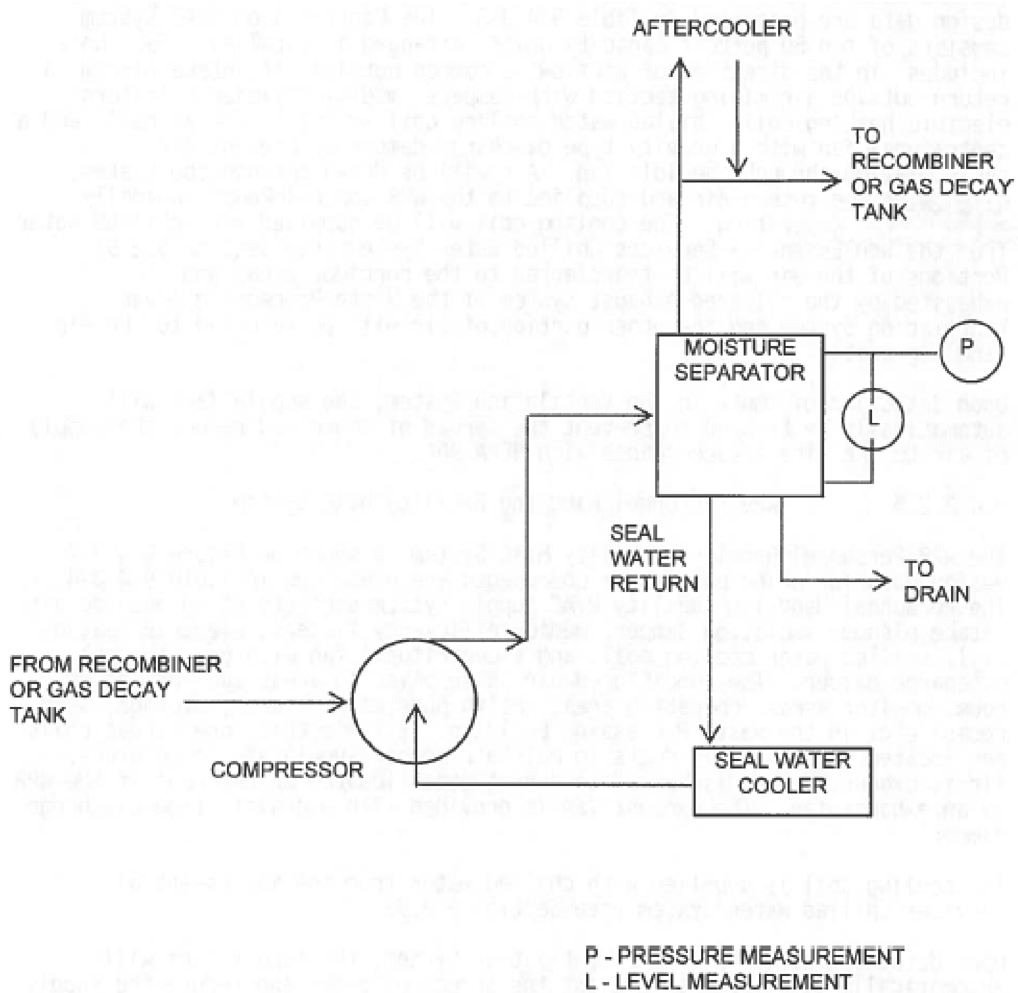


FIGURE 11.3.2-8

CATALYTIC HYDROGEN RECOMBINER PACKAGE

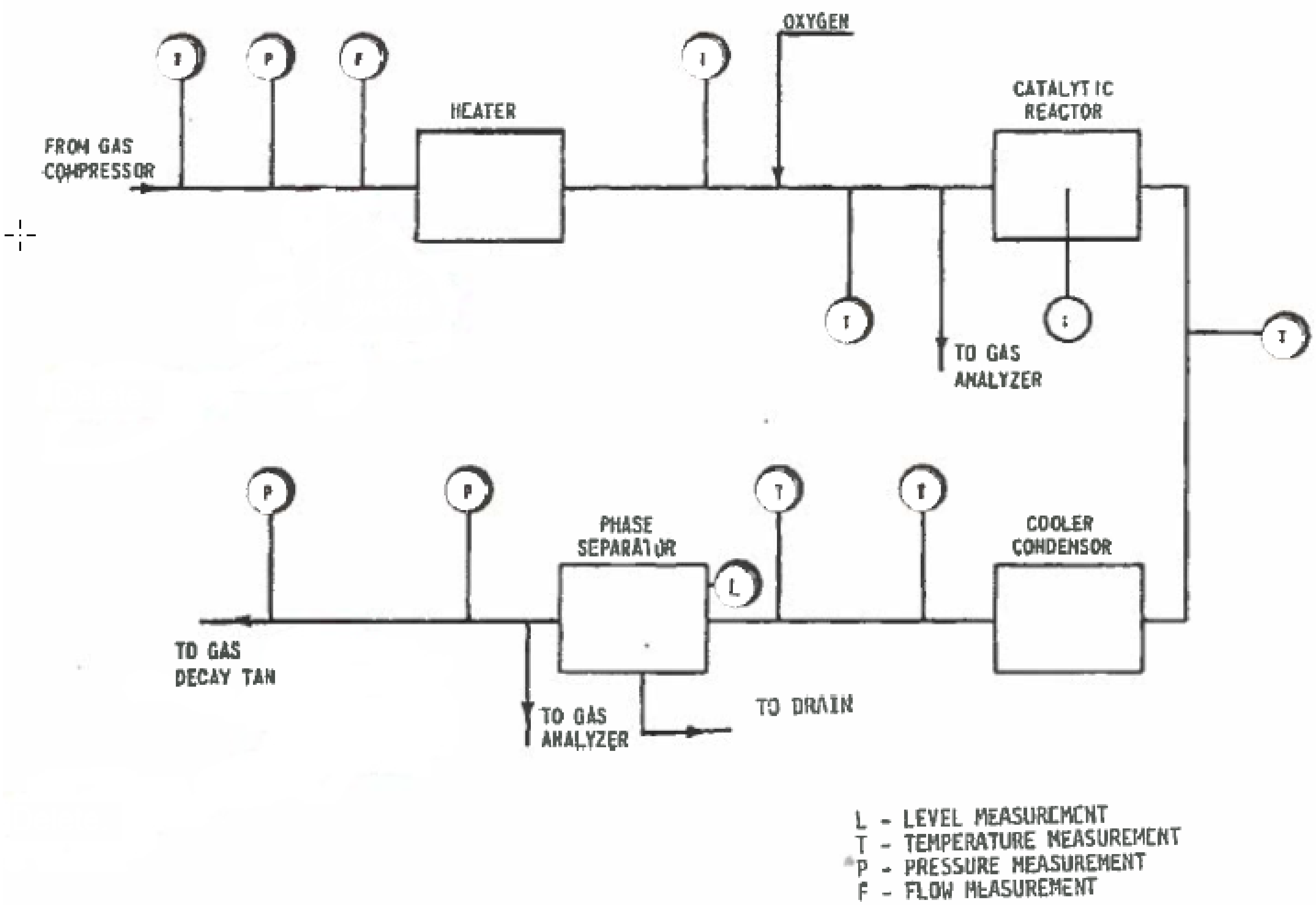
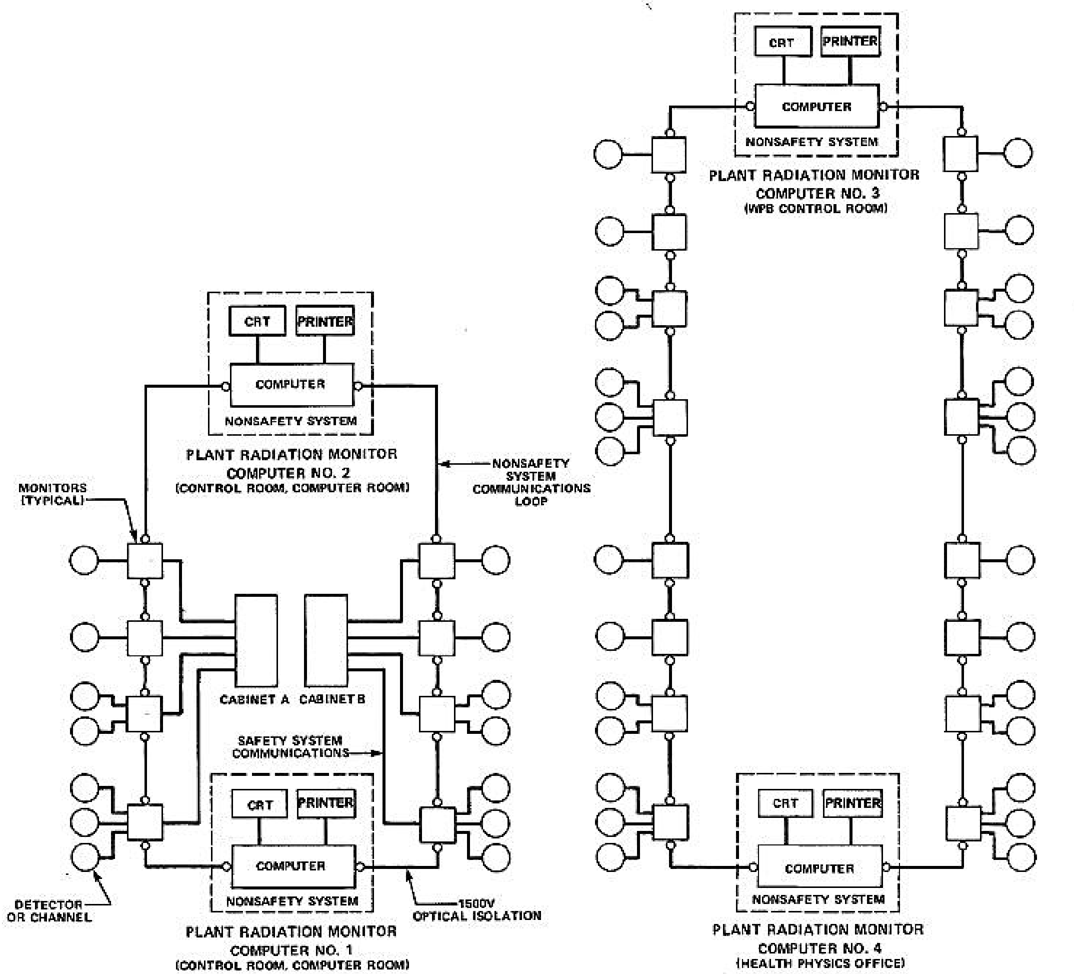


FIGURE 11.5.2-1

SCHEMATIC OF RADIATION MONITORING SYSTEM



NOTE:

ONLY MONITORS THAT ARE SAFETY HAVE THE SAFETY COMMUNICATIONS LOOPS.

DATA LINKS BETWEEN ALL FOUR MINICOMPUTERS AND THE DATA STORAGE COMPUTER IS NOT SHOWN.